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Environmental assessment of menus for toddlers serviced at nursery canteen following the Atlantic diet recommendations

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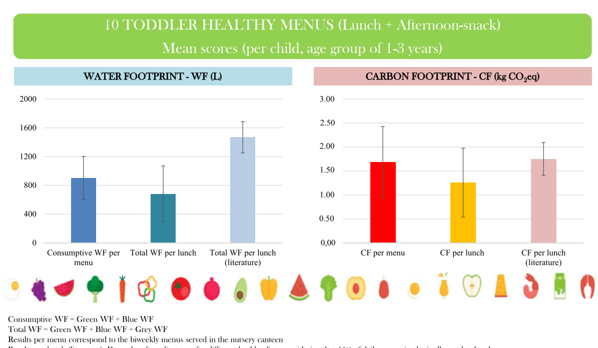
HIGHLIGHTS

- Huge variations on environmental scores are associated to the menus composition.
- Animal source food is the responsible for the highest water demands and GHG emission.
- Menus incorporating beef meat are associated with the highest impacts.
- Introducing changes on the most harmful menus allows outstanding environmental improvements.
- Menus rich on animal source food can have low scores if they are adequately combined.

GRAPHICAL ABSTRACT



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ABSTRACT

Menus served at public services can be considered as a good opportunity for consumers to demand a service that ensures healthy and environmentally friendly food. It is especially in the sector of nurseries and schools, where these demands make the most sense since they call for the protection of particularly vulnerable population: children. The purpose of this study is to analyze the biweekly menus served at a public Spanish nursery canteen considering the link with the two most recognized environmental indicators: the consumptive water footprint (WF) and the carbon footprint (CF). The WF and CF of the menus vary considerably between menus (619–1359 L·menu^{-1} and 0.75–2.95 kg CO_2eq·menu^{-1}). The assessment has identified non-dairy sources of protein and dairy-based products as the key food categories in all menus. Menus with more meat (mostly beef) and dairy products (mainly cheese) were associated with higher impacts. That is, the average impact of menus with beef is about 2 times greater than the one of all other menus.

The distribution and cooking stages presented negligible contributions in terms of greenhouse gases emissions, mainly due to the consumption of local/regional products and low-energy intensive cooking techniques. The most important strategy for reducing environmental impacts is based on reducing the frequency of consumption of beef, so that poultry and lean pork are consumed alternately. This reduction should not compromise the necessary protein intake for toddlers. Attention should also be paid to afternoon snacks that are rich in cold meat and dairy products. Considering these issues, significant reductions in WF and CF indicators could be achieved, up to

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550 L·menu^{-1} and 0.70 kg CO_2eq·menu^{-1}. Since eating habits introduced at an early stage are more likely to develop into adult behaviour, children canteen services are an excellent opportunity to promote healthy eating habits in children and their families.

1. Introduction

Nowadays, dietary choices are shifting towards unhealthy patterns characterized by the consumption of ready-meals and sweets, driven by urbanization and globalization among other issues (Lindgren et al., 2018). As a result, this trend leads to an increase in indicators of overweight and obesity in the population, as well as the increment of incidence of cancer and other types of diseases such as stroke and diabetes (Ruiz et al., 2015; Swinburn et al., 2019; Afshin et al., 2019). Nevertheless, it is well-know that nutrition is at the heart of the 2030 Agenda for Sustainable Development (UN, 2015; WHO, 2018).

There is scientific evidence linking diets to human health and environmental sustainability, as reported by the EAT-*Lancet* Commission (Willet et al., 2019; Lang and Mason, 2019). The food production sector is a major contributor to negative environmental sustainability issues (FAO, 2010), including depletion of natural resources, loss of terrestrial and aquatic biodiversity, land use change, imbalances of nitrogen and phosphorous cycle and anthropogenic greenhouse gases (GHG) emissions (Bilali et al., 2018). In this regard, it is well-known the impact of the food system on GHG emissions and freshwater extraction. The food system is responsible for 20% to 30% of anthropogenic GHG emissions, the main impacts being those of agricultural activities (Springmann et al., 2016). In this sense, livestock alone contributes 15% of human made GHG emissions, mainly due to methane emissions from enteric fermentation and manure decomposition (FCRN, 2015). Regarding water use, food production requires a large consumption of fresh water, being agriculture responsible for 70% of all water withdrawals (Sokolow et al., 2019). Although food producers play a key role in the commitment to mitigate the effect of the food system on the environment, their capacity to reduce the impacts is limited (Poore and Nemecek, 2018). Consequently, human choices constitute a relevant part of this challenge and the shift towards sustainable dietary patterns is considered a key factor with the aim of reducing the incidence of diet-related diseases and nutrient deficiencies, as well as mitigating negative environmental consequences.

Bearing in mind the aforementioned issues, diet and nutrition link human health and the environment and accordingly, the sustainability of the food system is placed at the top of the agendas of politicians, society and scientists since the current food system is not sustainable. Therefore, the notion of sustainable diet has emerged strongly on the food policy agenda in recent years (Lang, 2014). The concept of sustainable diets has been defined as patterns of food consumption that are beneficial for human health, nutrition, environmental, ethical and economic domains for present and future generations (FAO, 2012; Allen et al., 2019).

Achieving a sustainable food system that can provide healthy diets to a growing population poses significant challenges (Willet et al., 2019). However, there is no metric or measure for assigning the title of sustainable to a specific dietary pattern. Johnston et al. (2014) consider this statement necessary for policymakers and consumers to understand how a sustainable diet may improve the health of individuals and populations while conserving resources and the environment. The role of researchers in discussing, researching, and promoting the specifics of (un)sustainable diets is remarkable (Lang and Mason, 2019).

In this regard, several indicators have been proposed to assess the environmental impacts of food systems and diets, such as carbon footprint and water footprint (Green et al., 2018; González-García et al., 2018; Blas et al., 2019). The former includes the quantification of GHG emissions throughout Life Cycle Assessment (LCA) approach. The latter estimates the water usage of foodstuffs throughout the Water Footprint (WF) assessment perspective. The Food and Agriculture Organization of the United Nations (FAO) estimates that between 2000 and 5000 L of water are needed to produce a person's daily food (FAO, 2017). Regarding GHG emissions, they can range from 0.58 to 13.43 kgCO_2eq·person^{-1}·day^{-1} (González-García et al., 2018). Fluctuations in the value of indicators are directly associated with the presence of certain foodstuffs in the diet, especially animal-based products (mainly those including ruminants meat) show the highest scores in terms of water and carbon footprints (González-García et al., 2018; Mertens et al., 2019). There are multiple studies that evaluate carbon and water footprints derived from dietary patterns (Saxe et al., 2012; Van Kernebeek et al., 2014; González-García et al., 2020; Green et al., 2018; Van de Kamp et al., 2018; Batlle-Bayer et al., 2019; Esteve-Llorens et al., 2019a, 2019b, 2020; Mertens et al., 2019; Blas et al., 2019).

However, little information is available on the environmental impacts associated with menus and recipes and much less regarding the meal service provided in public bodies. To our knowledge, only six publications have been published so far. Saxe et al. (2012) analysed the environmental impact of meal service catering for dependent senior citizens in Denmark. Oostindjer et al. (2017) discussed how school meals can constitute a viable and sustainable tool for improving the health and sustainability of children's diet. Benvenuti et al. (2016) considered the case of school lunch menus with the aim of defining menus with low environmental impact. De Laurentiis et al. (2017) quantified climate change and water use in school lunch menus served in England and proposed win-win strategies for their improvement. Saarinen et al. (2012) evaluated the impact of home-made, ready-to-eat and school lunches in the framework of a project aiming to elaborate a food-related communication tool for sustainable education for elementary school students. Martinez et al. (2020) evaluated the carbon footprint of school lunch menus adhering to Spanish dietary guidelines.

Within the population groups, toddlers are a key group. They grow rapidly and have dietary requirements different from those of older children, based on foods of high nutritional quality that provide sufficient micro and macronutrients to support their healthy growth and development (Cobaleda Rodrigo and Bousoño Garcia, 2007). Adequate nutrition in toddlers is essential for healthy growth and good cognitive development, to avoid behaviour problems and to achieve a good academic performance (Grantham-McGregor, 2005).

The incorporation of women into the workforce and the long distances between home and school/childcare have meant that the demand for canteen service has grown steadily even at an early age. Nowadays, this service is used by more than 32% of children from 2 to 5 years old in Spain (Leis Trabazo et al., 2007). Eating habits introduced at an early stage are more likely to become adult behaviours. Subsequently, nursery canteen services can be an excellent opportunity to promote healthy habits among children from a very early age, since younger children can adapt to changes in eating habits more flexibly than adults (Rozin, 2007). In addition, school canteens constitute a key platform since served meals are considered an issue of national responsibility in countries such as United Kingdom (Oostindjer et al., 2017) and Italy (Benvenuti et al., 2016).

The scope of this study is to evaluate the carbon and water footprints for the biweekly menus of a Spanish nursery school (ten different menus), to define improved menus with low environmental impact but maintaining the nutritional contribution. The typical daily menus (designed and supervised by a pediatrician) consist of a lunch and an afternoon snack and are based on the recommendations of the Atlantic diet. The lunch comprises a first course (pasta, rice, salad, pulses, …), a second course (mainly based on fish and meat) and a dessert (fruit or yogurt). The afternoon snack includes a cereal-based product (sandwich or cereals) and fruit/yogurt. Each menu provides the energy and nutrients needed for toddlers. This study opens a possible window of opportunity for intervention to promote balanced and healthy dietary habits among pre-school children, as well as to disseminate an environmentally sustainable education about food choices among families as a pattern of behaviour in the future development of children.

2. Materials and methods

2.1. Menus configuration

The present case study is focused on a representative Spanish public nursery located in Santiago de Compostela (northwest Spain). This nursery has its own canteen service where menus (lunch and afternoon-snack) are prepared at the nursery kitchen (no external catering service) according to a guide of health and nutritional practices established by the pediatrician and following the Atlantic diet guidelines (ADF, 2019). Therefore, the menus served are balanced, formulated under criteria of nutritional quality in a variety of foods that allow introducing children to different tastes and textures (Venter and Harris, 2009). Menus incorporate fruits, vegetables, dairy products, starch-based foodstuffs (potatoes, pasta, rice and bread), fish and seafood, lean and cold meat, eggs, legumes and olive oil as a fat-source. Whenever possible, local and seasonal foodstuffs are included in the daily menus, avoiding pre-cooked food. Regarding cooking techniques, boiling and stewing predominate in the preparation of meals as recommended by the Atlantic diet guidelines. About 75 daily menus are prepared in the nursery kitchen. The composition of the lunch and afternoon snack ensures an adequate intake of nutrients and energy for toddlers, estimated at 30–35% and 15% of the total daily energy intake, respectively (Cobaleda Rodrigo and Bousoño Garcia, 2007; Leis Trabazo et al., 2007).

The nursery under study prepares two types of menus according to the season (fall/winter and spring/summer) considering the preference of incorporating seasonal and fresh products. This study evaluates the biweekly menus corresponding to the spring-summer season, consisting of 10 different lunch-meals and afternoon snacks, which are combined with the aim of avoiding repetition of dishes. **Table SM1** (week 1) and **Table SM2** (week 2) in the **Supplementary Material** show the composition of each lunch meal and afternoon-snack. The different foodstuffs have been classified into five groups of ingredients that are 1) starch-based products (bread, rice, pasta, potatoes and cereals), 2) fruit and vegetables, 3) milk and dairy foods, 4) non-dairy sources of protein (meat – lean and cold, fish, seafood, eggs and pulses) and 5) other products such as olive oil and food seasonings. The rationale behind the classification of these five groups is double: i) they must be present in a healthy balanced diet for a young child according to Leis Trabazo et al. (2007) and ii) the groups with the highest contributions to the environmental indicators can be identified. The data on menu composition were collected by the authors of the study in collaboration with the cookers using a specific questionnaire over a two-month period. Information regarding the amount of each foodstuff required to prepare the meals, the origin of foodstuffs, the distribution as well as the cooking technique considered (cooking time, appliances, power) were provided directly by the nursery canteen's workers.

2.2. Functional unit

The functional unit is the reference flow for which environmental impacts are reported and therefore should be consistent with the function of the system under assessment. Accordingly, and bearing in mind the main goals of this study, a functional unit based on individual meals, i.e. one meal (lunch and afternoon-snack) served to a toddler at the nursery canteen, is considered for the analysis. It is important to consider that each daily menu supplies the nutritional requirements of each specific meal, which should be completed at home with breakfast, mid-morning meal and dinner.

2.3. Quantification of environmental impacts: Water Footprint (WF) and Carbon Footprint (CF)

Large water requirements of the food production system are mainly associated with crop irrigation, livestock rearing and food processing. Furthermore, there is also indirect water consumption that is, water stored in the soil and evapo-transpired by crops. In addition, food production entails significant environmental impacts on water resources due to eutrophication. Water Footprint Assessment (WFA) is the methodology described in the Global Water Footprint Assessment Standard developed by Water Footprint Network (WFN, 2020) to i) measure the volume of water directly and indirectly used to produce a product, ii) assess the sustainability, efficiency and equitability of water use and, iii) identify the most strategic actions to provide response strategies. WFA shows freshwater consumption by source and polluted volumes by the type of pollution (Hoekstra et al., 2011) and can be used to integrate water quantity and quality aspects in water resources assessment, planning and management. Bearing in mind the defined goals of this study, it has only focused on the estimation of water use that is, specifically on the Water Footprint (WF) indicator considering only phases one (setting goals and scope) and two (WF accounting) of the WFA. Thus, both phases provide an idea of the volume of freshwater used to produce a foodstuff (Vanham et al., 2017). Although the WF is the sum of three components (blue, green and grey), only blue and green WFs have been considered for the estimation of the WF associated with each menu, which is known as consumptive WF (sum of the green and blue components) since the aim is to identify the water demand per menu. According to Harris et al. (2020), it is the most used metric for assessing water use in diets. The blue WF measures the consumptive use of surface and ground water and the green WF measures consumption of rainwater (more relevant in agriculture and forestry). The grey WF is measured as the volume of water required to assimilate the load of pollutants based on the natural background concentration and existing ambient water quality standards (Hoekstra et al., 2011) and is therefore not an estimation of water polluted but of water demand. This approach has been also considered in other related studies (Green et al., 2018; Chenoweth et al., 2014). The WF was calculated only for the production phase of foodstuffs that constitute the menus as the other phases of the life cycle (distribution and cooking) present negligible impacts as reported by Jefferies et al. (2012) and De Laurentiis et al. (2017). Therefore, the water requirements for producing processed foods in the nursery kitchen to prepare the daily menus were only quantified.

The Carbon Footprint (CF) emerges as the environmental indicator related to the GHG emissions produced during the life cycle of the product, reporting a final index in CO_2-equivalents (Röös et al., 2013). In the literature there is an increasing number of studies focused on estimating CF associated with dietary patterns (González-García et al., 2018, 2020; Van de Kamp et al., 2018; Batlle-Bayer et al., 2019) In this work, an LCA approach has been followed to determine the GHG emissions associated with each menu served at the canteen. Thus, three life cycle stages have been considered: foodstuffs production, distribution and cooking.

2.4. Data quality and collection procedure

The estimation of the water footprint estimation has conducted according to the procedure reported by Mekonnen and Hoekstra (2011, 2012). Therefore, the identification of the origin of the different foods is required, since climate and production conditions are significant factors that affect consumptive water. As detailed above, the Atlantic diet approach is followed in the preparation of the menus and local and seasonal ingredients are predominant in the menus. The origin of each ingredient is detailed in **Table SM1** and **Table SM2** in the **Supplementary Material**. Moreover, the WF focuses on the amount of water required in the production of each foodstuff without considering the water requirements for cooking, bearing in mind that the largest fraction of the WF of dietary habits lays at the production level (Blas et al., 2016). The green and blue footprints for each ingredient were taken from the Water Footprint Network[1] and Mekonnen and Hoekstra (2011, 2012), where detailed data on green and blue WFs of crops, crop-based and farm-based products are reported at worldwide level.

Nevertheless, for aquaculture products only water requirements are computed and therefore, other fish and seafood products have not associated any water demand. The rationale behind this consideration is the lack of agreement concerning the quantification of WF for wild fish and seafood catch. The same approach has been established in other related studies (Blas et al., 2016, 2018a, 2018b, 2019; Harris et al., 2017; González-García et al., 2020). Accordingly, the WF scores identified by Pahlow et al. (2015) for aquaculture species, based on green and blue water demands of corresponding fish feed, have been taken into consideration. A detailed description of the green and blue water footprints managed per foodstuff is shown in **Table SM3** and **Table SM4** in the **Supplementary Material**. Full details of the WF estimation process can be found in González-García et al. (2020).

Concerning the estimation of the CF, a cradle-to-kitchen approach has been considered taking into account the production, distribution and cooking stages. A total of 52 different foodstuffs have been considered in the design of the menus and five LCA studies have been taken into consideration paying attention to the production stage that is, life cycle studies focused on a cradle to gate perspective (i.e., farm, industry or port) since these are the limits established for the production stage (S1). Thus, when cradle-to-grave, cradle-to-retailer or cradle-to-consumer studies were identified, these additional stages of foodstuffs production have been removed to avoid double counting of environmental impacts. **Table SM5** and **Table SM6** in the **Supplementary Material** detail the CF index and the corresponding reference per foodstuff and menu. For the distribution stage (S2), the transport activities from the production site to the kitchen have been computed. Thus, national and regional transports have been considered, taking into account the background life cycle inventory data from the Ecoinvent® database version 3.5. Concerning the cooking stage (S3), GHG emissions have been calculated considering the cooking techniques: boiling, frying, stewing and baking. The energy use was estimated on the energy consumption of electrical kitchen appliances such as oven and glass-ceramic hob (Sonesson et al., 2003). An emission factor of 0.37 $kgCO_2eq$ per kWh has been assumed in the estimation according to the Ecoinvent® database version 3.5.

2.5. Proposal of improvements to reduce environmental indicators

As detailed above, this study has a two-fold objective: 1) quantifying the WF and CF for the current biweekly nursery menus and, 2) introducing modifications to those menus with the highest WF and CF scores. Thus, attention will be paid to those foodstuffs that have higher water demands and GHG emission, thus introducing alternative ingredients or meal modifications that improve their environmental profile but maintain their nutritional quality.

3. Results and discussion

3.1. Consumptive water footprint

3.1.1. Distribution between green and blue WF

Table 1 displays the consumptive WF per menu prepared for the toddlers in the nursery canteen. A wide variation in WF scores have been identified (619–1359 $L\cdot menu^{-1}$) and specifically in terms of green WF scores (773 ± 274 $L\cdot menu^{-1}$). It can be evidenced that these fluctuations are linked to the greater or lesser presence of some specific animal-based foodstuffs in the menus, namely beef meat, yogurt and milk, which will be discussed in detail below. The estimation of consumptive WF including the green and blue items per menu has been performed considering detailed information supplied in **Tables SM3-SM4** in the **Supplementary Material** and Fig. 1 depicts the distribution of WF score per menu between the green and blue WF indicators.

On average, 87% of the consumptive WF score is associated with the green WF, except in menus 5 and 8, where the contributing ratio (although remarkable) falls to 69% and 79% respectively. The rationale behind these lower contributing ratios of the green WF to the total score is associated with the absence of meat in both menus. Bearing in mind the beef meat (Mekonnen and Hoekstra, 2012), the associated green WF per kg of product is almost 11 times higher than the corresponding blue WF (even in the chicken and pork meats, the green water demand is more than 8 times higher than the blue one). Moreover, its WF values are considerably higher than those associated with vegetables. Menu 10 does not include meat either. Nevertheless, this menu is rich (in quantity required per child) in dairy products that are included in both the

Table 1
Consumptive Water Footprint (WF), Carbon Footprint (CF) and energy intake per individual menu (i.e., including lunch and afternoon snack) supplied in the nursery canteen under study.

	Consumptive WF ($L\cdot menu^{-1}$)	CF ($kgCO_2eq\cdot menu^{-1}$)	Energy intake (kcal)
Menu 1	619	0.75	460
Menu 2	1358	2.44	586
Menu 3	790	1.01	516
Menu 4	877	1.09	860
Menu 5	658	1.52	702
Menu 6	787	1.26	565
Menu 7	1242	2.95	587
Menu 8	625	1.32	663
Menu 9	1359	2.53	644
Menu 10	724	1.93	896
Average	904	1.68	648

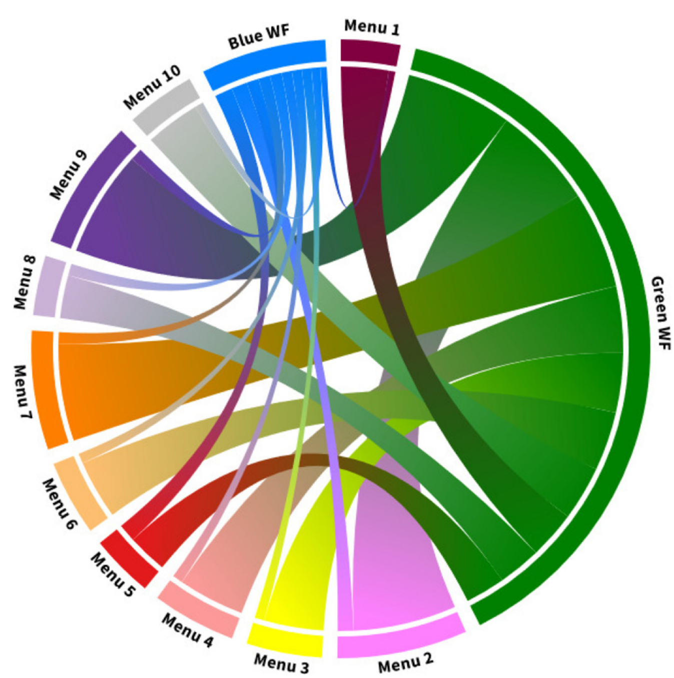


Fig. 1. Distribution of green and blue Water Footprints per menu.

[1] https://waterfootprint.org/en/

lunch (ice cream, 150 g) and the afternoon-snack (fresh cheese, 47 g), both of which demanding large amounts of green WF (1586 L and 4249 L per kg, respectively).

Regarding the blue WF scores, the differences between the menus (131 ± 36 L·menu^{-1}) are lower than for the green WF. Once again, menus that include beef meat (menus 2, 7 and 9) report high blue WFs. Nevertheless, menu 5 is the one with the highest score. This menu includes starch-based products in the lunch (rice) and in the afternoon-snack (cereals) and no meat. Both foodstuffs (rice and cereals) require large amounts of water for crop irrigation and thus, have associated blue WFs around 4 and 2 times higher (respectively) than the corresponding green WFs. Regarding menu 8, which has also a large blue WF, cereals, milk and olive oil are behind that score because of irrigation and production of animal feed.

3.1.2. Ranking of menus in terms of consumptive WFs

The average WF of the menus is 904 L·menu^{-1} although there are large fluctuations in line with their composition. Menus 2, 7 and 9 are those with the highest WF scores (1242–1358 L·menu^{-1}), being the only ones that present beef meat in their formulations. Accordingly, beef is the main hotspot of this environmental indicator, representing 56% (menus 2 and 9) and 82% (in menu 7) of the total consumptive WF score. Menus 3, 4 and 6 have similar WF scores (787–877 L·menu^{-1}) being dairy products the main responsible of water demands since they include about three and five dairy products, followed by meat (turkey breast and pork ham). Menus 1, 5 and 8 have the lowest WF scores (619–658 L·menu^{-1}) but remarkable differences in their origin are identified. In the case of menu 1, animal-based products such as mayonnaise and turkey breast are the main foods responsible for the water footprint indicator. In menu 5 the score is mainly associated with a dairy product (yogurt). Regarding menu 8, milk and olive oil are the critical foodstuffs. Finally, menu 10 reports a WF score of 724 L·menu^{-1}, mainly because of the large contribution of dairy products in form of ice cream in the lunch and cheese in the afternoon-snack. Bearing in mind that marine fish (e.g., hake, tuna and squid) has not associated a WF score according to Pahlow et al. (2015), Mekonnen and Hoekstra (2012) and Vanham et al. (2018), the WF results could be miscalculated in menus 1, 3, 5, 6, 7, 8 and 10.

3.1.3. Assessment per food group

The group entitled Non-dairy sources of protein includes fish, seafood, meat and legumes as foodstuffs. This group is primarily responsible for consumptive WF (see Fig. 2a) in menus 1, 2, 7 and 9. In all these menus there is meat either in the afternoon-snack (turkey breast or pork ham) or in the lunch (always beef). The food group Milk and dairy products plays a key role in the consumptive WF scores (see Fig. 2a), except for menu 1 where no dairy products are included and menu 7 where a small amount of cheese (4 g) is required in the lunch (first course). It is interesting to note that menus 3–6, 8 and 10, where dairy products rank first in terms of contributions to consumptive WF score. These menus are rich in dairy foodstuffs by including several products (yogurt, cheese, milk, butter) in each daily menu.

Accordingly, the products that account for the largest share of consumptive WFs are of animal origin: they represent 59–86% of the total water demand in all menus (see Fig. 2b), except in menus 5 (44%) and 8 (36%) since both are meat free. It can be reported that when beef/cow-based products (meat and dairy) are included in the menus, derived foodstuffs are by far the main hotspots in terms of water demand. Moreover, when beef is included in the lunch meal, the highest consumptive WF scores are identified and differ significantly from those of the other menus.

Bearing in mind the menus and specially the lunch meals, vegetables constitute a staple food group since they are present in all the menus under different preparations (salads, stews, cannelloni) or as side-dishes. Moreover, fruits are present in all daily menus, either in the dessert or afternoon snacks (or both). Nevertheless, both together represent between 2% and 14% of the total contributions to consumptive WFs, despite being the main food group in terms of quantity (g/menu) required to prepare the menus for toddlers. Starch-based products such as bread, rice and cereals constitute an important source of carbohydrates and energy in the menus and are essential in the daily diet of children.

Nevertheless, these ingredients do not make a significant contribution to the consumptive WF scores ranging from 2% to 18%, except in menu 5 (meat free and including fish), which accounts for 30%. The rationale behind that high contributing ratio is mainly since rice and cereals are included in the meals (lunch and afternoon-snack, respectively) as well as flour and potatoes. Thus, and in line with the findings of other studies available in the literature (Jalava et al., 2014; Harris et al., 2017; Blas et al., 2019; González-García et al., 2020), meals (and diets) based on plant-based foodstuffs (vegetables, fruits and legumes) allow for larger water savings.

3.1.4. Effect of meals on the consumptive WF

As indicated above, each daily menu consists of two meals: lunch and afternoon snack, which do not contribute in the same way either in terms of energy supply (≈35% and 15% of daily energy needs, respectively) or in consumptive water demand. Fig. 3 depicts the contribution of each meal to each daily menu. In general terms, lunch is the main meal responsible for consumptive water demand, with contributions ranging from 38% to 95%. Only in three menus (menus 1, 5 and 8) the afternoon-snack is the critical meal for the environment.

In the case of menu 1, there is no meat in the lunch and mayonnaise, eggs and canned tuna (the latter with no associated WF score) are of animal origin. On the contrary, turkey ham is present in the afternoon-snack, which is responsible for 81% of the consumptive WF associated with that meal and 35% of the total consumptive WF per menu. Regarding menu 5, milk and butter are present in the first dish and hake fillet in the second dish, the latter without a WF score. Nevertheless, yogurt is supplied to toddlers in the afternoon-snack. The major intake of yogurt in comparison with the other two ingredients together with the higher WF score associated to that dairy product are behind the effect of the afternoon-snack on the consumptive WF. Finally, menu 8 reports a similar trend to menu 5 since hake is the only animal-based foodstuff present in the lunch, which has not associated a WF score and the afternoon-snack includes semi-skimmed milk. Accordingly, the latter is the ingredient that constitutes the hotspot and thus, the afternoon-snack is the critical meal.

Regarding the remaining menus, animal-based foodstuffs such as beef, turkey, aquaculture-fish (prawns) and dairy products constitute the lunch and therefore that meal is the main responsible for the corresponding consumptive WF.

3.1.5. Changes on menus to reduce water use

As identified above, animal products have a large green water demand mostly associated with irrigation processes involved in the production of feed requirements. Therefore, reducing the consumption of these products would involve lower WF scores. Bearing in mind the consumptive WF scores identified per menu (see Table 1), attention should be paid to menus 2, 7 and 9 since their indexes are around 2 times higher than those corresponding to other menus such as menus 1, 5 and 8. Clearly, the incorporation of beef meat in the second course (stewed beef) is behind this outstanding score (see menus 2, 7 and 9). Moreover, menus 2 and 9 include yogurt and pork ham (cold meat) – both animal-based foodstuffs, in the afternoon-snack.

The consideration of substitute menus designed to combine beef with other meat source with lower WF scores such as turkey/chicken[2] or pork will be proposed and discussed in detail, as the introduction of menu alternatives such as eliminating the offer of other types of meat

[2] Turkey and chicken have been indistinctly considered considering that both are poultry meat. Thus, it has been assumed the same blue and green water footprints per kg (Mekonnen and Hoekstra, 2012)

Fig. 2. a) Distribution of consumptive Water Footprint score (L) per menu between the food categories considered; Acronyms: A – starchy products; B – Fruits & vegetables; C – Milk & dairy products; D – Non-dairy sources of protein; E – Other products. b) Distribution of consumptive WF score between animal-based foodstuffs and other food.

(i.e., at the snack) when beef is on the menu (menus 2 and 9). Attention should be also paid to menu 4. This menu ranks fourth in terms of water demand, including turkey breast in the second course of lunch. Nevertheless, five different types of dairy products are included to prepare the first course (milk, butter and cheese), as a dessert (yogurt) and also in the afternoon-snack (cheese), which considerably increase its water demands. Table 2 summarizes the modifications introduced over the critical menus with the aim of maintain nutritional quality and reduce their consumptive WFs.

Having in mind the changes made to the menus with the highest WF scores, promising reductions can be identified as depicted in Fig. 4. The substitution of beef in the meat stew by alternatives is the modification that involves higher improvements in terms of WF, which should be expected due to the huge difference in the WF score between beef, turkey and pork. The consideration of turkey breast (water demand per kg around 4 and 3 times lower than beef respectively for green and blue WFs) derives into reductions of 43%, 67% and 43% in menus 2, 7 and 9, respectively. While introducing lean pork (water demand per kg around

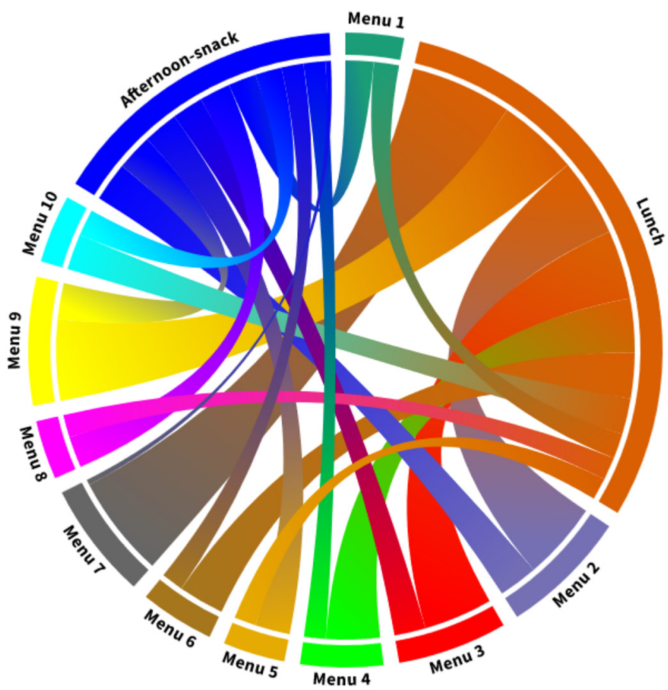


Fig. 3. Contribution to consumptive Water Footprint of the nursery canteen meals.

3 and 2 times lower than beef respectively for green and blue WFs) results in savings of 38%, 62% and 38% respectively for menus 2, 7 and 9.

If changes are introduced only in the afternoon snack in menus 2 and 9, savings on the WF scores can be achieved, although they are smaller. The combination of the cheese sandwich with apple derives into reductions of 15% and 12% for menus 2 and 9. In contrast, the consideration of tuna and tomato sandwich with banana, involves water demand savings of up to 29% and 26% respectively for menus 2 and 9. The consideration of both potential changes (turkey meat in the lunch and afternoon-snack based on tuna sandwich and banana) should yield an outstanding benefit in terms of water demand with water savings of 57% and 69% respectively for menus 2 and 9, as well as achieving the lowest WF scores (580 and 419 L/menu, respectively). Regarding menu 4, in which the yogurt supplied to toddlers in the lunch is substituted by pear, this action achieves a considerable reduction of 23% in water demand.

Table 2
Summary of modifications on foodstuffs in alternative menus to reduce water demand.

Menu 2	Menu 2a	Menu 2b	Menu 2c	Menu 2d
Lunch				
Beef meat ration	Turkey breast ration	Lean pork ration	Beef meat ration	
Afternoon-snack				
Pork ham sandwich Cereals with yogurt			Fresh cheese sandwich Apple	Tuna & tomato sandwich Banana
Menu 9	Menu 9a	Menu 9b	Menu 9c	Menu 9d
Lunch				
Beef meat ration	Turkey breast ration	Lean pork ration	Beef meat ration	
Afternoon-snack				
Pork ham sandwich Yogurt			Fresh cheese sandwich Apple	Tuna & tomato sandwich Banana
Menu 7	Menu 7a	Menu 7b	Menu 4	Menu 4a
Lunch				
Beef meat ration	Turkey breast ration	Lean pork ration	Yogurt	Pear

It is important to note that the suggestion of fish (e.g., frozen hake) as an alternative to beef meat in the stews in menus 2, 7 and 9 has not been assessed due to the uncertainty in estimating the water footprint for marine products as previously detailed in Section 2.4.

3.2. Carbon footprint

3.2.1. Ranking of menus in terms of CF

The CF score has been estimated considering food production, transport and cooking and an average value of 1.68 kg $CO_2eq \cdot menu^{-1}$ has been quantified as detailed in Table 1. According to the results, large differences are observed between the menus, with CF scores ranging from 0.75 (menu 1) to 2.95 (menu 7) kg $CO_2eq \cdot menu^{-1}$. The rationale behind these differences is the composition of the menus and the greater or lesser presence of foods of animal origin. Moreover, the effect of transport and cooking activities are almost negligible as depicted in Fig. 5a, regardless of the menu (between 2% and 8%), mainly due to the inherent characteristics of the Atlantic diet which are i) consumption of mainly local products (i.e., relatively short associated distribution distances) and ii) low processed cooking techniques performed in electric devices that require low energy consumption (mostly boiling). Consequently, the food production stage required to prepare the biweekly menus is by far the largest contributor to GHG emissions from the preparation of each menu. This finding agrees with Esteve-Llorens et al. (2019a, 2019b), where GHG emissions derived from the Atlantic dietary pattern were quantified and the production of food requirements was identified as the critical stage.

3.2.2. Assessment per food group

Following the assessment carried out in the WF assessment, it is quite necessary to identify how the different foodstuffs contribute to the CF since, according to the literature (Tilman and Clark, 2014; Joyce et al., 2014; Hyland et al., 2017), GHG emission vary widely among foods. It is well known that animal-based foods generally have higher GHG emissions than plant—based foods and, in special, ruminant meats and dairy products due to the methane generated from enteric fermentation.

Fig. 5b displays, per menu, the distribution of GHG emission (in CO_2 eq) per food categories involved in the menus. According to the results, non-dairy sources of protein is by far the main group responsible for GHG emissions in all menus, except in Menu 4, where this position is occupied by milk and dairy products (in fact, this menu incorporates five dairy products in the form of milk, butter, cheese and yogurt) – although it is important to bear in mind that the mentioned group occupies the second position in terms of contributions to CF in almost all menus.

Non-dairy sources of protein include not only meat but also fish, seafood, eggs and pulses. The effect of meat on GHG emissions is outstanding and it is regularly the main contributor to CF when this food item is incorporated in the menus as detailed in Table 3.

Specifically, the incorporation of beef meat in the menus (always in the lunch as main course) is associated with the highest CF scores as depicted in Menus 2 (2.44 kg $CO_2eq \cdot menu^{-1}$), 7 (2.95 kg $CO_2eq \cdot menu^{-1}$) and 9 (2.54 kg$CO_2eq \cdot menu^{-1}$), being the lunch the main meal responsible for GHG emissions (see Fig. 6). These menus report CF scores around 3.5 times higher than the menu with the lowest one (Menu 1), which incorporates non-ruminant meat (i.e., cooked turkey breast) among other products. Therefore, and in line with the results identified for WF, attention should be paid to substitute in the menus the beef meat with the aim of reducing their CF scores.

When cold meat-based sandwiches are included in the afternoon snacks (Menus 1, 3, 6 and 9), this foodstuff has also a significant impact on the CF score (see Table 3) since the production of this type of meat involves remarkable GHG emission derived from its background

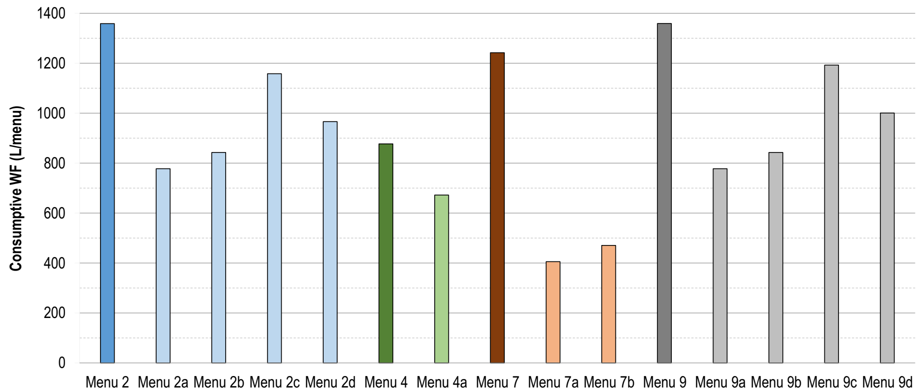


Fig. 4. Improvements in Water Footprint scores due to menu changes.

processes involved (≈8.6 kg CO_2eq per kg cold meat[3]). Menus 5, 8 and 10 do not include any kind of meat. They include frozen hake, which occupies the leading position in terms of GHG emissions, as summarized in Table 3. Pulses such as chickpeas and lentils are included in Menus 8 and 9, which are sources of vegetable protein. Their effect on the global CF scores is negligible. According to Tilman and Clark (2014), the CF per gram of protein in around 250 times lower for legumes than for ruminant meat (lamb and beef). Thus, omnivorous diets can be healthy and more environmentally sustainable if they contain legumes as an alternative to red meat, dairy and fish (Hyland et al., 2017).

Regarding dairy sources of protein, this group plays a key role, as depicted in Fig. 5b, mainly due to cow milk-based products. This food group is present in all daily menus provided in the nursery – except in Menu 1, either in form of milk, yogurt, butter or cheese. Its effect can be highlighted in Menus 3 (41% of CF derived from food production), 4 (58%), 6 (32%) and 10 (44%).

Other food groups such as starch-based products, as well as fruits and vegetables, all of which are staple food in an omnivorous and healthy diet, report contributions to the CF scores ranging from 4% in Menu 9 to 25% in Menu 1. The effect is more remarkable in Menu 1 since it incorporates neither dairy products nor beef, being the menu with the lowest CF score and high presence of vegetables and fruits.

3.2.3. Effect of meals on the CF

Fig. 6 displays the GHG emissions shared between lunch and afternoon snack for each menu. The lunch meal, including first and second courses, as well as dessert, is in general the meal with the greatest effect on the CF scores. In this sense, lunch implies contributions ranging from 66% to 86%, except for menus 1 and 3, where the ratios drop to 54% and 50%, respectively. As expected, menus 2, 7 and 9, those that include beef meat into the second course, have the highest effect on the overall CF score.

In terms of kg CO_2eq per meal, menus 2, 3 and 10 are those with the highest CF index associated with the afternoon-snack (around 0.51 kg $CO_2\text{eq} \cdot \text{afternoon-snack}^{-1}$). In the case of menus 2 and 3, both comprise a cold-meat based sandwich and a yogurt. In the menu 10, fresh-cheese sandwich (not locally produced) is included, while menu 8 is the one with the afternoon-snack (cereals with milk and apple) associated with the lowest CF index.

On the contrary, menu 8 is the one with the afternoon-snack that have associated the lowest CF index (0.31 $\text{kg}CO_2\text{eq} \cdot \text{afternoon-snack}^{-1}$). This meal incorporates cereals with milk and a fruit (apple).

[3] Because of the lack of valuable data, an average carbon footprint (CF) score of 8.6 kg CO_2eq per kg cold meat has been assumed regardless the type of meat processed i.e., pork, chicken or turkey although it could be expected differences derived from different CF of corresponding raw meats.

Milk is the dairy product with the lowest CF score (around 1.39 kg kg $CO_2\text{eq} \cdot \text{kg}^{-1}$).

Accordingly, it can be deduced that our choice on incorporating specific ingredients or foodstuffs in the menus plays a crucial role on the CF scores associated with our diets.

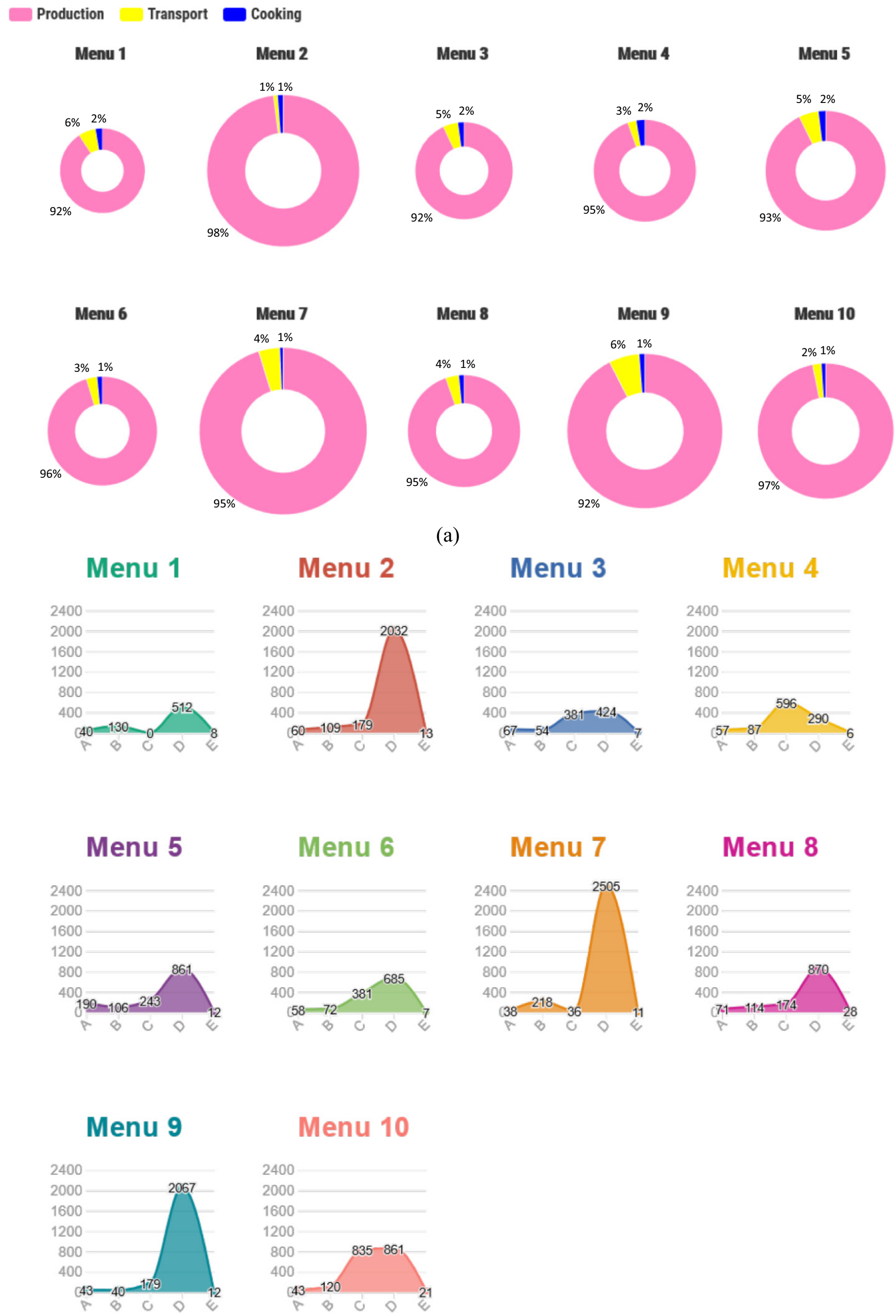
3.2.4. Changes on menus to reduce GHG emission

As identified above, food consumption is responsible for GHG emissions. Hence, food choices have the potential to substantially influence the CF associated with the diet. According to the literature (Hyland et al., 2017; Clune et al., 2017), foods of animal origin are relatively high in terms of GHG emissions (specifically, food derived from ruminants). Thus, the implementation of dietary solutions can contribute to mitigate the effects of our daily diet. Bearing in mind the CF scores identified for the biweekly menus prepared at the nursery, dietary changes could be incorporated into those menus with the highest scores, i.e., menus 2, 7 and 9. Following the strategies proposed to reduce water demand and taking into account that beef meat is the critical foodstuff in the mentioned menus (contributions to CF over 70% of the total) alternatives will be focused on incorporating turkey (Scenarios A), pork (Scenarios B) and chicken (Scenarios C) meat as alternative to beef in the lunch, as summarized in Table 4.

According to the results depicted in Fig. 7, the alternative C-scenarios allow for a reduction in the CF scores of up to 55%, 63% and 66% in menus 7, 9 and 2 respectively if the beef meat ration in the stew is changed to the same amount of chicken. The reductions, although slightly lower, should be achieved when considering pork and turkey. Thus, the effect that the type of meat has on the CF is evidenced. Given that the Atlantic diet promotes the consumption of fish and seafood (Esteve-Llorens et al., 2019a, 2019b), the potential introduction of frozen hake (Scenarios E) as a substitute for beef meat has been considered. Regardless of the menu, the reduction in the GHG emissions per menu should be around ±34%.

As described above, the main meal responsible for contributions to the CF index is, in general terms, the lunch. However, the afternoon-snack is a meal rich in dairy products and cold meat and, in some specific menus, this meal can play a key role. Changes to the afternoon-snack have been only proposed for Menu 2, since in terms of CF, it is one of the three with the highest GHG emission scores in the afternoon-snack (0.51 $\text{kg}CO_2\text{eq}$). Changes to Menus 1 and 3, which have a greater effect on the total CF of this meal rather than lunch, have not been considered since both report the lowest total CF indexes (0.75 and 1.01 $\text{kg}CO_2\text{eq} \cdot \text{menu}^{-1}$, respectively) and it would not make sense to make changes in the short term.

Regarding the alternative foodstuffs to be considered in Menu 2, attention has been paid to the menu that reports the lowest GHG emission rates associated with the afternoon-snack, i.e. Menu 8 (0.31



(b)

Fig. 5. a) Distribution of Carbon Footprint score per stages involved in the life cycle; The size of the circles represents the differences on the GHG emissions associated with each menu (major size, major CF score). b) Distribution of Carbon Footprint score per food groups categories (in gCO_2eq); Acronyms: A – starchy products; B – Fruits & vegetables; C – Milk & dairy products; D – Non-dairy sources of protein; E – Other products.

$kgCO_2eq \cdot afternoon\text{-}snack^{-1}$). In that menu, cereals with milk and fruit (apple) constitute the afternoon-snack and thus, this choice has been considered as an alternative to Menu 2 which has also incorporated a dairy product (pork ham sandwich and cereals with yogurt). This measure (Scenario 2E) allows decreasing the total CF per menu by around 8%.

Accordingly, a final alternative scenario (Scenario 2F) combining Scenarios 2C and 2E has been proposed for assessment. Thus, chicken meat should substitute beef meat in the lunch and the afternoon-snack should be also modified as mentioned above. This alternative combination should achieve the highest reduction ratio (around 74%) in terms of GHG emissions, acquiring a CF score of 0.64 $kgCO_2eq \cdot menu^{-1}$.

3.3. Selected alternative menus

Different alternatives have been suggested in the menus with the highest consumptive WF and CF scores (mostly menus 2, 7 and 9). Although animal source foods have been identified as responsible for the highest contributions rates to both indicators (mainly beef and same dairy products such as yogurt), the options for modifying the menus vary according to the considered indicator. Thus, and bearing

Table 3
Top three ranking of foodstuffs per menu responsible for the highest CF scores. Cold meat includes cooked pork ham, serrano ham, cooked turkey breast and cooked turkey ham.

	Foodstuffs		
Menu 1	Cold meat (43.8%)	Canned tuna (17.7%)	Egg (6.3%)
Menu 2	Beef (73.0%)	Cold meat (11.1%)	Yogurt (7.9%)
Menu 3	Cold meat (33.25)	Butter (12.9%)	Milk (8.2%)
Menu 4	Cheese (28.3%)	Turkey breast (27.3%)	Yogurt (17.8%)
Menu 5	Frozen hake (58.0%)	Yogurt (15.7%)	Rice (8.1%)
Menu 6	Cold meat (21.7%)	Prawns (16.4%)	Yogurt (15.3%)
Menu 7	Beef (80.2%)	Banana (8.1%)	Canned tuna (5.6%)
Menu 8	Frozen hake (66.0%)	Milk (14.2%)	Apple (5.2%)
Menu 9	Beef (74.4%)	Cold meat (11.3%)	Yogurt (8.0%)
Menu 10	Frozen hake (45.1%)	Ice cream (22.6%)	Cheese (21.9%)

in mind the results of *Section 3.1.5*. and *Section 3.2.4*., the aim is to identify a potential alternative menu with low consumptive WF and CF scores while ensuring the supply of nutrients. The consideration of a modified Menu 2 (hereafter referred to as Menu A), incorporating chicken meat in the stew and a cereal-based snack with milk and apple, should achieve a consumptive WF of 684 L·menu^{-1}, and a CF of 0.64 kgCO$_2$eq·menu^{-1} (as summarized in Table 5), both in line with Menu 1, the one with the best indexes. This alternative menu (Menu A) should be varied (consisting of vegetables, fruits, cereals, potatoes, yogurt and meat), healthy (supplying the nutrients requirement for toddlers), and environmentally more sustainable than the initial option.

Bearing in mind the lunch meals options, the top three menus with the lowest GHG emissions associated with that meal are Menu 1, followed by Menu 3 and then, Menu 4 as detailed in Table 6. In terms of consumptive WF, the ranking should be Menu 5, Menu 8 and Menu 1. Therefore, the lunch meal corresponding to Menu 1 should be selected for inclusion in a more environmentally friendly menu.

Regarding the afternoon-snack, attention should be paid to menus 4 and 6 as summarized in Table 6. Accordingly, two designed menus should be obtained that are, Menu B and Menu C. These menus have very low WF and CF scores, which are even lower than the scores corresponding to Menu 1. However, Menu B includes apple in the dessert and the afternoon-snack, so an additional menu (Menu D) has been

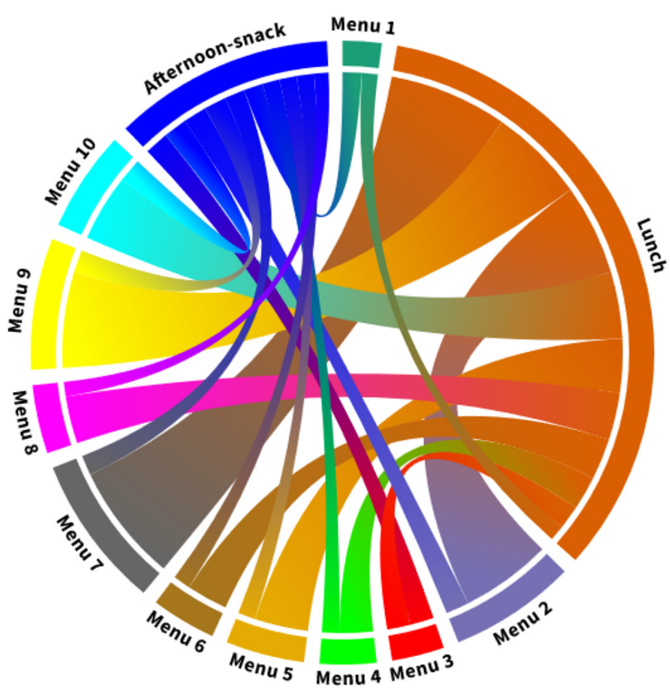


Fig. 6. Contribution to Carbon Footprint of the nursery canteen meals.

Table 4
Summary of modifications on foodstuffs in alternative menus to reduce GHG emission.

Menu 2/7/9	Menu 2A/7A/9A	Menu 2B/7B/9B	Menu 2C/7C/9C	Menu 2D/7D/9D
Lunch				
Beef meat ration	Turkey breast ration	Lean pork ration	Chicken breast ration	Frozen hake
Afternoon-snack				
Pork ham sandwich + Cereals with yogurt				
Menu 2E			Menu 2F	
Lunch				
Beef meat ration			Chicken breast ration	
Afternoon-snack				
Cereals with milk + Apple				

proposed which substitutes the apple in the afternoon-snack by pear. This alternative menu (Menu D) reports a similar CF score and a slightly higher WF but considerably lower in comparison with the menus supplied in the canteen. Consequently, Menu A, Menu C and Menu D can be considered as potential healthy and environmentally friendly food options, which could be incorporated in the biweekly menus.

3.4. Comparison with literature

As previously reported, special attention needs to be given to school menus for multiple reasons. In Spain, around 1.8 million children attending primary education consume meals served in school canteens, which represents 40% of the total provided to school-age children (Ministerio de Educacion, 2016). Thus, adherence of the menus that follow healthy and nutritious guidelines is required, especially because children are at a stage of growth and development. In our study, the Atlantic diet guidelines were followed in detail to design balanced menus based on children's needs. The Spanish school dietary guidelines (Spanish Ministry of Health and Consumption, 2008) are based on the Mediterranean diet recommendations, which are very close to the Atlantic ones (González-García et al., 2020). Several authors investigated the potential impact on the environment of diets that follow national dietary recommendations (Garnett and Strong, 2014; Gonzalez Fischer and Garnett, 2016; Kuluttajaliitto-Konsumentförbundet, 2015; Esteve-Llorens et al., 2019b; González-García et al., 2020) showing that these diets for a healthy diet could have lower environmental impacts. Nevertheless, there is no metrics that allow a diet to be classified as environmentally sustainable and it would be desirable that information on the environmental impacts of the diets and dietary patterns be included in the future. The average CF and consumptive WF identified in our study for the menus that include lunch and afternoon snack are 1.68 kg CO$_2$eq and 904 L per menu, i.e., per child. With the aim of comparing our results with those reported in the literature, attention should pay first to lunch only, since the afternoon-snack was never considered in the analysis, probably because it is not always supplied. Thus, the average scores for the lunch are 1.26 kg CO$_2$eq and 583 L per lunch and child. Regarding the former, its value is like the one reported by Martinez et al. (2020) for the school menus designed according to the Mediterranean diet (1.22 kg CO$_2$eq). On the contrary, it is slightly higher than the score reported by De Laurentiis et al. (2017) – 1.02 kg CO$_2$eq, for menus served in English schools. However, attention should be paid to the assumptions considered in the assessment since, among other issues, a coefficient factor of 1.1 was considered for waste along the supply chain, which is a general approximation with an inherent uncertainty (Garcia-Herrero et al., 2018).

Regarding the WF, De Laurentiis et al. (2017) reported 554 L per lunch including the three components of WF (i.e., green, blue and grey). Considering the same approach in our study, the average WF score is 680 L and 1038 L per lunch and menu, respective. Therefore,

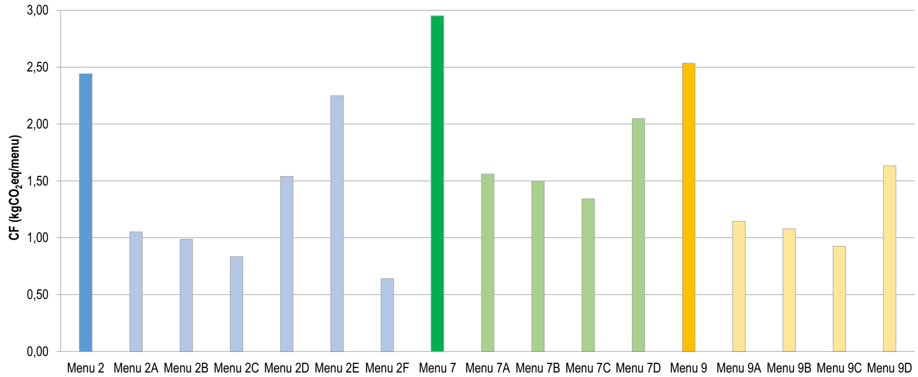


Fig. 7. Improvements in Carbon Footprint scores due to menu changes.

our score is 23% higher than the one reported in the literature. The mentioned assumptions and composition of the lunch are behind these differences Although these comparisons are provisional and scores are affected by multiple factors (age, calories, climate, habits as well as methodological issues), they give an idea of the environmental sustainability of the menus served following the Atlantic diet guidelines and thus, of menus without excluding any food groups. To complete the assessment, the results estimated here were compared with others available in the literature for recommended diets and considering that lunch represents 44% of the total daily energy intake according to Martinez et al. (2020) – remaining 44% and 12% corresponds to dinner and breakfast. In the case of children, lunch and snacks should provide about 45–50% of total daily energy requirements (1000–14,000 kcal per child and day, for moderately active child in the age group of 1–3 years) according to Cobaleda Rodrigo and Bousoño Garcia (2007). This is a straightforward comparison, considering studies with the same approach for the estimation of scores (system boundaries and assumptions).

Healthful eating patterns developed in Germany (Vanham, 2013), Spain (González-García et al., 2020), The Netherlands (Van Dooren et al., 2014; Van de Kamp et al., 2018), Italy (Pairotti et al., 2015), Sweden (Röös et al., 2015) and in Northern, Eastern and Southern European countries (Vanham et al., 2013) have been considered for comparison along with the well-known Mediterranean and Atlantic diets (González-García et al., 2020) and the New Nordic diet (van Dooren et al., 2016). In addition, the scores for the current consumption habits in Spain (Batlle-Bayer et al., 2019; Blas et al., 2019) and in Galicia (Esteve-Llorens et al., 2019b) have been included for comparison in order to identify differences. It is important to bear in mind that these studies refer to diets for adults, i.e. the supply of their total nutrients and caloric intake per day (around 2000–2500 kcal per day and adult). In our study, the average energy intake is around 600 kcal per menu, distributed between lunch (ca. 385 kcal) and afternoon snack (ca. 215 kcal), which is considerably lower than those of adults (880–1100 kcal per lunch –assuming only three meals per day). Bearing in mind the scores identified in the literature (see Table 7), the average CF estimation per lunch (1.26 kg CO_2eq) is in line with those metrics reported in the literature on healthy diets and is considerably lower than those for the current consumption habits (ca. 1.93–2.30 kg CO_2eq per lunch).

Table 6
Meals and menus occupying the top three ranking positions in terms of lower consumptive WF and CF scores.

Lunch			
CF (kgCO_2eq)	Menu 1 0.34	Menu 3 0.50	Menu 4 0.72
Consumptive WF (L)	Menu 5 253	Menu 8 264	Menu 1 292
Afternoon-snack			
CF (kgCO_2eq)	Menu 8 0.31	Menus 4–5-6 0.37	
Consumptive WF (L)	Menu 7 62	Menu 4 254	Menu 6 257

Concerning the WF considering the green, blue and grey components, the average score (680 L) is considerably lower than those corresponding to recommended patterns and around 54% lower than the score associated with the current Spanish consumption habit. The rationale behind these results is linked to the remarkable presence of fresh and local products in all the prepared menus, which translates into significant environmental benefits. Moreover, attention should be also paid to energy intake, which is considerably lower in the case of toddlers and pre-school children. Nevertheless, the results from this study give a clear message that is, adherence to healthy eating patterns is linked to more environmentally friendly diets and does not exclude any food group.

4. Conclusions

This study has a twofold objective, i.e. to quantify the consumptive WF and CF scores for the current biweekly menus prepared in the nursery kitchen and to introduce modifications to those menus with the highest rates, defining new realistic menus with reduced environmental impact. Although promoting the reduction of animal source foods

Table 5
Summary of environmentally friendly menus with both low consumptive Water Footprint and low Carbon Footprint.

	Lunch			Afternoon-snack		Consumptive WF (L/menu)	CF (kg CO_2eq/menu)
Menu A	Ratatouille	Stewed chicken with potatoes	Fruit salad	Cereals with milk	Apple	684	0.64
Menu B	Russian salad	Spaghettis with tuna and tomato	Apple	Slide of cheese with bread	Apple	546	0.71
Menu C	Russian salad	Spaghettis with tuna and tomato	Apple	Serrano ham and tomato sandwich	Pear	549	0.72
Menu D	Russian salad	Spaghettis with tuna and tomato	Apple	Slide of cheese with bread	Pear	588	0.72

Table 7
Carbon and Water footprints of different diets available in the literature. Scores assuming that 44% of daily energy intake is allocated to lunch.

Diet type	Reference	Carbon Footprint ($kgCO_2eq \cdot lunch^{-1}$)	Water Footprint ($L \cdot lunch^{-1}$)
German guidelines	Vanham et al. (2013)	–	1448
Spanish guidelines	González-García et al. (2020)	1.39	1512
Dutch guidelines	Van Dooren et al. (2014)	1.58	–
	van de Kamp et al. (2018)	1.85	–
Swedish guidelines	Röös et al. (2015)	1.69	–
Italian guidelines	Pairotti et al. (2015)	2.35	–
New Nordic diet	van Dooren et al. (2016)	1.68	–
Mediterranean diet	González-García et al. (2020)	1.23	1339
Atlantic diet	González-García et al. (2020)	1.59	1652
Northern EU countries	Vanham et al. (2013)	–	1360
Eastern EU countries	Vanham et al. (2013)	–	1587
Southern EU countries	Vanham et al. (2013)	–	1808
Current Spanish diet	Batlle-Bayer et al. (2019); Blas et al. (2019)	1.93	1474
Current Galician diet	Esteve-Llorens et al. (2019b)	2.30	–
Average menu	This study	1.26	680

(mostly beef meat) through increased ingestion of plant-based products is a very widespread message within the scientific world, it cannot be directly extended to toddlers and pre-school children which need to follow balanced and healthy diets that provide all energy and nutrients requirements. Diets lacking animal source foods such as meat, fish and dairy products can be deficient in some micronutrients, which can lead to a potential risk for balanced growth.

There is a wide variation in both environmental indicators in the analysed menus, which is directly related to the foods included. Considering the results, it can be concluded that the incorporation of beef meat in the menus is equivalent to the largest water demands and GHG emissions. Although beef should not be absent in the children's diet, reductions in its consumption can be promoted by incorporating alternative types of meat such as poultry. Combining beef on menus with more environmentally friendly food products (e.g. fruits or milk) could be also considering as an attractive strategy. Attention must be paid to assumptions and data quality since results can be quite sensible. That is the case of considering marine fish with a WF equal to zero and an average CF score for cold meat regardless the type of processed meat either chicken, turkey or pork.

Finally, the result of this cooperative interdisciplinary work provides insight to nursery managers and nutritionists to design menus with principles of health, variety and sustainability. In addition, this study could be further used as an educative tool to gain a more complete understanding of the environmental impacts from dietary patterns not only among students (elementary and secondary schools, universities) and their corresponding families and carer but also for the catering sector. More attention should be paid to how students respond to the new healthy and low impact menus, and how this would help change eating behaviours outside the educational setting. Food and parenting are inseparably linked. Parents' eating practices and children's eating behaviour shape their early eating environment and underpin their future dietary habits and health consequences. In this regard, greater participation outside of school is required and families play a key role. It is important to work on obtaining scores that include health and sustainability parameters to promote changes in current consumption patterns.

CRediT authorship contribution statement

There was an error concerning the name of one of the authors in the previous version, which was not incorporated because of a mistake attaching the names.

S.G.-G. conceived the presented study, prepared the questionnaire, collected and analysed the main data, performed the water and carbon footprints measurements and led the writing of the article.

X.E.-Ll. collected and analysed the main data, performed carbon footprint measurements

R.G.-G. analysed the nutritional and energy content of the menus, contributed to the literature review and to the design of the alternative balanced menus.

L.G.V. was in charge of filling the questionnaires.

R.G.G. and R.L. made substantial contributions to conception and design, analysis and interpretation of data.

M.T.M. made substantial contributions to the Introduction section.

G.F., M.T.M. and R.L. participated in drafting and revising the article.

S.G.-G., X.E.-Ll., R.G.-G., L.V.G., G.F., M.T.M. and R.L. gave final approval of the version to be submitted and any revised version.

S.G.-G. and R.L. supervised the work in detail.

Declaration of competing interest

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.

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Appendix A. Supplementary data

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