The drivers of the nutritional quality and carbon footprint of school menus in the Paris area

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Abstract: Public school food procurement has been identified as a key lever in the transition towards sustainable food systems. In this study, we assess the nutritional quality and the carbon footprint of 2020 school menus served in 101 municipalities in the inner suburbs of Paris. In this sample, school canteens menus meet an average 8.2/15 (min = 4, max = 14) adequacy score to the regulatory nutritional quality frequency criteria and their carbon footprint averages at 1.9 (min = 1.2, max = 2.6) $kgCO_2e$/day. The nutritional and environmental qualities of canteen menus were not correlated with each other. In-house canteens have a significantly higher nutritional quality - 0.7 more points – and so do larger canteens. The carbon footprint significantly decreases with an increasing education level of the population and, for in-house canteens, it also decreases by 0.16 $kgCO_2e$/day with a ten-fold increase in canteen size and by 0.0035 $kgCO_2e$/day per percent of left-wing vote, breaking even with delegated canteens above 3,500 enrolled children and 53% of left-wing vote respectively. The frequency of certified food (mean = 18%, min= 0%, max=51%), a cornerstone of the 2018 national law aiming at more sustainable institutional catering, has no impact on our indicators of nutritional quality and carbon footprint. The substantial variations between canteens in both nutritional and environmental qualities suggests that there is room for improvement on both ends.

Keywords: green public procurement, public school food procurement, food sustainability, school canteen menus, nutrition.

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1 Introduction

Current food systems have unsustainable impacts on both climate change and human health. With regard to climate change mitigation, the global food system is responsible for 28 % of global emissions, two thirds of which stem from animal products (Rogissart, Foucherot, and Bellassen 2019). Concerning human health, half of Europeans over 18 years of age were overweight (36%) or obese (16%) in 2014 (Eurostat 2016), increasing morbidity, mortality as well as loss of self-esteem and self-confidence.

There is a growing interest from policy makers to address these environmental and nutritional challenges through public food procurement strategies. This is particularly salient within the EU with regulatory initiatives developed by public authorities at various administrative levels (European, national, local) to drive food procurement towards more sustainable supply and demand patterns. Public procurement – representing 14% of EU GDP in terms of government spending – is an important instrument for promoting sustainable policy goals owing to its buying power (European Commission 2016). Public school food procurement accounts for 31% of the total value of food purchased by catering services in Europe (Boyano et al. 2019). In France, nearly 3 billion meals are served each year in schools, amounting to 7 billion euros of food purchases (Institut de la gestion déléguée 2019). These numbers demonstrate the pivotal potential of public-school food procurement in fostering sustainable food systems in Europe.

Policies promoting healthier environment in schools and pre-schools are already the cornerstone of the EU action plan looking for halting the rise of overweight and obesity among children (European Commission 2014). By 2017, all EU member states had implemented some policies with this purpose

(European Commission 2017). Successful strategies to improve children's nutrition in school are the results of many reinforcing policies from voluntary to mandatory aiming at reducing unhealthy food availability while favouring healthy food provision and protecting schools from marketing activities (Kovacs et al. 2020). In addition, centralized school systems managed by national governments providing early compulsory education offer the highest potential thanks to their ability to set national standards and to reach all crucial ages for shaping food habits, from childhood and adolescence (Kovacs et al. 2020). On the environmental aspects, the European Commission introduced in 2004 a green public procurement (GPP) scheme as a tool to reduce the environmental impacts of public procurement (European Commission 2016). GPP is able to influence both the production and consumption sides by stimulating the demand for more environmental-friendly goods and services (Testa et al. 2012). While GPP in public school food procurement is not yet widespread in Europe, pioneer initiatives in some municipalities have shown that reducing meat consumption and requiring a shift from conventional to organic products or integrated production system are promising ways to reduce the carbon footprint (Cerutti et al. 2016; 2018; Tregear et al. 2019).

In France, recent policy instruments have been designed to enhance the sustainability of public food procurement. In 2011, a decree set up mandatory nutritional quality criteria for school meals, establishing for instance a minimal frequency to serve vegetables and fruit (Décret n° 2011-1227). A 2015 law committed canteens to fight against food waste (LOI n° 2015-992) and in 2018, the EGALIM law incentivized experimental vegetarian menus once per week. In addition, this law set specific targets on food purchase in public collective catering, including public schools. By 2022, the food procured must contain 50% of products certified by a public label (PDO/PGI, "Label Rouge" certifying higher quality products, etc.) with a minimum of 20% of organic products (LOI n° 2018-938).

Because canteen menus are so pivotal in policies aiming at improving the sustainability of diets, identifying which factors help canteens in designing more sustainable menus becomes a key question. The contribution of this paper towards answering it is twofold. First, it develops a method to measure the carbon footprint and nutritional quality on the sole basis of school menus. While less accurate than the list of ingredients and the quantity used for each meal, it allows us to substantially enlarge sample size compared to comparable studies and is more easily replicable. The other main innovation of the present study is to investigate for the first time the determinants of the nutritional quality and carbon footprint of contemporary school menus. In particular, we assess the relative merits of the two main governance modes for school catering management: direct management by municipalities (*in house* provision) versus outsourcing the catering service (delegated provision)..

The paper is structured as follows. The first two sections present the literature background on the school canteen meal quality enabling us to formulate hypotheses on its determinants. The following two sections describe the data and methodological approach used to evaluate both nutritional quality and carbon footprint of canteen meals. The results of the analysis are then presented and discussed. In a last section, recommendations for procurement policies are drawn from our findings.

2 Literature Review

2.1 Nutritional nutritional quality and carbon footprint of canteen menus

2.1.1 Carbon footprint of canteen menus

In the studies identified, the agricultural production step is responsible for 60-70% of the carbon footprint of canteen menus (Table 1). Most studies highlight the presence of animal products and especially red meat in canteen menus as the main determinant of their carbon footprint (between 40% and 50% on average, see Table 1). Substituting plant-based ingredients for animal products is therefore considered as an effective way to reduce GHG emissions (Takacs and Borrion 2020). Introducing food from organic practices does not necessarily reduce the carbon footprint of canteen menus: while the carbon emissions per hectare are undisputedly lower in organic systems, the impact per kilogram of product is often similar to conventional production due to lower yields in organic systems (Bellassen et al. 2021; Meier et al. 2015; Mondelaers, Aertsens, and Van

Huylenbroeck 2009; Tuomisto et al. 2012). Interventions addressing other food processing stages (food storage, preparation and waste management) such as cooking methods prioritizing a cook-warm system (Fusi, Guidetti, and Azapagic 2016), technologies saving water and energy (Mudie and Vadhati 2017) and low carbon disposal methods such as anaerobic digestion, composting and animal feed (Tregear et al. 2019) have lower mitigation potentials (Takacs and Borrion 2020). Accordingly, these levers are not considered here.

Table 1: Mean GHGE value school meal in previous studies

Authors	**Places**	**Sample size**	**Period**	**School level**	**Mean GHGE value per school meal (kgCO_2e)**	**Min GHGE value per school meal (kgCO_2e)**	**Max GHGE value per school meal (kgCO_2e)**	**Share of the meat components in the carbon footprint**
Eco2 Initiative (2020)	Paris	n=1	/	Primary school	1.8 kgCO_2e	/	/	/
Cerutti et al (2018)	Turin	n=1	1 year	Secondary school	1.67 kgCO_2e	/	/	39%-51%
Wickramasinghe et al. (2016)	United Kingdom (UK)	n=139	1 week	Primary school	0.72 kgCO_2e	0.52 kgCO_2e	1.34 kgCO_2e	41.5%
Jungbluth et al. (2016)	Switzerland	n=240	1 year	/	4.1 kgCO_2e	/	/	48%
Tregear et al. (2019)	Croatia, Greece, Italy, Servia, UK	n=10	1 or 2 weeks	Primary school	/	0.84 kgCO2e	2.14 kgCO2e	21%-43%
ADEME. (2016)	France	n=14	3 days	Primary school (n=1), secondary school (n=2), high school (n=2), university (n=1), other (mass catering in the health and private sector, n =8)	2,65 kgCO_2e	0.9 kgCO_2e	5.7 kgCO_2e	/
De Laurentiis et al. (2017)	UK	n=136	2 weeks	Primary school	1.02 kgCO_2e	/	/	52%
Batlle-Bayer et al.(2021)	Spain	n=7	1 week	High school	/	< 2 kgCO_2e	> 12 kgCO_2e	/
González-García et al.(2021)	Spain	n=1	2 weeks	Pre-school	1.26 kgCO_2e	0.75 kgCO_2e	2.95 kgCO_2e	/
Martinez et al.(2020)	Spain	Baseline menu based on 88 dishes	/	Pre and primary school	1.2 kgCO_2e	/	/	/

2.1.2 Nutritional quality of canteen menus

Food nutritional guidelines are often only partly implemented by canteen managers (Brennan et al. 2019; Woods et al. 2014; Vieux et al. 2018). The complexity of guidelines, lack of human resources and knowledge are often identified as significant barriers: classifying food products and dishes into food groups is a necessary step which is reported to be challenging (Ardzejewska, Tadros, and Baxter 2013; Downs et al. 2012; Girona et al. 2019; Pettigrew et al. 2014). In addition, the absence of strong legal sanctions or monitoring mechanisms does not provide incentives to canteen managers to modify canteen menus (Girona et al. 2019; Woods et al. 2014). Socio-economic factors - e.g. pupils' demands, religious or cultural food habits, lack of parental support, and psychological resistance, e.g. food neophobia, etc. - can generate additional barriers (Ardzejewska, Tadros, and Baxter 2013; Cho and Nadow 2004; Downs et al. 2012; Pettigrew et al. 2014). Finally, financial constraints on canteen budgets have been shown to negatively affect nutritional quality, because healthy food tends to be more expensive (Bell and Swinburn 2004; Billich et al. 2019; Downs et al. 2012).

2.1.3 Interactions between nutritional and environmental quality of diets

Studies based on optimized diets or *ad hoc* change in diets show that adopting healthier diets can also lead to a reduction in GHG emission (Doro and Réquillart 2020; Macdiarmid et al. 2012; Tukker 2011; Westhoek 2014; Kesse-Guyot et al. 2020). However, reduction in GHG emissions while sustaining nutritional adequacy requires significant changes in diet composition: substitutions between food product categories (substituting animal with plant-based products) and within food product categories (substituting red meat with other animal products) (Doro and Réquillart 2020).

Substituting plant-based products for animals should however be cautiously implemented as the health consequences of the shift are equivocal. On the one hand, low-meat meals reduce the risks of disease associated with protein and fats from animal products such as colorectal cancers (Chan et al. 2011; Pan et al. 2012), cardiovascular diseases and stroke (Westhoek 2014) and provide higher amounts of fibre and phytonutrients (Aleksandrowicz et al. 2016)[6]. On the other hand, plant-based diets in school canteens can pose serious nutritional challenges for some key nutrients (e.g., vitamin B12, vitamin D and DHA) which must be addressed when composing plant-based menus (Poinsot et al. 2020; Vieux et al. 2018).

To the best of our knowledge, only one study has assessed empirically the interaction between nutritional quality and carbon footprint in the specific case of canteen menus (K. K. Wickramasinghe et al. 2016). It showed that reducing greenhouse gas (GHG) emissions in canteens can compromise nutritional quality of school meals. Other studies using optimization methods manage to design optimal canteen menus ensuring nutritional adequacy while reducing carbon footprint (Benvenuti et al. 2016; Ribal et al. 2016; Eustachio Colombo et al. 2019).

2.2 Potential drivers of nutritional and environmental quality of schools' menus

2.2.1 Organizational factors

Previous economic literature on the relative performance of "in-house" versus delegated public service provision provides mixed results (O. Hart, Shleifer, and Vishny 1997; Hirsch 1995). Private firms produce goods more efficiently (in terms of production costs) than "in-house" mode because outsourcing provides high-powered incentives to cut costs (Andersson, Jordahl, and Josephson 2019) and private caterers can more easily reach economies of scale because they simultaneously serve several clients. However, this cost-efficiency can be counteracted by transaction costs in the design, implementation and monitoring of contractual arrangement (Andersson, Jordahl, and Josephson 2019; O. Hart 2003). In addition, the selection of contractors is complex, exposing public bodies to the "winner's curse" (Engel, Fischer, and Galetovic 1997) or aggressive bids (Guasch and Straub 2009); adapting the initial contract to unforeseen contingencies and the resulting renegotiation can

[6] In addition, a reduction in livestock production has indirect health benefits such as lower use of antibiotics (Marshall and Levy 2011), improved water quality (nitrates) (Powlson et al. 2008) and also air quality (particulate matter)(Moldanová et al. 2011).

also be costly (Saussier, Staropoli, and Yvrande-Billon 2009). Finally, Hart et al. (1997) suggested that the incentive power linked to the delegation decision may have detrimental effects on the quality of the good provided, in particular when this quality cannot be fully specified in the initial contract. When applied to institutional catering, this literature is inconclusive. Poor delegated contract performances explained by adverse selection, moral hazard and contract incompleteness, leading to poor quality of school catering service delivered by large private companies has been reported (Maietta and Gorgitano 2016). Similarly, in-house provision of catering services can be plagued by lack of financial and human resources, and administrative rigidities. The lack of staff with knowledge and skills is a key barrier to implement nutritional guidelines (Downs et al. 2012; MacLellan, Taylor, and Freeze 2009) and small in-house canteens are less likely to have enough resources to hire a full-time nutritionist (Cour des comptes 2020).

2.2.2 Certified products frequency

As mentioned previously, introducing food from organic practices does not necessarily reduce the carbon footprint of canteen menus because of lower yields in organic systems (see Section 2.1.1). However, the literature highlights that organic food sourcing of school canteens is connected with healthier and less carbon intensive dietary patterns by driving changes in meal composition (less red meat and more fruits and vegetables). Treagear et al. (2019) finds a lower carbon footprint of school canteen menus where school procurement encourages local or organic sourcing. Moreover, canteens providing a great quantity of organic food have been reported to provide menus with a higher nutritional quality (He, Løes, and Mikkelsen 2010; He and Mikkelsen 2014; Lassen et al. 2019; B. Mikkelsen et al. 2006). One reason was that “green” caterers were more conscious about the nutritional composition of their menus because they offered significantly more in-service training to implement organic foods successfully. This additional training was needed to successfully process organic food and increase the share of vegetarian dishes so that savings from lower meat purchases balance the price premium of organic products (B. Mikkelsen et al. 2006).

2.2.3 Political affiliation

Political affiliation refers to both the political sensitivity of individual citizens, or related pressure groups, and the political affiliation of the elected officials. Citizens who consider themselves close to the left are more likely to support environmental positions (Neumayer 2004) and have a higher willingness-to-pay for environmental good improvements (Li et al. 2009; Solomon and Johnson 2009). Hence, it is more likely that the parents (or parental associations) in left municipalities pressure local public officers and caterers to reduce GHG emissions. Similarly, the commitments and priorities of public officials at the municipal level are identified as a key determinant in overcoming the constraints of green public procurement (Brammer and Walker 2011; Filippini et al. 2018; B. E. Mikkelsen and Sylvest 2012). We can therefore presume that left-oriented public officials could be more inclined to commit to green public procurement by allocating more resources and relying on other criteria than price during tendering processes. The effect of political affiliation can interact with the management mode: right-wing individuals express a higher willingness-to-pay for environmental goods only when public procurement is outsourced, possibly due to a higher trust in private organisation/market solutions (Dupont and Bateman 2012).

2.2.4 Canteen size

Thorsen et al. (2009) show that the larger the canteens in terms of number of lunches served, the healthier the menus they provide due to better access of employees to health promotion programmes. Similarly, Wagner et al. (2007) highlight the key role of staff training enabling canteens to provide healthy foods without additional costs. Finally, large municipalities have potentially more staff to organize the catering services and dedicate resources to improve its sustainability. During the interviews conducted for this study, caterers and nutritionists indicate that larger in-house canteens are also more likely to hire a nutritionist to design their menus thanks to economies of scale while delegated canteens employ nutritionists in their headquarters which then interact with decentralized canteen managers in various ways (Canteen managers 2020). However, Maietta and Gorgitano

(2016) find that large private catering firms provide poorer quality services as they adopt predatory pricing strategies in order to win contracts.

2.2.5 Parent's educational level

Parents influence the food habits and dietary behavior of pupils by providing healthy food and high quality diet at home (van Ansem et al. 2013; Birch and Davison 2001; Haines et al. 2019). This role requires knowledge and motivation that parents with higher socio-economic status and higher educational attainment are more inclined to fulfil (K. H. Hart et al. 2003). They demonstrate a stronger environmental awareness (Aminrad, Zakaria, and Hadi 2011) and a lower consumption of red and processed meat in affluent countries (Gossard and York 2003). Families with higher education levels also more often opt for letting their children eat at school (Decataldo and Fiore 2018). In addition, they have a higher propensity to get involved in a pressure group (like parental associations) influencing both the nutritional (Ardzejewska, Tadros, and Baxter 2013; Cho and Nadow 2004; Clelland, Cushman, and Hawkins 2013; Downs et al. 2012) and environmental quality of meals in canteens (Cho and Nadow 2004; Dědina, Šánová, and Kadeřávková 2014; Filippini et al. 2018). Parents with higher socio-economic status are more likely to push toward a healthy diet at school for their children (K. H. Hart et al. 2003).

2.3 Empirical hypotheses

Based on this literature review, five key hypotheses are spelled out and tested.

Hypothesis 1.A *– In-house school canteen management provides menus of higher nutritional quality*

As mentioned in section 2.2.1, the literature on the impact of the management mode on the nutritional and environmental quality of school menus is equivocal. High incentives to save costs at the expense of quality and poor contract performances could drive down the nutritional and environmental quality of delegated canteens but this could be balanced by lack of trained personnel in smaller "in-house" canteens. We assume that the first effect is strongest.

Hypothesis 1.B *– Delegated canteens management provide menus of lower carbon footprint*

High incentives to save production and procurement costs in outsourced situations may incite caterers to substitute expensive meat products with cheaper plant-based products.

Hypothesis 2 *– A higher frequency of certified foods in school menus is associated with a lower carbon footprint and better nutritional quality*

Procurement contracts favoring certified foods are associated with more service training efforts improving nutritional quality and reducing meat products (and waste) to balance the price premium of certified products such as organic foods.

Hypothesis 3 *– Left-wing votes in municipal elections are associated with a lower carbon footprint of school canteen menus, in municipalities with in-house provision.*

Left-wing voters represent a higher support for local policy-makers to introduce environmental-friendly initiatives in canteens, especially in municipalities with “in-house” canteens.

Hypothesis 4 *– Municipalities with a population of higher education level provide school canteen menus associated with a higher nutritional quality and a lower carbon footprint*

Higher education level is related to healthier eating habits, higher environmental and health awareness, lower meat consumption and a higher use of school canteen which can lead to higher parental support to introduce more sustainable food in canteens.

Hypothesis 5 *– Larger in-house canteens are associated with higher nutritional quality and lower carbon footprint*

3 Municipalities with a larger number of pupils in elementary schools can dedicate more resources to organize the food catering service. In particular, they are more likely to hire nutritionists and to provide their staff with training on health

and environmental issues.The procurement of school meals in France

In France, institutional catering for pre and primary schools (pupils between 3-11 years old) is under the administrative responsibility of municipalities. However, 11 % of municipalities, mostly the smallest ones, chose to transfer this responsibility to an intercommunal association where several municipalities cooperate to provide meals to their public schools (Institut de la gestion déléguée 2019). Two management modes exist to organize the catering service. First, municipalities adopting in-house provision manage the entire school meal service themselves. They elaborate the menus, organize food procurement, hire and manage the personnel and build and maintain facilities necessary for cooking and serving food. Food suppliers are selected through awarding procedures complying with the national Code of Public procurement, involving public tender[7]. In 2019, 52% of French canteens were operated in-house (Institut de la gestion déléguée 2019). Second, municipalities can choose to delegate the catering service to, most of the time, a private contractor through competitive tenders where the contractor's remuneration is linked to its activity. Sometimes, delegated provision is further subdivided into delegated provision where the contractor's remuneration is linked to its activity and bears the risk of fluctuating numbers of meals and public market provision where the contractor is remunerated by the municipality according to its cost. Municipalities have an indirect influence on the quality of canteen menus by designing the call for tender thereby defining the set of criteria used to assess the various bids received from the potential suppliers (the price being only one of them), and through negotiating specific contractual provisions with the selected operator.

French school canteen management is the subject of various recommendations and regulations. On the nutrition side, the entire institutional catering sector (both public and private) is the subject of national guidelines elaborated since 1999 by the *Groupe d'Etude des Marchés Restauration Collective*

[7] National regulation in public procurement is derived from the European Union directive 2014/24. The main principles are transparency of the procedures, equal and free access to public markets. For more details, see: https://ec.europa.eu/environment/gpp/eu_public_directives_en.htm

et Nutrition (GEM-RCN, public catering and nutrition market study group). This group is made of representatives of various relevant stakeholders involved in the catering sector under the auspice of the French Ministry of Economy. The broad goal is to promote healthy eating behaviors and to prevent obesity. GEM-RCN defines the general format of meals and sets adequate portion sizes of the dishes according to three different age classes[8]. It also sets the maximal and minimal frequency of a set of 15 food groups in a series of 20 consecutive lunches. For example, canteens must serve fruits or vegetables as starters or side dishes at least 10 times and red meat as a protein dish at least 4 times (Table 5). This voluntary guidance became mandatory in 2011 (Décret n° 2011-1227). On the environmental side, the food procured must contain 50% of products certified by a public label with a minimum of 20% of organic products by 2022 (LOI n° 2018-938). In addition, the EGALIM law incentivized experimental vegetarian menus once per week.

4 Material and method

4.1 Sample and data gathering

Primary school canteen menus were downloaded from the web sites of the 123 municipalities of the inner suburbs of Paris (Ile-de-France region) over a period of 20 days at school in November 2018 (see map in Annex 1. 1). For 33 municipalities, we identified at least one other municipality offering similar menus on the same days, thereby indicating an intercommunal cooperation in charge of school canteens (Annex 1. 2). These municipalities were therefore regrouped into one of the corresponding 11 intercommunal associations, reducing the sample size to 101 municipalities or intercommunal associations (hereafter municipalities). For these intercommunal associations, the simple average over their constitutive municipalities of the independent variables – left-wing vote, educational attainment, …, was used. The database thus includes the name of 10,816 different dishes belonging to one of the five meal components: starter, protein dish, side dish, dairy product, and

[8] The three age classes correspond to pre-school, primary school and both secondary and high school levels. This study is based on guidelines designed for elementary schools.

dessert (full database available in Annex 2. 1). All menus also indicate the presence of products with a public certification (organic, protected designation of origin (PDO), protected geographical indication (PGI) and label rouge products (a public certification on the high quality of the product)) as well as the non-certified "local" origin of dishes. Sometimes, canteens offer a choice between two or three dishes for the same component. This kind of alternative occurred on 20% of days for the main course, most often with a choice between pork or poultry, or a vegetarian option or fish alternative to meat (Annex 1. 3). Alternatives are seldom offered for the other meal components.

4.2 Dependent variables

Our dependent variables are continuous measures that capture the nutritional and environmental quality of canteen meals. The environmental impact of school menus is assessed through their carbon footprint for two reasons. First because climate change is arguably one of the most pressing environmental challenges of the 21st century and second because GHG emissions are correlated with most environmental impacts such as eutrophication, acidification and energy use (Röös et al. 2013). The nutritional quality of canteen menus is assessed through their conformity to the 2011 national nutritional guidelines, namely, the extent to which each of the 15 GEM-RCN's frequency criteria (FC, see section 3) are fulfilled, as in Vieux et al (2018).

4.2.1 Carbon footprint

The carbon footprint of canteen menus is assessed in three steps. First, a list of 38 categories of dishes with homogeneous carbon footprint is designed (Table 2). The 38 categories and the carbon footprint of each of their ingredient (Table 2) are based on the Etiquettable tool developed by ECO2 initiative. The categories were designed to be both relevant to canteen managers and homogeneous in terms of carbon footprint (eg. main dish with more than 70 % of red meat, starter with more than 50 % of raw vegetable or fruit, …). In particular, they either coincide with - or can be merged into - a nutritional category as specified by GEM-RCN (Table 2). We control their homogeneity by ensuring, based on Agribalyse 3.0, that the standard deviation of a given category did not exceed 25 % of its average (Annex 1. 4). For each category, a typical composition – types of ingredients and associated quantities – has been determined based on the detailed ingredient lists of dishes served in school canteens from the 9th and 10th districts of Paris. For example, a typical dish of the category "raw vegetable and cheese with less than 150 mg of calcium per portion" is estimated to contain 40 g of raw vegetable, 20 g of cheese and 14 g of dressing (Table 2). The carbon footprint of each ingredient type is then estimated by selecting a set of representative actual ingredients (e.g. raw vegetables are represented by an equal share of tomatoes, carrots, and lettuce), and computing their average carbon footprint from the Agribalyse 3.0 database (Agribalyse 3.0 2020). The GHG emissions from the transportation step were reassessed by Eco2 initiative according to the actual provenance of food in the Parisian canteens they surveyed and are also used for the present analysis. Second, each dish is assigned to a single category based on its name, resulting in the "activity data", here the number of times a given category is served in each municipality. Finally, the average carbon footprint of school menus is estimated from the combination of the carbon footprint of food ingredients and activity data (Equation 1). Equation 1 shows that average carbon footprint of school menus sums the carbon footprint of the food ingredients multiplied by the mass of food served (dish share) for the 38 categories.

Equation 1:

$$Menu\ Emissions_{d,j} = \sum_{k=1}^{5}\sum_{i=1}^{38} dish\_share_{kijd} \times Carbon\ footprint\ of\ food\ ingredients_{ki}$$

where Menu Emissions_j are the emissions of the menu on day d in city j, dish_share_{kijd} is the share of food category i in dishes category k served on day d (either 0 or 1, except when the canteen offers alternatives for a given dish, see *Annex 1. 3 and Annex 1. 5*), and finally $Carbon\ footprint\ of\ food\ ingredients_{ki}$ is the carbon footprint of food ingredients of food category i of dish category k.

Table 2: Carbon footprint of ingredients (CFI), GEM-RCN equivalence and portion size for each of the 38 food categories served in school canteen, based on their three main ingredients

Component	GEM-RCN equivalence (Simplified FC name)	Categories used in the environmental classification	Ingredient 1	Quantity 1 (g)	*CFI* 1 (gCO2/g)	Ingredient 2	Quantity 2 (g)	*CFI* 2 (gCO2/g)	Ingredient 3	Quantity 3 (g)	*CFI* 3 (gCO2/g)	Total Quantity (g)	Emissions (gCO2e)	Rounded emissions (gCO2e)
Starter	Raw fruits or vegetables starters	Raw vegetables	Vegetables	70	0,92				Sauce	14	2,06	84	93	90
	Raw fruits or vegetables starters	Raw vegetables + cheese < 150 mg Ca[9]	Vegetables	40	0,92	Cheese	20	5,68	Sauce	14	2,06	74	179	180
	Raw fruits or vegetables starters	Raw vegetables + cheese > 150 mg Ca	Vegetables	40	0,92	Cheese	20	5,68	Sauce	14	2,06	74	179	180
	Other starters	Cuidité	Vegetables	70	0,92				Sauce	14	2,06	84	93	90
	Other starters	Cuidité + cheese < 150 mg Ca	Vegetables	40	0,92	Cheese	20	5,68	Sauce	14	2,06	74	179	180
	Other starters	Cuidité + cheese > 150 mg Ca	Vegetables	40	0,92	Cheese	20	5,68	Sauce	14	2,06	74	179	180
	Other starters	Cereals or pulses	Cereals / pulses	30	1,36				Sauce	14	2,06	44	70	70
	Other starters	Cereals or pulses + cheese < 150 mg Ca	Cereals / pulses	25	1,36	Cheese	20	5,68	Sauce	14	2,06	59	176	180
	Other starters	Cereals or pulses + cheese > 150 mg Ca	Cereals / pulses	25	1,36	Cheese	20	5,68	Sauce	14	2,06	59	176	180
	Fatty starters	vegetables/starches + Meat/fish/egg	Vegetable / starches	30	1,14	Meat / fish / egg	20	5,12	Sauce	14	2,06	64	165	170
	Fatty starters	Meat/fish/egg mainly	Meat / fish / egg	35	5,12				Sauce	14	2,06	49	208	210
Main dish	Red Meat	Ungrounded red meat >70%	Red meat	100	32,1				Sauce	20	3,25	120	3277	3280
	Other main dish	Grounded red meat >70%	Red meat	100	32,1				Sauce	20	3,25	120	3277	3280
	Other main dish	White meat > 70%	White meat	100	6,5				Sauce	20	3,25	120	720	720

[9]Despite they share similar emissions, we separate raw fruits or vegetables starters including cheese with more and less than 150 mg Ca

	Fish	Fish > 70%	Fish	90	6,2				Sauce	20	3,25	110	624	620
	Pre-processed dishes/Fatty protein dishes/ Fried dishes	Red meat < 70%	Red meat	70	32,1				Sauce	30	3,25	100	2346	2350
	Pre-processed dishes/Fatty protein dishes/ Fried dishes	White meat < 70%	White meat	70	6,5				Sauce	30	3,25	100	556	560
	Pre-processed dishes/Fatty protein dishes/ Fried dishes	Fish < 70%	Fish	60	6,2				Sauce	30	3,25	90	470	470
	Other main dish	Egg	Egg	90	2,6				Sauce	20	3,25	110	299	300
	Other main dish	Cheese	Cheese	70	5,7				Sauce	20	3,25	90	463	460
	Other main dish	Cereals/pulses association	Cereals / pulses	60	1,4				Sauce	20	3,25	80	147	150
	Other main dish	Soy	Soy	60	1,4				Sauce	20	3,25	80	147	150
	Other main dish	Cereals + eggs and/or dairy products	Cereals	30	1,4	Eggs and/or dairy products	50	4,62	Sauce	20	3,25	100	337	340
	Other main dish	Pulses + eggs and/or dairy products	Pulses	30	1,4	Eggs and/or dairy products	50	4,62	Sauce	20	3,25	100	337	340
Side dish	Pre-processed dishes	> 50% vegetables	Vegetables	83	0,9	Starches	17	1,4	Sauce	11	3,25	110	134	130
	Pulses or starches	> 50% potatoes	Vegetables	83	0,9	Starches	17	1,4	Sauce	11	3,25	110	134	130
	Pulses or starches	> 50% cereals	Starches	53	1,4	Vegetables	17	0,9	Sauce	11	3,25	80	122	120
	Pulses or starches	> 50% pulses	Starches	53	1,4	Vegetables	17	0,9	Sauce	11	3,25	80	122	120
Dairy product	Soft cheese	Cheese < 150 mg Ca	Cheese	25	5,7							25	142	140
	Hard cheese	Cheese > 150 mg Ca	Cheese	25	5,7							25	142	140
	Non-cheese dairy product	White cheese	Yaourt and dairy desert	125	2,5							125	317	320
	Non-cheese dairy product	Yoghurt	Yaourt and dairy desert	125	2,5							125	317	320

Dessert	Raw fruit dessert	Raw fruit	Fruit	110	0,8							110	87	90
	Other dessert	Baked fruit	Fruit	110	0,8							110	87	90
	Sugary low-fat dessert	Biscuit/cake < 15% de mg	Dessert	40	2,6							40	105	100
	Fatty dessert	Biscuit/cake/pastry > 15% of fat	Dessert	40	2,6							40	105	100
	Non-cheese dairy product	Dairy desert	Yaourt and dairy desert	125	2,5							125	317	320
Bread	Bread	Bread	Bread	40	0,7							40	30	30

4.2.2 Nutritional quality

Four scores are used to evaluate the level of compliance with the FC. First, a “Global Compliance Score” is defined as the sum of 15 binary sub-scores corresponding to compliance with each of the 15 FC. If the series of 20 meals complied with one criterion, a sub-score of 1 was assigned for these criteria; if it did not comply, the sub-score was 0. The series of 20 school canteen menus for a given municipality can therefore obtain a score ranging from 0 to 15 (Table 4). Second, the “Relative Compliance Score” (RCS), which is used in our regression model, is proportional to the distance to the FC, with a maximum of 1 when the criterion is met (Equation 2).

Equation 2:

$$RCS_i = \frac{\sum_{k=1}^{15} RCS_{i,k}}{15}$$

$$RCS_{i,k} = \begin{cases} 1 - \frac{\max(Obs\_freq_{i,k} - Rec\_freq_k, 0)}{Rec\_freq_c} \; if\ Rec\_freq_k\ is\ a\ maximal\ frequency\ criterion \\ 1 - \frac{\max(Rec\_freq_{i,k} - Obs\_freq_k, 0)}{Rec\_freq_c} \; if\ Rec\_freq_k\ is\ a\ minimal\ frequency\ criterion \\ 1 - \frac{|Obs\_freq_{i,k} - Rec\_freq_k|}{Rec\_freq_k} \; if\ Rec\_freq_k\ is\ an\ exact\ frequency\ criterion \end{cases}$$

where Rec_freq_k and $Obs\_freq_{i,k}$ are the GEM-RCN frequency criterion and the observed frequency in municipality i respectively for food category k, $RCS_{i,k}$ is the Relative Compliance Score for food categorgy k in municipality i and RCS_i is Relative Compliance Score in municipality i.

For example, the category “starter containing more than 15% fat” should not be served more than four times out of 20 meals (Table 5). A series containing four starters of this type thus scores 1 on the two scores. However, a series that contained 5 starters of this type scores 0 in the “global compliance score” and 0.75 in the relative compliance score.

Alternatively, the same two indicators are computed on a restricted number of four FCs (in bold in Table 5) instead of the whole 15. The four FC are arguably the most important ones because they have the highest nutritional values and concern costly food items often wasted by children (ADEME 2016). They are also the most reliable when detailed nutritional information is not available – as is our case: for example, raw fruits to be crunched are unequivocally classified into the category « Raw fruit dessert » on the sole basis of the menu. By contrast, beef lasagne or moussaka is classified into «protein dishes with a ratio of protein over fat lower than 1» based on their typical nutritional content, but misclassification is possible if the actual recipe of the canteen differs from the typical recipe.

Dish frequency is obtained from the classification described above for the carbon footprint (Table 5). For example, the nutrition-based category "pulses, starches or grains, alone or in a mixture containing at least 50% pulses, starches or grains" (GEM-RCN frequency criterion) is obtained by summing the carbon emission-based categories "more than 50% potatoes", "more than 50% cereals" and "more than 50% pulses". Only three additional categories not considered in the environmental part were required to assess the 15 FC (fatty starters, fatty protein dishes and fried dishes). Note that some dishes do not count towards any of the 15 FC such as cuidité[10] or meat dishes with more than 70% of white meat.

4.2.3 Classification algorithm

In order to assess the nutritional and environmental quality of the large number of dishes, a dedicated algorithm was developed using the R software to automatically classify them. Its rationale is based on the presence or absence of keywords in the names of dishes. First, the existence of alternatives is detected through the presence of "or". Second, dish names are broken down into single words. These words were then "cleaned" (no upper case and no plural) and compared to two types of word lists for each category: one or two lists containing words that must be present and the other containing words that must be absent. For example, a main dish containing the word "beef" but not "lasagne" or "ground" is classified in the category "Unground beef, veal or lamb and offal". As in this example, many of these rules are intuitive. However, some word combinations could not be intuitively classified. For example, classifying in "Vegetables, other than pulses, alone or in a mixture containing at least 50% vegetables" a "poêlée forestière" with potatoes, green beans and

[10] Cooked vegetable served cold as a starter.

mushrooms required the portion of potatoes with respect to green beans and mushrooms to be established. Similarly, the presence of “sausage” and the absence of any poultry-related word indicates the presence of red meat but whether it has a protein/fat ratio lower than one is not intuitive. In these ambiguous cases, we relied on the 2,500 technical files of school canteen dishes collected by Vieux et al. (2018) as a reference. The technical files were screened for possible correspondences with the ambiguous word combinations, and the word combinations were sorted in the most frequent category among the corresponding technical files. The code is provided in *Annex 3. 1.*

Overall, this method enables us to substantially increase sample size at the cost of a few possible misclassifications of dishes into nutritional and environmental categories. Two quality checks were implemented to minimize the risk of classification error. A first automatic step consisted in checking that each dish was sorted into a single category. A second manual step consisted in checking that each category contained dishes which intuitively belong there.

4.3 Explanatory variables

Our sample of municipalities has similar socio-economic characteristics to the Ile-de-France NUTS2 region to which it belongs, except for a slightly more pronounced left-wing orientation (Table 3). It is however substantially richer and better educated than the rest of France. Data on the management mode for school canteens (“in house” provision vs. outsourcing) and on the frequency of certified products were collected from the municipalities’ websites (propositions 1 and 2). To test proposition 3, the vote shares for the first round of the 2014 municipal elections were aggregated into left (left-oriented: from diverse left to far left also including the Greens) and right (right-oriented: from the centrists to the far right, see Annex 1. 6 for details). For proposition 4, we relied on data from the National Statistical Institutes (INSEE). The educational level was measured as the proportion of the population with at least a second-year university level. Finally, for proposition 5, canteen size was approximated by the population of children enrolled in school between 6 and 10 years old (absolute number). We cannot compare directly the average population aged between 6-10 years old with the France and Ile-de France level because the different municipalities in intercommunal associations were summed rather than averaged to capture the size effect of central kitchens.

Table 3: Descriptive characteristics of the involved municipalities and comparison with larger areas

Statistic	**Mean**	**St. Dev.**	**Min**	**Max**
In-house provision model	0.475			
Population aged between 6-10 years old (2017)	2,973	3,259	129	25,985
Average population aged between 6-10 years old (2017), Metropolitan France	116			
Average population aged between 6-10 years old (2017), Ile-de-France region	614			
Proportion of the population with a higher diploma (2017)	0.425	0.142	0.137	0.688
Average proportion of the population with a higher diploma (2017), Metropolitan France	0.299			
Average proportion of the population with a higher diploma (2017), Ile-de-France region	0.426			
Proportion of left-wing voters (2014)	0.386	0.246	0.000	1.000
Average proportion of left-wing voters (2014), Metropolitan France	0.332			
Average proportion of left-wing voters (2014), Ile-de-France region	0.290			

4.4 Model specification

To test our propositions on the drivers of nutritional and environmental quality, an OLS specification is used (Equation 3).

Equation 3:

$$Y_i = B_0 + B.X_i + \varepsilon_i$$

where Yi is either the nutritional quality (15 or 4 FC global or relative score) or the average carbon footprint of menus in municipality i, and X_i is a vector of characteristics of municipality i used to test the previously described propositions. The proportion of the population with a higher education degree, which is strongly correlated with the median income[11] (Annex 1. 7), is used as a proxy of socio-economic level for Proposition 4. Where residuals are heteroskedastic (Breusch-Pagan test), a robust model using the bisquare weighting function is estimated in addition to the ordinary least squares (e.g. see Table 6 and Annex 1. 13).

5 Results

5.1 Descriptive statistics of nutritional quality and carbon footprint

On average, a municipality in our sample fulfilled 8.2 (min = 4, max = 14) out of the 15 FC (Table 4). A maximum frequency of 4/20 serving of "fried dishes" and a minimum of 8/20 serving of "Raw fruit dessert" are the FC most often met (Table 5). Criteria expressed by a strict equality (eg. 10 dishes containing at least 50% pulses, starches or grains or 10 dishes containing at least 50% vegetables") are weakly respected as in Vieux et al. (2018). In addition, the minimal frequency of 8/20 servings of "hard cheese" (25.7% binary and 70.2% relative) and the maximum of 2/20 serving of "fatty protein" (22.8% binary and 37.9% relative) are also poorly met. Substantial (> 30 percentage points) differences are however identified with Vieux et al (2018) on the following six FC: "Raw fruits or vegetables starters", "Pre-processed dishes", "Hard cheese", "Non-cheese dairy products", "Sugary low-fat desserts" and "Fatty desserts" (Table 5).

According to interviews with kitchen managers and public caterers, the attendance of school canteens on Wednesday is six times lower than for the rest of the week[12]. We therefore tested the sensitivity of our results by removing the 4 Wednesdays of the 20-day period of analysis. We recalculate the expected frequency on the basis of 16 days. The compliance with the adjusted minimum frequency of 3.2 serving of red meat decreases dramatically with respect to the 20-day

[11] Similar results were found when performing OLS regression with the median income rather than the education level.
[12] For most French elementary public schools' children attend school only Wednesday morning.

period (Annex 1. 8 and Annex 1. 9), binary score: -43%, relative score: -12%) suggesting that caterers are more inclined to serve expensive red meat on Wednesdays when fewer children eat at school.

The carbon footprint of canteen menus averages at 1.9 ± 0.24 kgCO_2e/day, with minimal and maximal monthly averages at 1.2 and 2.6 kgCO_2e/day respectively (Table 4). Meat dishes add up to 72% of the carbon footprint (Figure 1), which is higher with respect to the 40%-50% found in the previous studies (Table 1) while no French comparisons exist.

Based on descriptive statistics, in-house canteens offered menus with a slightly better nutritional quality than delegated canteens for the 15 FC relative score but not for the 4 FC scores (see Annex 1. 11). In-house and delegated canteens have a similar carbon footprint and delegated canteens serve certified products slightly more often (21% against 15%, see Annex 1. 11).

Table 4: Nutritional quality and carbon footprint of school canteen menus

School canteen menu quality score	N	Mean	St. Dev.	Min	P25	P75	Max
Relative score (15 FC)	101	12.6	1.1	9.9	11.8	13.6	14.7
Binary score (15 FC)	101	8.2	1.9	3	7	9	13
Relative score (4 FC)	101	3.5	0.4	2.0	3.4	3.8	4.0
Binary score (4 FC)	101	1.4	0.8	0	1	2	4
Average emissions of canteen menus (kgCO_2e)	101	1.88	0.243	1.17	1.72	2.02	2.59
Frequency of certified products	101	0.18	0.12	0.000	0.09	0.26	0.51

Table 5: The 15 frequency criteria for nutritional quality and the percentage of municipalities fulfilling each criterion (global compliance score)

Frequency criterion (FC)	Simplified FC name	Component(s) concerned	Expected frequency	% of series fulfilling the criterion in the Paris Area (this	% of series fulfilling the criterion in France (Vieux et al., 2018)

				study)	
Starters containing more than 15% fat	Fatty starters	starter	4/20 max	83,2%	82,5%
Raw vegetable or fruit dishes containing at least 50% vegetables or fruits	**Raw fruits or vegetables starters**	**starter, side dish**	**10/20 min**	**38.6%**	**70%**
Dishes to fry or pre-fried dishes containing more than 15% fat	Fried dishes	protein dish, side dish	4/20 max	98%	100%
Protein dishes with a protein/fat ratio lower than 1	Fatty protein dishes	protein dish	2/20 max	22,8%	55%
Fish or fish-based dishes containing at least 70% fish and having a protein/fat ratio higher than 2	Fish	protein dish	4/20 min	86%	60%
Unground beef, veal or lamb, and offal	**Red meat**	**protein dish**	**4/20 min**	**63,4%**	**77,5%**
Preparations or ready-to-eat dishes containing less than 70% of the recommended weight for the portion of meat, fish or eggs	Pre-processed dishes	protein dish	4/20 max	74,2%	25%
Vegetables, other than pulses, alone or in a mixture containing at least 50% vegetables	**Vegetable side dishes**	**side dish**	**=10/20**	**22,8%**	**27,5%**
Pulses, starches or grains, alone or in a mixture containing at least 50% pulses, starches or grains	Pulses or starches	side dish	=10/20	20,8%	27,5%
Cheese containing at least 150 mg of calcium per portion	Hard cheese	starter, dairy product	8/20 min	25,7%	77,5%
Cheese with a calcium content of more than 100 mg and less than 150 mg per portion	Soft cheese	starter, dairy product	4/20 min	73,3%	57,5%
Dairy (fresh dairy products, dairy-based desserts) containing more than 100 mg of milk calcium and less than 5 g of fat per portion	Non-cheese dairy product	dairy product, dessert	6/20 min	77,2%	40%
Desserts containing more than 15% fat	Fatty dessert	dessert	3/20 max	61,4%	95%
Desserts or dairy products containing more than 20 g of total	Sugary low-fat dessert	dairy product, dessert	4/20 max	41,6%	100%

simple sugars per portion and less than 15% fat					
Raw fruit dessert 100% raw fruit without added sugars	**Raw fruit dessert**	**dessert**	**8/20 min**	**93%**	**77,5%**

Legend: in bold, the 4 FC with a particular nutritional importance

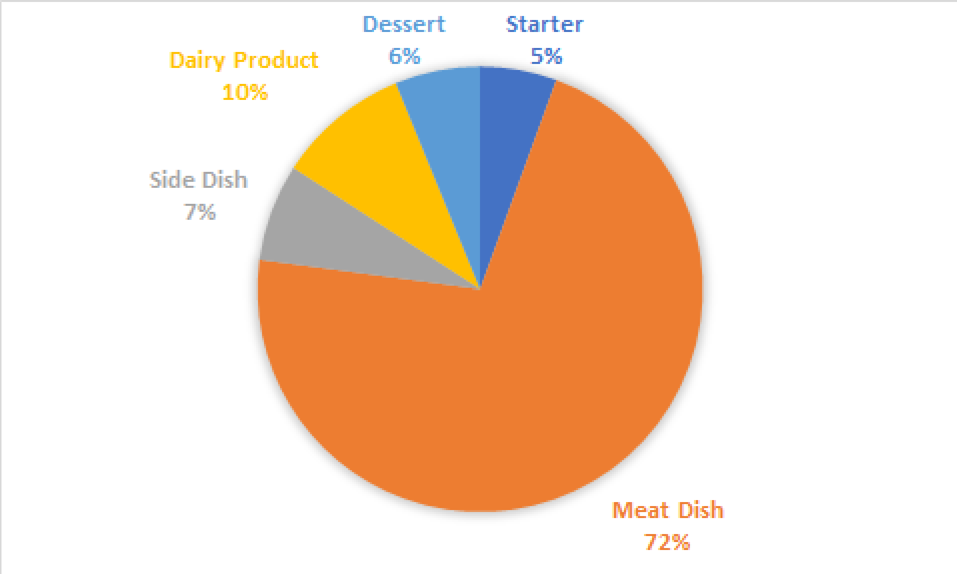


Figure 1: Share of greenhouse gas emissions (in percentage) by food component (average GHG emissons, 1.9 $kgCO_2e$).

5.2 Interactions between nutritional quality and carbon footprint

There is no correlation between nutritional quality and carbon footprint (Figure 2.A). However, when nutritional quality is restricted to the 4 FC score, nutritional quality and environmental performance are antagonistic (Figure 2.B.). This antagonism is mainly driven by the FC requesting a minimal frequency of four red meat dishes per cycle, which is less diluted in the 4 FC score. Interestingly, there is substantial variability in the carbon footprint of the menus with the highest nutritional quality (e.g. higher than 13, see Figure 2),

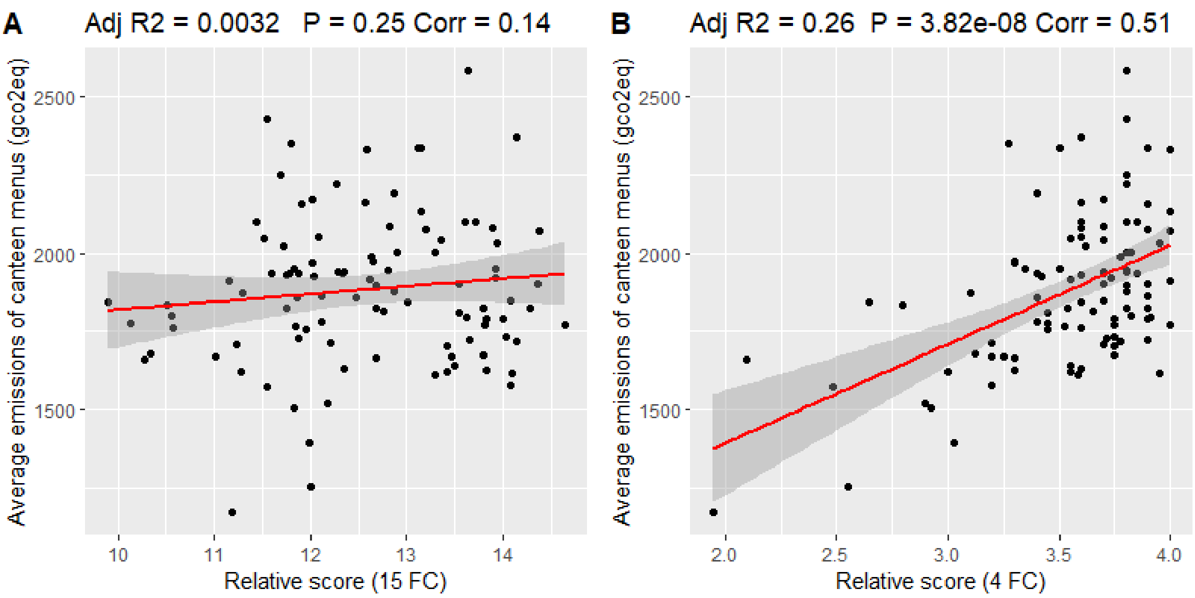


Figure 2: Correlation between carbon footprint and nutritional score

5.3 Higher nutritional quality in municipalities with large and in-house canteens

Only propositions 1.a and 5 on the management model and the canteen size are verified as determinants of nutritional quality (Table 6, column 2): the nutritional quality of meals is significantly higher in in-house municipalities – partial effect at the average (PEA) of 0.66-0.8 more points compared to an average relative 15 FC score of 12.6 – and larger canteens (0.62 more points when the number of pupils is multiplied by 10). Left-wing vote also seems to be associated with higher nutritional quality but with a lower significance level, in particular when canteen size is controlled for. The effects of parental education level and the frequency of certified products are not significant. When nutritional quality is assessed by the 4 FC score instead of the 15 FC score, none of the independent variables has a significant effect (Annex 1. 14).

Table 6: 15 FC relative score and its determinants (robust regression using Bisquare weighting function; the table reports regression coefficients)

	Dependent variable:		
	Relative Score (15 FC) using bisquare weighting function		
	(1)	(2)	(3)
In-house provision	0.794***	0.666***	0.290
	(0.221)	(0.221)	(1.635)
Frequency of certified products	−0.524	−0.924	−0.903
	(0.873)	(0.886)	(0.896)
Proportion of the population with a high diploma	0.496	0.504	0.523
	(0.838)	(0.825)	(0.831)
Proportion of the left-wing voters during the first round	1.171**	0.804*	0.808*
	(0.461)	(0.482)	(0.487)
log(Population of 6-10 years old enrolled)		0.617**	0.552
		(0.271)	(0.390)
In-house provision * log(Population of 6-10 years old enrolled)			0.116
			(0.494)
Constant	11.719***	9.966***	10.157***
	(0.468)	(0.916)	(1.256)
Observations	101	101	101
Residual Std. Error	0.955 (df = 96)	0.875 (df = 95)	0.880 (df = 94)
R^2	0.347	0.400	0.399
Adjusted R^2	0.319	0.369	0.361
F Statistic	7.0906*** (df = 4; 96)	6.9168*** (df = 5; 95)	5.6693*** (df = 6; 94)

Note: *p<0.1; **p<0.05; ***p<0.01

5.4 Lower carbon footprint in municipalities with a higher education level and in-house canteens of larger size

On average, the management model has no impact on the environmental impact of menus (Table 7, column 1). However, this average result hides interactions with canteen size or left-wing vote. In-house canteens serving more than 3,500 pupils[13] indeed have a lower environmental impact (0.16 $kgCO_2e$ less when the number of pupils is multiplied by 10, see Table 7, Annex 1. 15 *and* Annex 2. 1 *for* the details of the calculations). Similarly, in-house canteens in left-wing municipalities (with more than 53% of left-wing votes) have a higher environmental quality (0.0035 $kgCO_2e$ less with a one percent increase of left-wing votes, see Table 7, Annex 1. 16 and Annex 2. 1). In addition, a lower carbon footprint of canteen menus is observed in municipalities with a better educated population (4,30-4,40 $kgCO_2$ less with a 1% increase of the population with a second-year university level) while the frequency of certified food products has no significant effect (Table 7). This result is confirmed when we restrict the certified food category to organic food (see Annex 1. 17).

[13] This number refers to the total number of pupils in the school. Based on interviews with canteen managers, among them, an average two thirds of pupils have lunch in the canteen.

Table 7: Average GHG footprint per school meal and its determinants (OLS regression)

	Dependent variable:		
	Average emissions of canteen menus (gco2e)		
	(1)	(2)	(3)
In-house provision	64.882	871.630**	216.703**
	(52.015)	(375.443)	(90.860)
Frequency of certified products	6.825	−29.823	−82.943
	(209.036)	(205.771)	(210.451)
Proportion of the population with a high diploma	−434.252**	−442.824**	−443.229**
	(194.544)	(190.900)	(191.507)
Proportion of the left-wing voters during the first round	−159.981	−176.693	59.295
	(113.638)	(111.751)	(155.762)
log(Population of 6-10 years old enrolled)	−56.281	82.260	−56.193
	(63.989)	(89.560)	(62.973)
In-house provision * log(Population of 6-10 years old enrolled)		−246.055**	
		(113.446)	
In-house provision * Proportion of the left-wing voters during the first round			−410.507**
			(202.976)
Constant	2,281.486***	1,856.864***	2,235.479***
	(216.053)	(288.540)	(213.836)
Observations	101	101	101
R^2	0.094	0.137	0.132
Adjusted R^2	0.046	0.082	0.076
Residual Std. Error	233.709 (df = 95)	229.282 (df = 94)	229.998 (df = 94)
F Statistic	1.971* (df = 5; 95)	2.491** (df = 6; 94)	2.378** (df = 6; 94)
Note:			*p<0.1; **p<0.05; ***p<0.01

6 Discussion and policy recommendations

6.1 Benchmarking of nutritional and environmental scores

Our results confirm that nutritional guidelines are only partially met. Similar results are found by Vieux et al (2018) when comparing FC suggesting that potential misclassification of dishes into nutritional categories is limited. However, some caution is warranted on the six FC where substantial differences are identified. There are at least two elements which can explain these differences. First, Vieux et al. (2018) had access to the “technical files” (indicating the composition of each dish, namely the ingredients and the quantities used). Without this information, our method based on the sole menus could suffer from a few misclassifications, especially in GEM-RCN’s categories that explicitly refer to nutritional content or ingredient proportion. This likely explains part of the difference in the "hard cheese" category, which can easily be misclassified into "soft cheese" when the exact calcium content is unknown. Second, the two samples do not cover the same period and location and data were collected differently. The higher compliance score in Vieux et al. (2018) may be partly explained by social desirability bias as their canteen menus were provided by canteens on a voluntary basis whereas we exhaustively sampled our target area.

Our average monthly carbon footprint of 1.9 kgCO_2e/day is close to the averages reported by Eco2 Initiative (2020) for Parisian canteens. To a certain extent, this similarity confirms the robustness of our classification despite the absence of detailed dish composition. The misclassification risk is intrinsically reduced for the environmental indicator by the fact that all cheeses have the same emissions factor, no matter whether their calcium content is higher or lower than 150 mg. Our estimate is also close to the average carbon footprint of a French meal estimated at 2.3 kgCO_2e (ADEME 2016). Overall, our average estimate lies within the 0.72-4.1 kgCO_2e range from the existing literature. However, this robustness assessment relying on previous literature is limited given that carbon footprint is strictly dependent on a set of factors that we cannot control (e.g. food consumption patterns in each country reviewed, the amount of food served, food ingredients geographical origin and the agricultural method used to its production, as well as the conservation methods used for food ingredients). Large differences have nevertheless been identified between studies evaluating the mean GHG value per school meal. Exploring the drivers of these gaps such as the country's food culture or GHG calculation method can provide a valuable source of information to improve either the methods or the environmental quality of the meals.

Overall, we find that nutritional and environmental quality are not correlated. This echoes the previously stressed finding that a synergy between environmental and nutritional qualities is possible but not systematic (Doro et al, 2020). Some studies suggest antagonism between the two goals (Vieux et al. 2013; K. Wickramasinghe et al. 2017) while most found synergies (Behrens et al. 2017; van Dooren et al. 2014; Irz et al. 2016; Kesse-Guyot et al. 2020). Note however that the potential antagonism between nutritional quality and carbon footprint tends to arise with very specific micro-nutrients, e.g. vitamin B12 and D, omega 3, calcium which are mainly found in animal products, largely out of the reach of our menu-based estimation of nutritional quality (Vieux et al. 2013; K. K. Wickramasinghe et al. 2016). The high variability in the carbon footprint of the menus with the highest nutritional quality suggests that it is possible to identify high quality school meal series with low carbon footprint, despite the importance given by GEM-RCN criteria to animal products.

6.2 Drivers of nutritional quality and carbon footprint

In-house provision is associated with both higher nutritional quality and lower carbon footprint in larger canteens. This may be explained by a stronger cost constraint in delegated canteens, incentivizing canteen managers to cut healthy but expensive food items such as fruits and vegetables although the reverse could have been expected for polluting and expensive food items such as red meat. Indeed, profitability was reported to be negatively affected by the introduction of healthier options (Jaworowska et al. 2013) due to a reduction of meal palatability and therefore customer satisfaction (Cohen et al. 2012). Outsourcing can also be plagued with difficulties in contracting, in particular on quality (Andersson et al., 2019; Hart et al., 1997; Saussier et al., 2009), explaining lower nutritional quality in delegated canteens. The endogeneity of the canteen management model is likely the most important limit of our study, preventing any strong causal interpretation of our results related to the management model. Indeed, previous research on public-private partnerships for other public services, like water management, has shown that this bias is not negligible (Chong et al. 2006; Ménard and Stéphane 2003). For instance, a simple comparison on the price of water paid by taxpayers between cities that delegate the water provision and those that run the system in-house shows that this price is lower under in-house provision. But this simple comparison tends to ignore the fact that municipalities mostly outsource the water provision when water treatment is complex and therefore intrinsically more costly[14]. More generally, the decision to delegate the provision of public service can be motivated by a lack of in-house competencies, financial constraints, or the

[14] Once this is factored in the econometric analysis, price difference is no longer statistically different.

substantial investments required for in-house provision (Ménard and Stéphane 2003). Our results show that the management model is not correlated with any other observed municipality characteristics, which reduces the risk of bias (Annex 1.7). However, endogeneity can be caused by variables affecting meal quality that we cannot control for such as a lack of an adequate place (Abery and Drummond 2014; Girona et al. 2019) or equipped kitchens (Wagner, Senauer, and Runge 2007), both requiring investments. Overall, a better understanding of the reasons that both motivate outsourcing and affect nutritional and environmental quality of canteen meals is crucial to make finer conclusions on the provision model impact.

Our finding that canteen size is associated with higher nutritional quality is consistent with the qualitative literature. This size effect may be caused by the higher staff training permitted by economies of scale in larger canteens (Thorsen et al., 2009). Indeed, canteen managers emphasize the paramount importance of dieticians in the design of nutritionally balanced menus and that access to this competence is likely challenging in small canteens (Cour des comptes 2020). A similar rationale could apply to environmental quality, although we have shown that it then depends on the management model: large in-house canteens offer menus with a lower carbon footprint than large delegated canteens. We can presume that higher staff training access in larger in-house canteens facilitates the substitution of meat products with plant-based products, for which recipe creation might be challenging and time-consuming.

Parents strongly influence the nutritional quality of their children's diet (Ardzejewska, Tadros, and Baxter 2013; Clelland, Cushman, and Hawkins 2013; Downs et al. 2012), as well as its environmental quality (Cho and Nadow 2004; Dědina, Šánová, and Kadeřávková 2014; Filippini et al. 2018). Our results show that this influence can extend to canteen menus on environmental quality, but not nutritional quality (*Table 4*). One explanation may be that parents are more inclined to put pressure on policy makers and caterers to reduce canteen meal GHGEs because of their higher environmental awareness (Aminrad, Zakaria, and Hadi 2011) and lower meat consumption (Gossard and York 2003).

There again, one must remain cautious on the causal interpretation. An alternative explanation could be that canteen managers are keener to serve red meat in poor neighborhood where this expensive food item may be less frequently offered in children's homes. This hypothesis would call for a further exploration of food choices of canteen managers, which is beyond the objective of this study. Overall, further research on the possible lines of action of parents about canteen manager decisions as well as additional factors which would enhance parental involvement is required to interpret these results.

The introduction of certified food in canteen meals is independent from the nutritional and quality and carbon footprint of canteen menus. This finding contradicts previous research showing that organic food in canteens improve the nutritional quality (Lassen et al. 2019; B. Mikkelsen et al. 2006) and carbon footprint (Tregear et al. 2019) of canteen menus. This contradiction may stem from the differing motivations for introducing certified food by canteen managers. In our context, their motivation is partly an anticipation of the recent EGALIM law (LOI n° 2018-938) which requires public institutional catering to serve at least 20% organic food and 50% certified food (including organic products) by January 2022 and may therefore be disconnected from broader nutritional or environmental concerns.

The left-wing vote only has an effect when interacting with the management mode: canteens with in-house provision in leftist municipalities have lower environmental impact than canteens with delegated management. This could be related to the emphasis put by left parties – and in particular the Green party – on school catering during the municipal campaigns. Once in charge of municipalities, left-wing parties may have more difficulties to implement their electoral promises when school catering is delegated, since the delegation may have been contracted before the elections or catering companies may not respect this contracted commitment in the absence of strong control capability. That would mean costly renegotiations with private providers, in particular if the contract has been recently agreed. Unfortunately, we did not have access to this information.

6.3 Policy and Managerial Implications

Our results confirm those found in the literature showing that canteens are far from fulfilling nutritional guidelines (Brennan et al. 2019; Woods et al. 2014; Vieux et al. 2018) calling into question their usefulness. Guideline's complexity, lack of human resources and knowledge and the absence of strong legal sanctions or monitoring mechanisms are identified in the literature as significant barriers to their implementations. For example, managing fifteen frequency criteria as defined by the French regulations, some of which require the detailed nutrient content of dishes, is both complex and constraining when also trying to reduce the environmental footprint of meals. This is especially true for small municipalities unable to have enough dedicated staff to follow this guideline. One way to facilitate the fulfillment of nutritional guidelines would be to adapt them to the size of municipalities (as measured for instance by the number of meal served), larger municipalities being for instance compelled to fulfill more nutritional criteria. While harsh penalties for non-compliance would likely be counter-productive, their total absence does not provide incentives to canteen managers to improve meal quality.

The presence of a minimal frequency of red meat in nutritional guidelines may be seriously questioned in light of its environmental aftermaths. Alternative meat types with lower carbon footprint (e.g. poultry) or dishes based on vegetal proteins (e.g. pulse-based) can provide similar nutritional benefits without the environmental downside. However, introducing vegetarian meals with lower environmental impact requires both cooking know-how and a good understanding of their nutritional quality. For example, vegetarian dishes containing eggs and/or dairy products other than cheese have a better nutritional quality than vegan dishes and vegetarian dishes containing cheese (Poinsot et al. 2020). Alternatively, portion size of meat-based dishes could also be questioned, since average protein intake by French children is currently exceeding nutritional guidelines (e.g., INCA3, Anses). More broadly, the leeway allowed by the nutritional guidelines to reduce the carbon footprint of canteen meals must be further explored: in less than 2 years, a few Parisian school canteens have succeeded in reducing by 30% GHG emissions of canteen meals (from

1.8 to 1.2 kgCO2e) while complying with the GEM-RCN (Eco2 Initiative 2020). They mainly modified the frequencies and portion sizes of food, two actions which require staff training, children's awareness and commitments from local public officers but no additional costs. Our results point out however that reducing the frequency of red meat quickly runs into the minimal frequency recommended by the GEM-RCN.

The compliance with the adjusted minimum frequency of 3.2 serving of red meat decreases dramatically when removing the Wednesday of the 20-day period of analysis. It suggests that caterers are more inclined to serve expensive red meat on Wednesdays when fewer children eat at school. This peculiarity should be considered, for example by excluding Wednesdays from the accounting of frequency criteria while maintaining minimal nutritional requirements (e.g., 5 component meal).

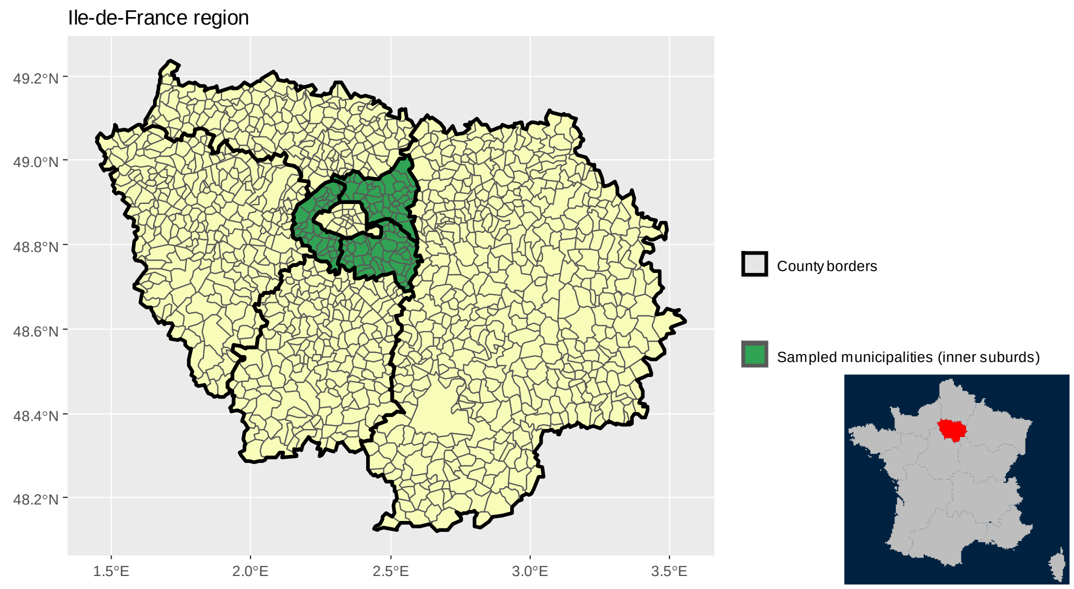
The introduction of more publicly certified food products (like PDO and PGI) is a cornerstone of the recent French EGALIM law on public institutional catering. However, we found no significant impact of the frequency of these products on nutritional quality or carbon footprint. Their goals are to certify a geographical origin or a higher quality that are not necessarily related to health and environmental issues. While these results should be interpreted cautiously due to limited precision of our measurement of certified food frequency, they certainly call for more research on the environmental impact of mandatory procurement of certified food.

7 Conclusion

The present study evaluates simultaneously the nutritional quality and the carbon footprint of canteen meals of municipalities in the inner suburbs of Paris and their determinants. We find that canteens meet an average 8.2 nutritional frequency criteria out of 15 as defined by national regulation and that their menus average 1.9 kgCO2e/day, which is consistent with previous literature. No correlation is found between the nutritional and environmental qualities of canteens menus. In-house canteens have a significantly higher nutritional quality and so do larger canteens. The carbon footprint is significantly lower in municipalities with a higher educational level and, for in-house canteens, it is also significantly lower in larger canteens and where left-wing vote is higher, breaking even with delegated canteens above 3,500 enrolled children and 53% of left-wing vote respectively. Further research based on a larger and more diverse sample, applying a different sampling method, would overcome some of the limits of the present study.

ANNEXES 1.

Annex 1. 1: Sampled municipalities within the Ile-De-France region

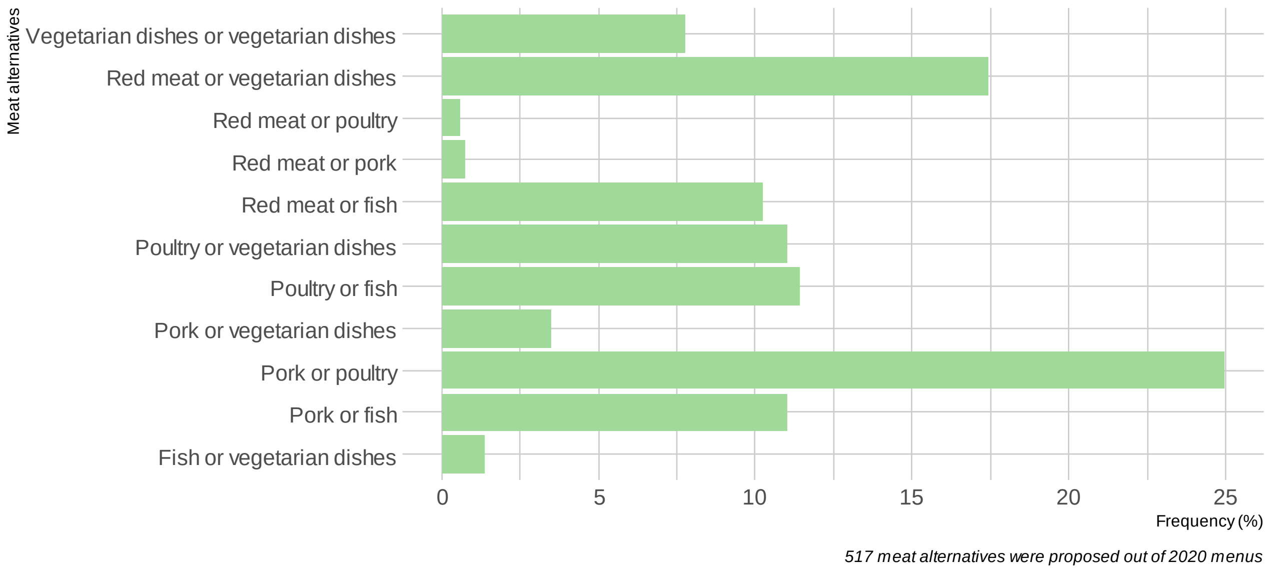


Annex 1. 2: Central kitchens of intercommunal associations

Central kitchen	Municipalities in the intercommunal association
COCLICO	Clichy, Colombes
cantine de Bagneux	Bagneux, Cachan
SIPLARC	Bondy, Noisy-le-Sec
SIRESCO	Bobigny, Aubervilliers, La Courneuve,Romainville, Tremblay-en-France, Arcueil, Champigny-sur-Marne, Ivry-sur-Seine, La Queue-en-Brie
SIVURESC	Le Blanc-Mesnil, Pantin
SIVOM	Pierrefitte-sur-Seine, Stains
SYREC	Saint-Ouen, Villepinte, Gennevilliers

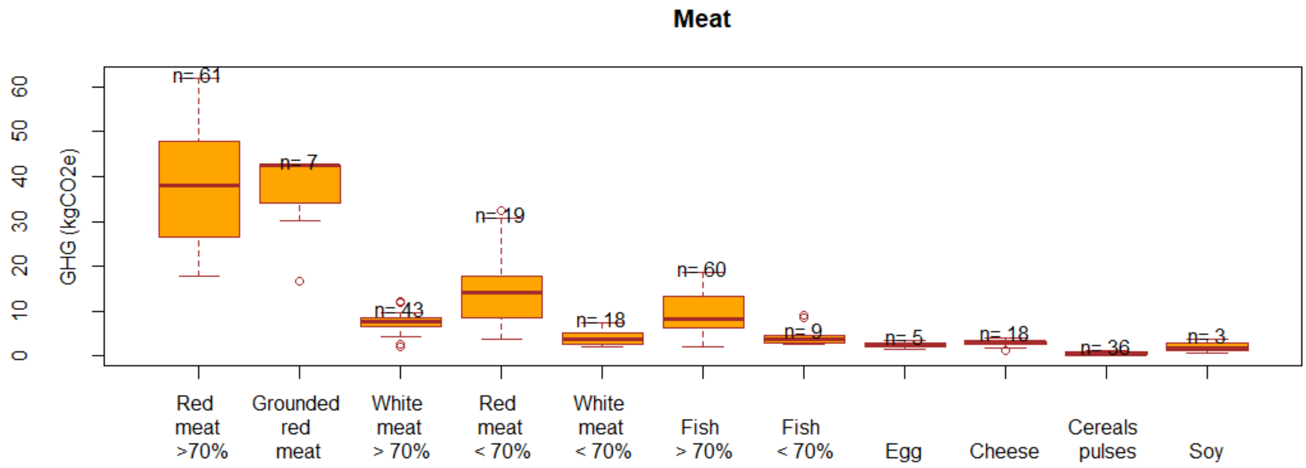
SIRM	Boissy-Saint-Léger, Villeneuve-Saint-Georges, Bonneuil-sur-Marne
Central kitchen of the Grand Paris Sud Est Avenir	Alfortville, Limeil-Brévannes et Créteil
Sidoresto	Gentilly, Vitry-sur-Seine
Communauté Bourget	Dugny, Le bourget,Drancy

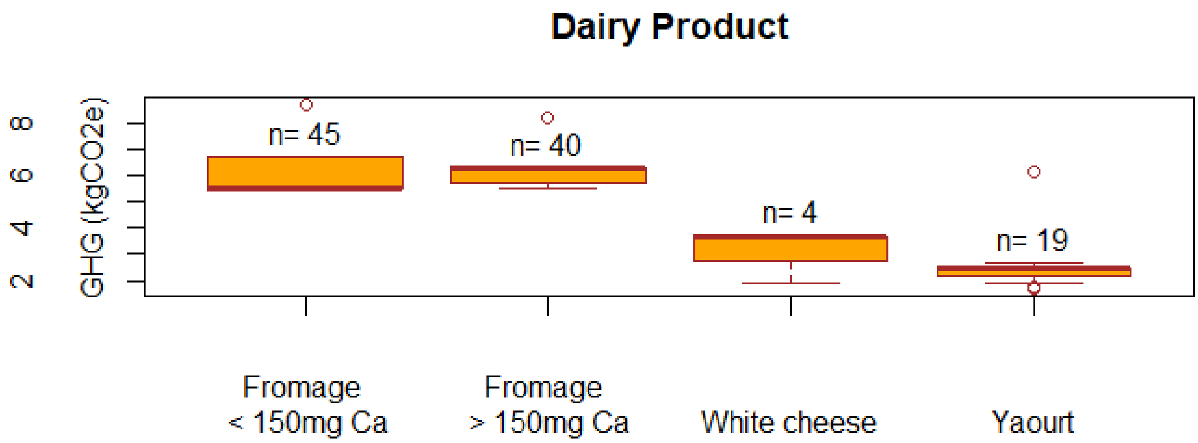
Annex 1. 3: Type of alternative when a choice is offered on protein dishes

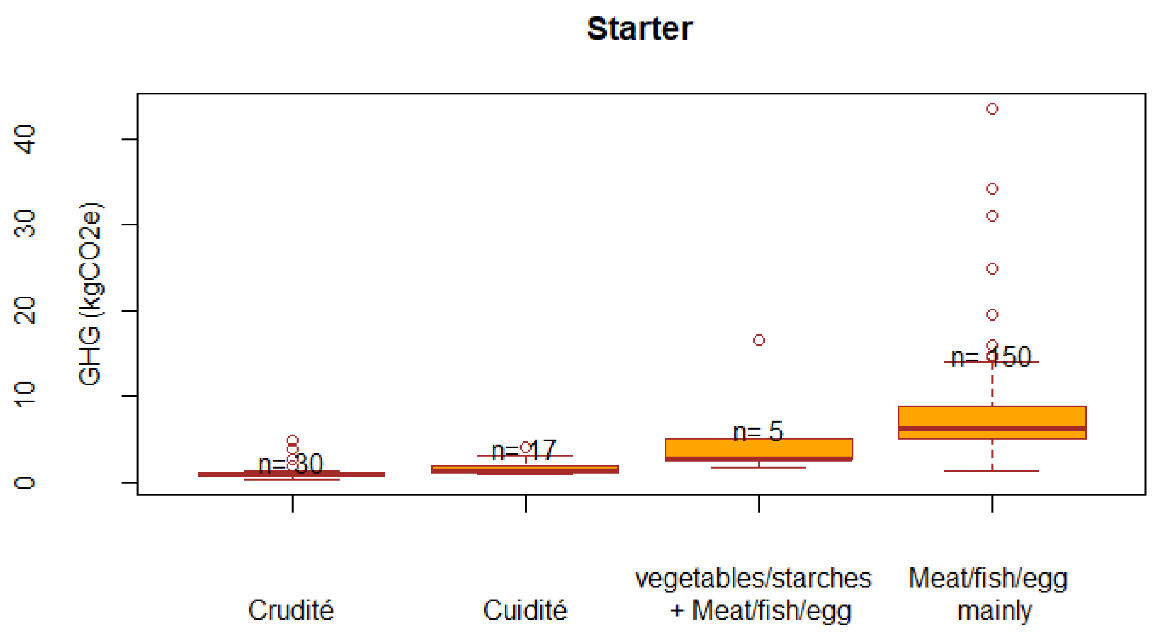


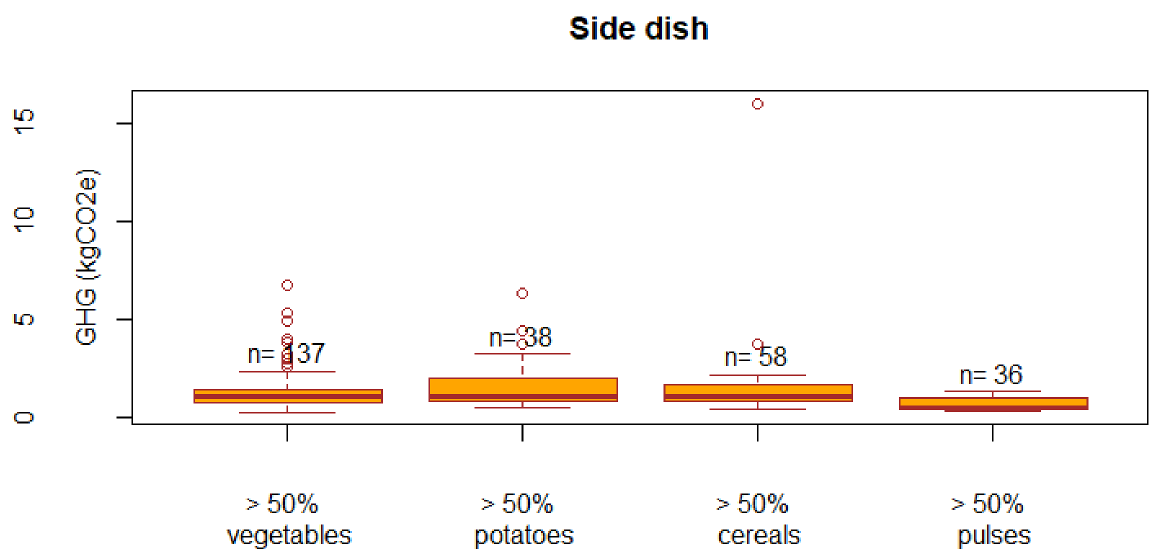
Annex 1. 4: Controlling carbon footprint homogeneity of the food categories used based on representative dishes from Agribalyse 3.0

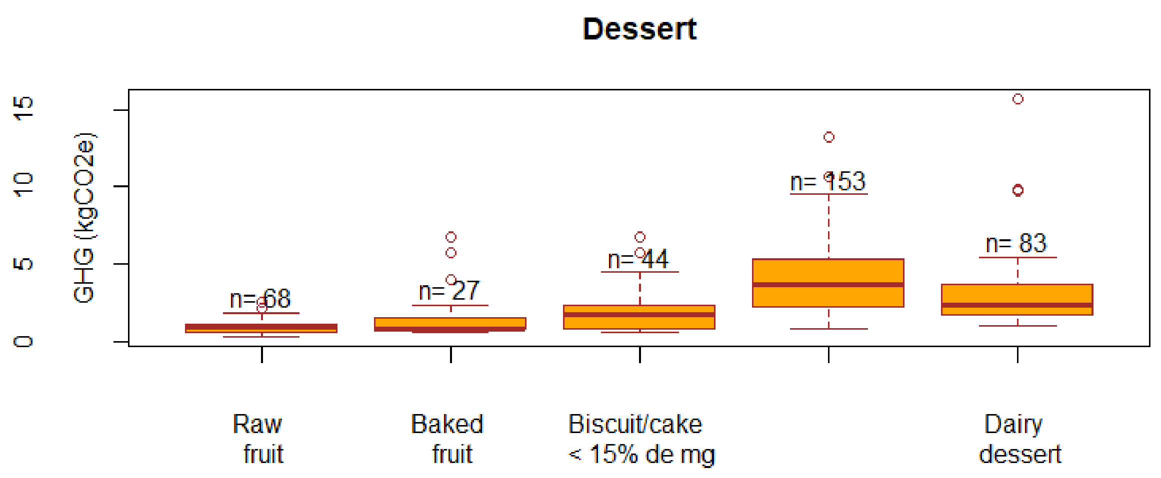
Each of the following figures represents the mean (median?), first and third quartiles, and XX of the all dishes belonging to the relevant category in Agribalyse 3.0.






Starter
GHG (kgCO2e)
0
10
20
30
40
n= 30
n= 17
n= 5
n= 150
Crudité
Cuidité
vegetables/starches + Meat/fish/egg
Meat/fish/egg mainly


Side dish
GHG (kgCO2e)
0
5
10
15
n= 137
n= 38
n= 58
n= 36
> 50% vegetables
> 50% potatoes
> 50% cereals
> 50% pulses



Annex 1. 5: Weightings applied in the case of alternative choices

	Fish dish	Meat dish	Vegetarian dish
Meat dish	Meat: 0.8 Fish: 0.2		
Vegetarian dish	Vegetarian: 0.05 Fish: 0.95	Vegetarian: 0.05 Meat: 0.95	

For example, when an alternative is offered between fish and meat, we assume that 80% of pupils get a meat dish and 20% get a fish dish.

Annex 1. 6: Classification of the political nuances between right and left affiliations[15]

Abbreviation	**Political nuance**	**Affiliation**
LDVG	Liste divers gauche	Left
LDVD	Liste divers droite	Right
LUMP	Liste de l'UMP	Right

[15] The "Liste diverse" (LDIV) political nuance was not ranged because it contains disparate parties, difficult to classify between right and left.

LSOC	Liste du Parti Socialiste	Left
LEXG	Liste d'extrême gauche	Left
LVEC	Liste Europe Écologie Les Verts	Left
LUG	Liste Union de la gauche	Left
LUDI	Liste Union des Démocrates et des Indépendants	Right
LFG	Liste Front de Gauche	Left
LCOM	Liste du Parti communiste français	Left
LPG	Liste du Parti de Gauche	Left
LUD	Liste Union de la Droite	Right
LMDM	Liste Modem	Right
LUC	Liste Union du Centre	Right
LFN	Liste Rassemblement National	Right
LEXD	Liste Extrême droite	Right

Annex 1. 7: Correlation matrix of municipality descriptive variables

	Left-wing voters	In-house	Pop high degree diploma	children 6-10	Median Income
Left-wing voters	1	0.31	-0.4	0.33	-0.57
In-house	0.31	1	-0.34	0.28	-0.37
Pop high degree diploma	-0.4	-0.34	1	-0.23	0.91
children 6-10	0.33	0.28	-0.23	1	-0.36
Median Income	-0.57	-0.37	0.91	-0.36	1

Annex 1. 8: The 15 frequency criteria for school meal service and the percentage of series fulfilling each criterion among the 101 observed series of 16 meals (binary scores without Wednesdays)

Simplified FC name[16]	**Component(s) concerned**	**Expected frequency**	**% of series fulfilling the criterion in Paris Area (binary score)**	**% of series fulfilling the criterion without Wednesdays (binary)**
Fatty starters	starter	3.2/20 max	83,2%	80,2%
Raw fruits or vegetables starters	**starter, side dish**	**8/20 min**	**38.6%**	**41,6%**
Fried dishes	protein dish, side dish	3.2/20 max	98%	96%
Fatty protein dishes	protein dish	1.6/20 max	22,8%	13,9%
Fish	protein dish	3.2/20 min	86%	73,3%

[16] See the complete frequency criterion name in Table 3.

Red meat	**protein dish**	**3.2/20 min**	**63,4%**	**20,8%**
Pre-processed dishes	protein dish	3.2/20 max	74,2%	59,4%
Vegetable side dishes	**side dish**	**=8/20**	**22,8%**	**18,8%**
Pulses or starches	side dish	=8/20	20,8%	18,8%
Hard cheese	starter, dairy product	6.4/20 min	25,7%	19,8%
Soft cheese	starter, dairy product	3.2/20 min	73,3%	59,4%
Non-cheese dairy product	dairy product, dessert	4.8/20 min	77,2%	79,2%
Fatty dessert	dessert	2.4/20 max	61,4%	49,5%
Sugary low-fat dessert	dairy product, dessert	3.2/20 max	41,6%	32,7%
Raw fruit dessert	**dessert**	**6.4/20 min**	**93%**	**83%**

Annex 1. 9: The 15 frequency criteria for school meal service and the percentage of series fulfilling each criterion among the 101 observed series of 16 meals (relative scores without Wednesdays)

Simplified FC name[17]	**Component(s) concerned**	**Expected frequency**	**% of series fulfilling the criterion (relative Score)**	**% of series fulfilling the criterion without Wednesdays (relative score)**
Fatty starters	starter	3.2/20 max	94,4%	92,5%
Raw fruits or vegetables starters	**starter, side dish**	**8/20 min**	**84,4%**	**84,8%**
Fried dishes	protein dish, side dish	3.2/20 max	99,5%	99%
Fatty protein dishes	protein dish	1.6/20 max	37,9%	40,5%
Fish	protein dish	3.2/20 min	95,7%	94,5%
Red meat	**protein dish**	**3.2/20 min**	**87,8%**	**75,9%**
Pre-processed dishes	protein dish	3.2/20 max	96,7%	79%
Vegetable side dishes	**side dish**	**=8/20**	**83,8%**	**80,6%**
Pulses or starches	side dish	=8/20	82,2%	79,7%

[17] See the complete frequency criterion name in Table 3.

Hard cheese	starter, dairy product	6.4/20 min	70,2%	67,2%
Soft cheese	starter, dairy product	3.2/20 min	87,2%	86,6%
Non-cheese dairy product	dairy product, dessert	4.8/20 min	95,8%	94,8%
Fatty dessert	dessert	2.4/20 max	80,2%	73,3%
Sugary low-fat dessert	dairy product, dessert	3.2/20 max	72,6%	69,7%
Raw fruit dessert	**dessert**	**6.4/20 min**	**98,8%**	**97,5%**

***Annex 1.* 10:** The 15 frequency criteria for school meal service in Paris area and the percentage of municipalities fulfilling each criterion among the 101 series of 20 meals (binary vs relative scores)

Simplified FC name[18]	Component(s) concerned	Expected frequency	% of series fulfilling the criterion in Paris Area (binary score)	% of series fulfilling the criterion in Paris Area (relative Score)
Fatty starters	starter	4/20 max	83,2%	94,4%
Raw fruits or vegetables starters	**starter, side dish**	**10/20 min**	**38.6%**	**84,4%**
Fried dishes	protein dish, side dish	4/20 max	98%	99,5%
Fatty protein dishes	protein dish	2/20 max	22,8%	37,9%
Fish	protein dish	4/20 min	86%	95,7%
Red meat	**protein dish**	**4/20 min**	**63,4%**	**87,8%**
Pre-processed dishes	protein dish	4/20 max	74,2%	88,6%
Vegetable side dishes	**side dish**	**=10/20**	**22,8%**	**83,8%**
Pulses or starches	side dish	=10/20	20,8%	82,2%
Hard cheese	starter, dairy product	8/20 min	25,7%	70,2%
Soft cheese	starter, dairy product	4/20 min	73,3%	87,2%
Non-cheese dairy product	dairy product, dessert	6/20 min	77,2%	95,8%
Fatty dessert	dessert	3/20 max	61,4%	80,2%
Sugary low-fat dessert	dairy product, dessert	4/20 max	41,6%	72,6%
Raw fruit dessert	**dessert**	**8/20 min**	**93%**	**98,8%**

[18] See the complete frequency criterion name in Table 3

Annex 1. 11: Nutritional and environmental quality of school canteen menus for municipalities by the provision model (including a student t-test)

Variable	Overall, N = 101[1]	Delegated provision, N = 53[1]	In-house provi
Relative score (15 FC)	12.59 (1.11)	12.22 (0.98)	12.99 (1.11)
Binary score (15 FC)	8.16 (1.93)	8.32 (1.96)	7.98 (1.90)
Relative score (4 FC)	3.55 (0.39)	3.57 (0.38)	3.52 (0.40)
Binary score (4 FC)	1.38 (0.82)	1.45 (0.85)	1.29 (0.80)
Average emissions of canteen menus (kgCO2e)	1.88 (0.239)	1,85 (0.254)	1.9 (0.218)
Frequency of certified products	0.18 (0.12)	0.21 (0.13)	0.15 (0.12)

[1] Mean (SD)

[2] Welch Two Sample t-test

Annex 1. 12: *15 FC relative score* and its determinants (OLS)

	Dependent variable:		
	Relative Score (15 FC)		
	(1)	(2)	(3)
In-house provision	0.688***	0.581**	0.108
	(0.231)	(0.228)	(1.685)
Frequency of certified products	−0.103	−0.711	−0.689
	(0.911)	(0.916)	(0.923)
Proportion of the population with a high diploma	0.168	0.325	0.330
	(0.875)	(0.852)	(0.857)
Proportion of the left-wing voters during the first round	0.565	0.123	0.133
	(0.481)	(0.498)	(0.501)
log(Population of 6-10 years old enrolled)		0.723**	0.642
		(0.280)	(0.402)
In-house provision * log(Population of 6-10 years old enrolled)			0.144
			(0.509)
Constant	11.988***	9.876***	10.124***
	(0.488)	(0.947)	(1.295)
Observations	101	101	101
R^2	0.133	0.189	0.190
Adjusted R^2	0.097	0.147	0.138
Residual Std. Error	1.054 (df = 96)	1.024 (df = 95)	1.029 (df = 94)
F Statistic	3.672*** (df = 4; 96)	4.441*** (df = 5; 95)	3.678*** (df = 6; 94)
Note:			*p<0.1; **p<0.05; ***p<0.01

Annex 1. 13: 4 FC relative score and its determinants (OLS)

	Dependent variable:		
	Relative Score (4 FC)		
	(1)	(2)	(3)
In-house provision	0.159*	0.139	1.582***
	(0.082)	(0.083)	(0.599)
Frequency of certified products	0.447	0.333	0.268
	(0.325)	(0.336)	(0.328)
Proportion of the population with a high diploma	−0.665**	−0.636**	−0.651**
	(0.313)	(0.312)	(0.305)
Proportion of the left-wing voters during the first round	−0.206	−0.289	−0.318*
	(0.172)	(0.182)	(0.178)
log(Population of 6-10 years old enrolled)		0.135	0.383***
		(0.103)	(0.143)
In-house provision * log(Population of 6-10 years old enrolled)			−0.440**
			(0.181)
Constant	3.753***	3.358***	2.599***
	(0.174)	(0.347)	(0.460)
Observations	101	101	101
R^2	0.096	0.112	0.164
Adjusted R^2	0.058	0.065	0.111
Residual Std. Error	0.377 (df = 96)	0.375 (df = 95)	0.366 (df = 94)
F Statistic	2.538** (df = 4; 96)	2.392** (df = 5; 95)	3.082*** (df = 6; 94)

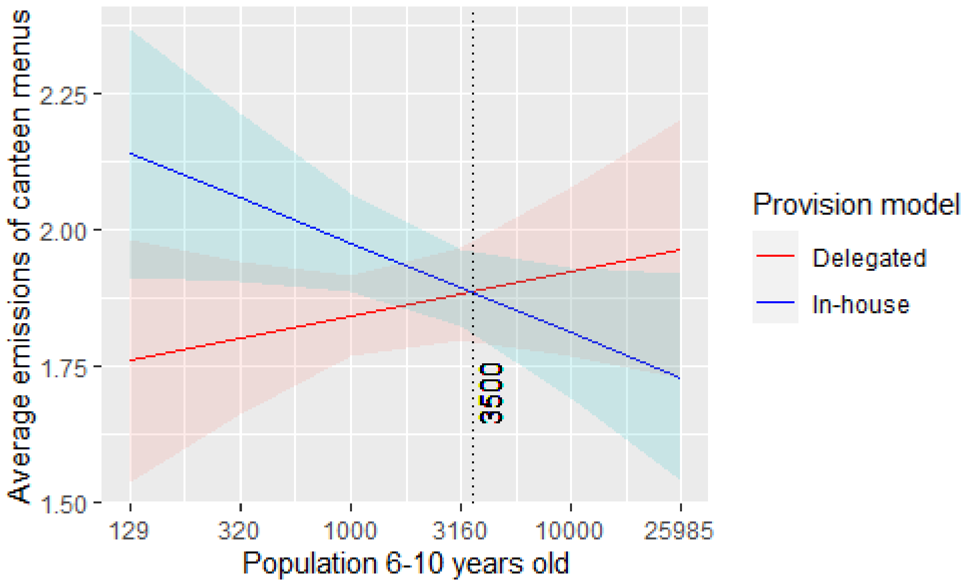
Note: *p<0.1; **p<0.05; ***p<0.01

Annex 1. 14: 4 FC relative score and its determinants (robust regression using Bisquare weighting function)

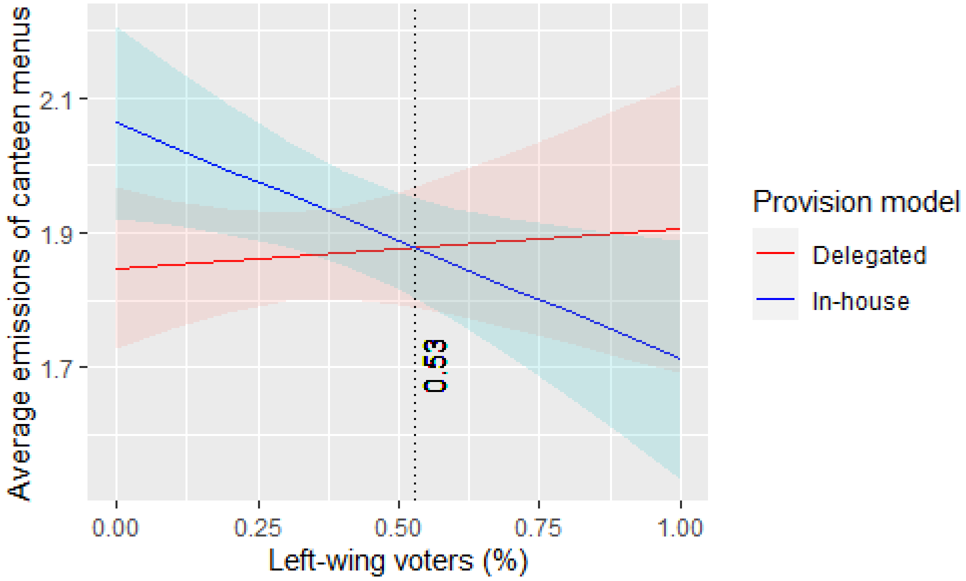
	Dependent variable:		
	Relative Score (4 FC) using bisquare weigthing function		
	(1)	(2)	(3)
In-house provision	0.086	0.085	0.608
	(0.064)	(0.065)	(0.479)
Frequency of certified products	−0.201	−0.203	−0.233
	(0.251)	(0.262)	(0.263)
Proportion of the population with a high diploma	−0.099	−0.099	−0.105
	(0.241)	(0.244)	(0.244)
Proportion of the left-wing voters during the first round	−0.052	−0.054	−0.047
	(0.132)	(0.142)	(0.143)
log(Population of 6-10 years old enrolled)		0.003	0.099
		(0.080)	(0.114)
In-house provision * log(Population of 6-10 years old enrolled)			−0.160
			(0.145)
Constant	3.683***	3.675***	3.375***
	(0.134)	(0.271)	(0.368)
Observations	101	101	101
R^2	0.200	0.200	0.224
Adjusted R^2	0.167	0.158	0.174
Residual Std. Error	0.281 (df = 96)	0.281 (df = 95)	0.270 (df = 94)
F Statistic	1.0543 (df = 4; 96)	0.82948 (df = 5; 95)	0.90347 (df = 6; 94)

Note: *p<0.1; **p<0.05; ***p<0.01

Annex 1. 15: Interaction term between in-house provision and canteen size (min = 129 pupils, max = 25,985 pupils) on GHG ($kgCO_2e$) of canteen menus



Annex 1. 16: Interaction term between In-house provision and the proportion of left-wing voters[19] on GHG ($kgCO_2e$) of canteen menus



[19] A 0% share vote is obtained for municipalities without left or right candidates.

Annex 1. 17: 15 FC relative score using bisquare weighting function and its determinants (including organic labels rather than certified, using bisquare weigthing function)

	Dependent variable:		
	Relative Score (15 FC) using bisquare weigthing function		
	(1)	(2)	(3)
In-house provision	0.801***	0.669***	0.302
	(0.219)	(0.217)	(1.624)
Frequency of organic products	−0.742	−1.155	−1.144
	(0.933)	(0.941)	(0.949)
Proportion of the population with a high diploma	0.515	0.482	0.508
	(0.823)	(0.806)	(0.813)
Proportion of the left-wing voters during the first round	1.187***	0.760	0.784
	(0.458)	(0.479)	(0.484)
log(Population of 6-10 years old enrolled)		0.633**	0.565
		(0.269)	(0.385)
In-house provision * log(Population of 6-10 years old enrolled)			0.113
			(0.490)
Constant	11.729***	9.955***	10.146***
	(0.467)	(0.907)	(1.241)
Observations	101	101	101
R^2	0.354	0.397	0.401
Adjusted R^2	0.327	0.365	0.363
Residual Std. Error	0.943 (df = 96)	0.900 (df = 95)	0.890 (df = 94)
F Statistic	7.2838*** (df = 4; 96)	6.9587*** (df = 5; 95)	5.7592*** (df = 6; 94)
Note:			*p<0.1; **p<0.05; ***p<0.01

Annex 1. 18: Mean GHG value per school meal (gCO2e) and its determinants (including organic labels rather than certified, OLS regression)

	Dependent variable:		
	Average emissions of canteen menus (gco2e)		
	(1)	(2)	(3)
In-house provision	63.356	873.032**	218.169**
	(51.447)	(375.002)	(90.860)
Frequency of organic products	−40.416	−67.190	−122.197
	(223.146)	(219.215)	(223.062)
Proportion of the population with a high diploma	−423.284**	−436.614**	−440.444**
	(191.305)	(187.739)	(188.340)
Proportion of the left-wing voters during the first round	−159.971	−177.068	59.963
	(113.605)	(111.704)	(154.851)
log(Population of 6-10 years old enrolled)	−52.958	84.870	−54.351
	(63.709)	(88.915)	(62.663)
In-house provision * log(Population of 6-10 years old enrolled)		−246.649**	
		(113.197)	
In-house provision * Proportion of the left-wing voters during the first round			−413.364**
			(201.502)
Constant	2,274.376***	1,851.517***	2,232.601***
	(215.106)	(286.664)	(212.541)
Observations	101	101	101
R^2	0.094	0.138	0.133
Adjusted R^2	0.047	0.083	0.078
Residual Std. Error	233.670 (df = 95)	229.193 (df = 94)	229.821 (df = 94)
F Statistic	1.978* (df = 5; 95)	2.505** (df = 6; 94)	2.405** (df = 6; 94)
Note:			*p<0.1; **p<0.05; ***p<0.01

Annex 2.

Annex 2. 1.

Annex 2. 1: Canteen menu and explanatory variable database

See MenuR.xlsx.

Annex 3.

Annex 3. 1: Classification algorithm

See Algorithm.rar

References

Abery, Elizabeth, and Claire Drummond. 2014. ‘Implementation of Mandatory Nutritional Guidelines in South Australian Primary School Canteens: A Qualitative Study’, 15.

ADEME. 2016. ‘APPROCHE DU COUT COMPLET DES PERTES ET GASPILLAGE ALIMENTAIRE EN RESTAURATION COLLECTIVE’. https://nouvelle-aquitaine.ademe.fr/sites/default/files/cout-complet-pertes-gaspillage-restauration-collectiv.pdf.

Agribalyse 3.0. 2020. ‘LCA database of French food’. 2020. https://agribalyse3.site.ademe.fr.

Aleksandrowicz, Lukasz, Rosemary Green, Edward J. M. Joy, Pete Smith, and Andy Haines. 2016. ‘The Impacts of Dietary Change on Greenhouse Gas Emissions, Land Use, Water Use, and Health: A Systematic Review’. Edited by Andrea S. Wiley. *PLOS ONE* 11 (11): e0165797. https://doi.org/10.1371/journal.pone.0165797.

Aminrad, Z., Sharifah Zarina Bint Zakaria, and A. Hadi. 2011. ‘Influence of Age and Level of Education on Environmental Awareness and Attitude: Case Study on Iranian Students in Malaysian Universities’. https://doi.org/10.3923/SSCIENCE.2011.15.19.

Andersson, Fredrik, Henrik Jordahl, and Jens Josephson. 2019. ‘Outsourcing Public Services: Contractibility, Cost, and Quality’. *CESifo Economic Studies* 65 (4): 349–72. https://doi.org/10.1093/cesifo/ifz009.

Ansem, Wilke JC van, Carola TM Schrijvers, Gerda Rodenburg, Albertine J Schuit, and Dike van de Mheen. 2013. ‘School Food Policy at Dutch Primary Schools: Room for Improvement? Cross-Sectional Findings from the INPACT Study’. *BMC Public Health* 13 (1): 339. https://doi.org/10.1186/1471-2458-13-339.

Ardzejewska, K, R Tadros, and D Baxter. 2013. ‘A Descriptive Study on the Barriers and Facilitators to Implementation of the NSW (Australia) Healthy School Canteen Strategy’. *Health Education Journal* 72 (2): 136–45. https://doi.org/10.1177/0017896912437288.

Batlle-Bayer, Laura, Alba Bala, Rubén Aldaco, Berta Vidal-Monés, Rosa Colomé, and Pere Fullana-i-Palmer. 2021. ‘An Explorative Assessment of Environmental and Nutritional Benefits of Introducing Low-Carbon Meals to Barcelona Schools’. *Science of The Total Environment* 756 (February): 143879. https://doi.org/10.1016/j.scitotenv.2020.143879.

Behrens, Paul, Jessica C. Kiefte-de Jong, Thijs Bosker, João F. D. Rodrigues, Arjan de Koning, and Arnold Tukker. 2017. ‘Evaluating the Environmental Impacts of Dietary Recommendations’. *Proceedings of the National Academy of Sciences* 114 (51): 13412–17. https://doi.org/10.1073/pnas.1711889114.

Bell, A C, and B A Swinburn. 2004. ‘What Are the Key Food Groups to Target for Preventing Obesity and Improving Nutrition in Schools?’ *European Journal of Clinical Nutrition* 58 (2): 258–63. https://doi.org/10.1038/sj.ejcn.1601775.

Bellassen, Valentin, Marion Drut, Federico Antonioli, Ružica Brečić, Michele Donati, Hugo Ferrer-Pérez, Lisa Gauvrit, et al. 2021. ‘The Carbon and Land Footprint of Certified Food Products’. *Journal of Agricultural & Food Industrial Organization*, February. https://doi.org/10.1515/jafio-2019-0037.

Benvenuti, Luca, Alberto De Santis, Fabio Santesarti, and Luigino Tocca. 2016. ‘An Optimal Plan for Food Consumption with Minimal Environmental Impact: The Case of School Lunch Menus’. *Journal of Cleaner Production* 129 (August): 704–13. https://doi.org/10.1016/j.jclepro.2016.03.051.

Billich, Natassja, Marijke Adderley, Laura Ford, Isabel Keeton, Claire Palermo, Anna Peeters, Julie Woods, and Kathryn Backholer. 2019. ‘The Relative Price of Healthy and Less Healthy Foods Available in Australian School Canteens’. *Health Promotion International* 34 (4): 677–86. https://doi.org/10.1093/heapro/day025.

Birch, Leann Lipps, and Kirsten Krahnstoever Davison. 2001. ‘FAMILY ENVIRONMENTAL FACTORS INFLUENCING THE DEVELOPING BEHAVIORAL CONTROLS OF FOOD INTAKE AND CHILDHOOD OVERWEIGHT’. *Pediatric Clinics of North America* 48 (4): 893–907. https://doi.org/10.1016/S0031-3955(05)70347-3.

Boyano, A, N Espinosa, R Rodriguez Quintero, B Neto, M Gama Caldas, and O Wolf. 2019. ‘EU GPP Criteria for Food Procurement, Catering Services and Vending Machines.’ Website. Publications Office of the European Union. 4 November 2019. http://op.europa.eu/en/publication-detail/-/publication/f8e9fe10-ff7d-11e9-8c1f-01aa75ed71a1/language-en.

Brammer, Stephen, and Helen Walker. 2011. ‘Sustainable Procurement in the Public Sector: An International Comparative Study’. *International Journal of Operations & Production Management* 31 (4): 452–76. https://doi.org/10.1108/01443571111119551.

Brennan, M, A Tregear, M Sayed, R Brečić, I Colić Barić, A Lučić, M Bituh, et al. 2019. 'Evaluation of the Nutritional Impact of Different Models of PSFP in a School Context'. *STRENGTH2FOOD*. https://www.strength2food.eu/2019/02/28/evaluation-of-the-nutritional-impact-of-different-models-of-psfp-in-a-school-context/.

Canteen managers. 2020. '6 Interviews with Canteen Managers or Nutritionists (Personal Communication)'.

Cerutti, Alessandro K., Fulvio Ardente, Simone Contu, Dario Donno, and Gabriele L. Beccaro. 2018. 'Modelling, Assessing, and Ranking Public Procurement Options for a Climate-Friendly Catering Service'. *The International Journal of Life Cycle Assessment* 23 (1): 95–115. https://doi.org/10.1007/s11367-017-1306-y.

Cerutti, Alessandro K., Simone Contu, Fulvio Ardente, Dario Donno, and Gabriele L. Beccaro. 2016. 'Carbon Footprint in Green Public Procurement: Policy Evaluation from a Case Study in the Food Sector'. *Food Policy* 58 (January): 82–93. https://doi.org/10.1016/j.foodpol.2015.12.001.

Chan, Doris S. M., Rosa Lau, Dagfinn Aune, Rui Vieira, Darren C. Greenwood, Ellen Kampman, and Teresa Norat. 2011. 'Red and Processed Meat and Colorectal Cancer Incidence: Meta-Analysis of Prospective Studies'. Edited by Daniel Tomé. *PLoS ONE* 6 (6): e20456. https://doi.org/10.1371/journal.pone.0020456.

Cho, Hyunyi, and Michelle Zbell Nadow. 2004. 'Understanding Barriers to Implementing Quality Lunch and Nutrition Education'. *Journal of Community Health* 29 (5): 421–35. https://doi.org/10.1023/B:JOHE.0000038656.32950.45.

Chong, Eshien, Freddy Huet, Stéphane Saussier, and Faye Steiner. 2006. 'Public-Private Partnerships and Prices: Evidence from Water Distribution in France'. *Review of Industrial Organization* 29 (1–2): 149–69. https://doi.org/10.1007/s11151-006-9106-8.

Clelland, Tracy, Penni Cushman, and Jacinta Hawkins. 2013. 'Challenges of Parental Involvement Within a Health Promoting School Framework in New Zealand'. *Education Research International* 2013: 1–8. https://doi.org/10.1155/2013/131636.

Cohen, Juliana F. W., Liesbeth A. Smit, Ellen Parker, S. Bryn Austin, A. Lindsay Frazier, Christina D. Economos, and Eric B. Rimm. 2012. 'Long-Term Impact of a Chef on School Lunch Consumption: Findings from a 2-Year Pilot Study in Boston Middle Schools'. *Journal of the Academy of Nutrition and Dietetics* 112 (6): 927–33. https://doi.org/10.1016/j.jand.2012.01.015.

Cour des comptes. 2020. 'Les Services Communaux de La Restauration Collective de Nouvelles Attentes'. https://www.ccomptes.fr/system/files/2020-02/20200225-07-TomeI-services-communaux-restauration-collective.pdf.

De Laurentiis, Valeria, Dexter V. L. Hunt, and Christopher D. F. Rogers. 2017. 'Contribution of School Meals to Climate Change and Water Use in England'. *Energy Procedia*, Proceedings of 1st International Conference onSustainable Energy and Resource Use in Food ChainsincludingSymposium on Heat Recovery and Efficient Conversion and Utilisation of Waste HeatICSEF 2017, 19-20 April 2017, Windsor UK, 123 (September): 204–11. https://doi.org/10.1016/j.egypro.2017.07.241.

Decataldo, Alessandra, and Brunella Fiore. 2018. 'Is Eating in the School Canteen Better to Fight Overweight? A Sociological Observational Study on Nutrition in Italian Children'. *Children and Youth Services Review* 94 (November): 246–56. https://doi.org/10.1016/j.childyouth.2018.10.002.

Décret N° 2011-1227 Du 30 Septembre 2011 Relatif à La Qualité Nutritionnelle Des Repas Servis Dans Le Cadre de La Restauration Scolaire. 2011. *2011-1227*. https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000024614716.

Dědina, D, P Šánová, and A Kadeřávková. 2014. 'Parents´ Attitudes to Introduction of Organic Food in School Catering', 11.

Dooren, C. van, Mari Marinussen, Hans Blonk, Harry Aiking, and Pier Vellinga. 2014. ‘Exploring Dietary Guidelines Based on Ecological and Nutritional Values: A Comparison of Six Dietary Patterns’. *Food Policy* 44 (February): 36–46. https://doi.org/10.1016/j.foodpol.2013.11.002.

Doro, Erica, and Vincent Réquillart. 2020. ‘Review of Sustainable Diets: Are Nutritional Objectives and Low-Carbon-Emission Objectives Compatible?’ *Review of Agricultural, Food and Environmental Studies* 101 (1): 117–46. https://doi.org/10.1007/s41130-020-00110-2.

Downs, Shauna M., Anna Farmer, Maira Quintanilha, Tanya R. Berry, Diana R. Mager, Noreen D. Willows, and Linda J. McCargar. 2012. ‘From Paper to Practice: Barriers to Adopting Nutrition Guidelines in Schools’. *Journal of Nutrition Education and Behavior* 44 (2): 114–22. https://doi.org/10.1016/j.jneb.2011.04.005.

Dupont, Diane P., and Ian J. Bateman. 2012. ‘Political Affiliation and Willingness to Pay: An Examination of the Nature of Benefits and Means of Provision’. *Ecological Economics* 75 (March): 43–51. https://doi.org/10.1016/j.ecolecon.2012.01.012.

Eco2 Initiative. 2020. ‘LES CANTINES SCOLAIRES PASSENT AU BAS CARBONE (Webinaire)’. In .

Engel, Eduardo, Ronald Fischer, and Alexander Galetovic. 1997. ‘Highway Franchising: Pitfalls and Opportunities’. *The American Economic Review* 87 (2): 68–72.

European Commission. 2014. ‘1 EU Action Plan on Childhood Obesity 2014-2020’. https://ec.europa.eu/health/sites/health/files/nutrition_physical_activity/docs/childhoodobesity_actionplan_2014_2020_en.pdf.

———. 2016. *Buying Green! - A Handbook on Green Public Procurement*. https://ec.europa.eu/environment/gpp/buying_handbook_en.htm.

———. 2017. ‘Study on the Implementation of the EU Action Plan on Childhood Obesity 2014-2020’. https://www.eu2017.mt/Documents/Reports/mid-term%20evaluation%20APCO%20report%20Draft.pdf.

Eurostat. 2016. ‘Almost 1 Adult in 6 in the EU Is Considered Obese’. https://ec.europa.eu/eurostat/fr/web/products-press-releases/-/3-20102016-BP.

Eustachio Colombo, Patricia, Emma Patterson, Liselotte Schäfer Elinder, Anna Karin Lindroos, Ulf Sonesson, Nicole Darmon, and Alexandr Parlesak. 2019. ‘Optimizing School Food Supply: Integrating Environmental, Health, Economic, and Cultural Dimensions of Diet Sustainability with Linear Programming’. *International Journal of Environmental Research and Public Health* 16 (17). https://doi.org/10.3390/ijerph16173019.

Filippini, Rosalia, Ivan De Noni, Stefano Corsi, Roberto Spigarolo, and Stefano Bocchi. 2018. ‘Sustainable School Food Procurement: What Factors Do Affect the Introduction and the Increase of Organic Food?’ *Food Policy* 76 (April): 109–19. https://doi.org/10.1016/j.foodpol.2018.03.011.

Fusi, Alessandra, Riccardo Guidetti, and Adisa Azapagic. 2016. ‘Evaluation of Environmental Impacts in the Catering Sector: The Case of Pasta’. *Journal of Cleaner Production*, Absolute Reductions in Material Throughput, Energy Use and Emissions, 132 (September): 146–60. https://doi.org/10.1016/j.jclepro.2015.07.074.

Galli, Francesca, Gianluca Brunori, Francesco Di Iacovo, and Silvia Innocenti. 2014. ‘Co-Producing Sustainability: Involving Parents and Civil Society in the Governance of School Meal Services. A Case Study from Pisa, Italy’, 24.

Girona, Alejandra, Valentina Iragola, Florencia Alcaire, María Rosa Curutchet, Pablo Pereira, Daiana Magnani, Patricia Barreto, et al. 2019. ‘Factors Underlying Compliance with a Healthy Snacking Initiative in the School Environment: Accounts of School Principals in Montevideo (Uruguay)’. *Public Health Nutrition* 22 (4): 726–37. https://doi.org/10.1017/S1368980018003488.

González-García, Sara, Xavier Esteve-Llorens, Rebeca González-García, Luz González, Gumersindo Feijoo, Maria Teresa Moreira, and Rosaura Leis. 2021. ‘Environmental Assessment of Menus for Toddlers Serviced at Nursery Canteen Following the Atlantic Diet Recommendations’. *Science of The Total Environment* 770 (May): 145342. https://doi.org/10.1016/j.scitotenv.2021.145342.

Gossard, Marcia, and Richard York. 2003. ‘Social Structural Influences on Meat Consumption’. *Human Ecology Review* 10 (June).

Guasch, J. Luis, and Stephane Straub. 2009. ‘Corruption and Concession Renegotiations.: Evidence from the Water and Transport Sectors in Latin America’. *Utilities Policy* 17 (2): 185–90.

Haines, Jess, Emma Haycraft, Leslie Lytle, Sophie Nicklaus, Frans J. Kok, Mohamed Merdji, Mauro Fisberg, Luis A. Moreno, Olivier Goulet, and Sheryl O. Hughes. 2019. ‘Nurturing Children’s Healthy Eating: Position Statement’. *Appetite* 137 (June): 124–33. https://doi.org/10.1016/j.appet.2019.02.007.

Hart, K. H., A. Herriot, J. A. Bishop, and H. Truby. 2003. ‘Promoting Healthy Diet and Exercise Patterns amongst Primary School Children: A Qualitative Investigation of Parental Perspectives’. *Journal of Human Nutrition and Dietetics* 16 (2): 89–96.

Hart, Oliver. 2003. ‘Incomplete Contracts and Public Ownership: Remarks, and an Application to Public-Private Partnerships’. *The Economic Journal* 113 (486,): C69–76.

Hart, Oliver, Andrei Shleifer, and Robert Vishny. 1997. ‘The Proper Scope of Government: Theory and an Application to Prisons’. *Quarterly Journal of Economics* 112 (4): 1127–61.

He, Chen, Anne-Kristin Løes, and Bent Mikkelsen. 2010. ‘Organic School Food Policies Are Supportive for Healthier Eating Behaviours -Results from an Observational Study in Danish Schools’. *Medicine*, January.

He, Chen, and Bent E. Mikkelsen. 2014. ‘The Association between Organic School Food Policy and School Food Environment: Results from an Observational Study in Danish Schools’. *Perspectives in Public Health* 134 (2): 110–16. https://doi.org/10.1177/1757913913517976.

Hirsch, Werner Z. 1995. ‘Contracting out by Urban Governments: A Review’. https://journals.sagepub.com/doi/10.1177/107808749503000307.

Institut de la gestion déléguée (IGD). 2019. ‘ATLAS DE LA GESTION DES SERVICES PUBLICS LOCAUX 2019’. https://www.adcf.org/files/NOTES-et-ETUDES/19-IGD-AtlasVD.pdf.

Irz, Xavier, Pascal Leroy, Vincent Réquillart, and Louis-Georges Soler. 2016. ‘Welfare and Sustainability Effects of Dietary Recommendations’. *Ecological Economics* 130 (October): 139–55. https://doi.org/10.1016/j.ecolecon.2016.06.025.

Jaworowska, Agnieszka, Toni Blackham, Ian G. Davies, and Leonard Stevenson. 2013. ‘Nutritional Challenges and Health Implications of Takeaway and Fast Food’. *Nutrition Reviews* 71 (5): 310–18. https://doi.org/10.1111/nure.12031.

Jungbluth, Niels, Regula Keller, and Alex König. 2016. ‘ONE TWO WE—Life Cycle Management in Canteens Together with Suppliers, Customers and Guests’. *The International Journal of Life Cycle Assessment* 21 (5): 646–53. https://doi.org/10.1007/s11367-015-0982-8.

Kesse-Guyot, Emmanuelle, Dan Chaltiel, Juhui Wang, Philippe Pointereau, Brigitte Langevin, Benjamin Allès, Pauline Rebouillat, et al. 2020. ‘Sustainability Analysis of French Dietary Guidelines Using Multiple Criteria’. *Nature Sustainability* 3 (5): 377–85. https://doi.org/10.1038/s41893-020-0495-8.

Lassen, Anne, Lene Christensen, Max Spooner, and Ellen Trolle. 2019. ‘Characteristics of Canteens at Elementary Schools, Upper Secondary Schools and Workplaces That Comply with Food Service Guidelines and Have a Greater Focus on Food Waste’. *International Journal of Environmental Research and Public Health* 16 (7): 1115. https://doi.org/10.3390/ijerph16071115.

Li, Hui, Hank C. Jenkins-Smith, Carol L. Silva, Robert P. Berrens, and Kerry G. Herron. 2009. ‘Public Support for Reducing US Reliance on Fossil Fuels: Investigating Household Willingness-to-Pay for Energy Research and Development’. *Ecological Economics* 68 (3): 731–42. https://doi.org/10.1016/j.ecolecon.2008.06.005.

‘LOI N° 2015-992 Du 17 Août 2015 Relative à La Transition Énergétique Pour La Croissance Verte’. n.d. https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000031044385/.

‘LOI N° 2018-938 Du 30 Octobre 2018 Pour l’équilibre Des Relations Commerciales Dans Le Secteur Agricole et Alimentaire et Une Alimentation Saine, Durable et Accessible à Tous (1) - Légifrance’. n.d. https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000037547946/.

Macdiarmid, Jennie I., Janet Kyle, Graham W. Horgan, Jennifer Loe, Claire Fyfe, Alexandra Johnstone, and Geraldine McNeill. 2012. ‘Sustainable Diets for the Future: Can We Contribute to Reducing Greenhouse Gas Emissions by Eating a Healthy Diet?’ *The American Journal of Clinical Nutrition* 96 (3): 632–39. https://doi.org/10.3945/ajcn.112.038729.

MacLellan, Debbie, Jennifer Taylor, and Catherine Freeze. 2009. ‘Developing School Nutrition Policies: Enabling and Barrier Factors’. *Canadian Journal of Dietetic Practice and Research* 70 (4): 166–71. https://doi.org/10.3148/70.4.2009.166.

Maietta, Ornella, and Maria Teresa Gorgitano. 2016. ‘School Meals and Pupil Satisfaction. Evidence from Italian Primary Schools’. *Food Policy* 62 (July): 41–55. https://doi.org/10.1016/j.foodpol.2016.04.006.

Marshall, Bonnie M, and Stuart B Levy. 2011. ‘Food Animals and Antimicrobials: Impacts on Human Health’. *CLIN. MICROBIOL. REV.* 24: 16.

Martinez, Sara, Maria Del Mar Delgado, Ruben Marin, and Sergio Alvarez. 2020. ‘Carbon Footprint of School Lunch Menus Adhering to the Spanish Dietary Guidelines’. *Carbon Management* 11 (July): 1–13. https://doi.org/10.1080/17583004.2020.1796169.

Meier, Matthias S., Franziska Stoessel, Niels Jungbluth, Ronnie Juraske, Christian Schader, and Matthias Stolze. 2015. ‘Environmental Impacts of Organic and Conventional Agricultural Products--Are the Differences Captured by Life Cycle Assessment?’ *Journal of Environmental Management* 149 (February): 193–208. https://doi.org/10.1016/j.jenvman.2014.10.006.

Ménard, Claude, and Saussier Stéphane. 2003. ‘La Délégation de Service Public, Un Mode Organisationnel Efficace ? Le Cas de La Distribution d’eau En France’. https://journals.openedition.org/economiepublique/360.

Mikkelsen, Be, M Bruselius-Jensen, Js Andersen, and A Lassen. 2006. ‘Are Green Caterers More Likely to Serve Healthy Meals than Non-Green Caterers? Results from a Quantitative Study in Danish Worksite Catering’. *Public Health Nutrition* 9 (7): 846–50. https://doi.org/10.1017/PHN2005913.

Mikkelsen, Bent Egberg, and Janne Sylvest. 2012. ‘Organic Foods on the Public Plate: Technical Challenge or Organizational Change?’ *Journal of Foodservice Business Research* 15 (1): 64–83. https://doi.org/10.1080/15378020.2011.650541.

Moldanová, Jana, Peringe Grennfelt, Åsa Jonsson, David Simpson, Till Spranger, Wenche Aas, John Munthe, and Ari Rabl. 2011. ‘Nitrogen as a Threat to European Air Quality’. In *The European Nitrogen Assessment*, edited by Mark A. Sutton, Clare M. Howard, Jan Willem Erisman, Gilles Billen, Albert Bleeker, Peringe Grennfelt, Hans van Grinsven, and Bruna Grizzetti, 405–33. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511976988.021.

Mondelaers, Koen, Joris Aertsens, and Guido Van Huylenbroeck. 2009. ‘A Meta-analysis of the Differences in Environmental Impacts between Organic and Conventional Farming’. Edited by G. van Huylenbroek. *British Food Journal* 111 (10): 1098–1119. https://doi.org/10.1108/00070700910992925.

Mudie, Samantha, and Maria Vadhati. 2017. ‘Low Energy Catering Strategy: Insights from a Novel Carbon-Energy Calculator’. *Energy Procedia* 123 (September): 212–19. https://doi.org/10.1016/j.egypro.2017.07.244.

Neumayer, Eric. 2004. ‘The Environment, Left-Wing Political Orientation and Ecological Economics’. *Ecological Economics* 51 (3–4): 167–75. https://doi.org/10.1016/j.ecolecon.2004.06.006.

Pan, An, Qi Sun, Adam M Bernstein, Matthias B Schulze, JoAnn E Manson, Meir J Stampfer, Walter C Willett, and Frank B Hu. 2012. ‘Red Meat Consumption and Mortality’. *ARCH INTERN MED* 172 (7): 9.

Pettigrew, S., R. J. Donovan, G. Jalleh, and M. Pescud. 2014. ‘Predictors of Positive Outcomes of a School Food Provision Policy in Australia’. *Health Promotion International* 29 (2): 317–27. https://doi.org/10.1093/heapro/das075.

Poinsot, Romane, Florent Vieux, Christophe Dubois, Marlène Perignon, Caroline Méjean, and Nicole Darmon. 2020. ‘Nutritional Quality of Vegetarian and Non-Vegetarian Dishes at School: Are

Nutrient Profiling Systems Sufficiently Informative?' *Nutrients* 12 (8): 2256. https://doi.org/10.3390/nu12082256.

Powlson, D.s, Tom Addiscott, Nigel Benjamin, Kenneth Cassman, Theo de Kok, Hans Grinsven, Jean-Louis L'Hirondel, Alex Avery, and Chris Kessel. 2008. 'When Does Nitrate Become a Risk for Humans?' *Journal of Environmental Quality* 37 (March): 291–95. https://doi.org/10.2134/jeq2007.0177.

Ribal, Javier, M. Loreto Fenollosa, Purificación García-Segovia, Gabriela Clemente, Neus Escobar, and Neus Sanjuán. 2016. 'Designing Healthy, Climate Friendly and Affordable School Lunches'. *The International Journal of Life Cycle Assessment* 21 (5): 631–45. https://doi.org/10.1007/s11367-015-0905-8.

Rogissart, L, C Foucherot, and V Bellassen. 2019. 'Estimating Greenhouse Gas Emissions from Food Consumption: Methods and Results'. https://www.i4ce.org/download/estimating-greenhouse-gas-emissions-from-food-consumption-methods-and-results/.

Röös, Elin, Cecilia Sundberg, Pernilla Tidåker, Ingrid Strid, and Per-Anders Hansson. 2013. 'Can Carbon Footprint Serve as an Indicator of the Environmental Impact of Meat Production?' *Ecological Indicators* 24 (January): 573–81. https://doi.org/10.1016/j.ecolind.2012.08.004.

Saussier, Stéphane, Carine Staropoli, and Anne Yvrande-Billon. 2009. 'Public–Private Agreements, Institutions, and Competition: When Economic Theory Meets Facts'. *Review of Industrial Organization* 35 (1–2): 1–18. https://doi.org/10.1007/s11151-009-9226-z.

Solomon, Barry D., and Nicholas H. Johnson. 2009. 'Valuing Climate Protection through Willingness to Pay for Biomass Ethanol'. *Ecological Economics* 68 (7): 2137–44. https://doi.org/10.1016/j.ecolecon.2009.02.010.

Takacs, Berill, and Aiduan Borrion. 2020. 'The Use of Life Cycle-Based Approaches in the Food Service Sector to Improve Sustainability: A Systematic Review'. *Sustainability* 12 (9): 3504. https://doi.org/10.3390/su12093504.

Taylor, Peter. 2005. 'Do Public Sector Contract Catering Tender Procedures Result in an Auction for "Lemons"?' *International Journal of Public Sector Management* 18 (6): 484–97. https://doi.org/10.1108/09513550510616724.

Testa, Francesco, Fabio Iraldo, Marco Frey, and Tiberio Daddi. 2012. 'What Factors Influence the Uptake of GPP (Green Public Procurement) Practices? New Evidence from an Italian Survey'. *Ecological Economics* 82 (October): 88–96. https://doi.org/10.1016/j.ecolecon.2012.07.011.

Thorsen, Anne, Anne Lassen, Jens Andersen, and Bent Mikkelsen. 2009. 'Workforce Gender, Company Size and Corporate Financial Support Are Predictors of Availability of Healthy Meals in Danish Worksite Canteens'. *Public Health Nutrition* 12 (June): 2068–73. https://doi.org/10.1017/S1368980009005692.

Thorsen, Anne Vibeke, Anne Dahl Lassen, Jens Strodl Andersen, and Bent Egberg Mikkelsen. 2009. 'Workforce Gender, Company Size and Corporate Financial Support Are Predictors of Availability of Healthy Meals in Danish Worksite Canteens'. *Public Health Nutrition* 12 (11): 2068–73. https://doi.org/10.1017/S1368980009005692.

Tregear, A, M Brennan, R Brečić, I Colić Barić, A Lučić, M Bituh, A Ilić, et al. 2019. 'Evaluation of Environmental, Economic and Social Impacts of Different Models of PSFP in a School Context'. https://www.strength2food.eu/2019/02/27/evaluation-of-environmental-economic-and-social-impacts-of-different-models-of-psfp-in-a-school-context/.

Tukker, Arnold. 2011. 'Environmental Impacts of Changes to Healthier Diets in Europe'. *Ecological Economics*, 13.

Tuomisto, H. L., I. D. Hodge, P. Riordan, and D. W. Macdonald. 2012. 'Does Organic Farming Reduce Environmental Impacts?--A Meta-Analysis of European Research'. *Journal of Environmental Management* 112 (December): 309–20. https://doi.org/10.1016/j.jenvman.2012.08.018.

Vieux, Florent, Christophe Dubois, Christelle Duchêne, and Nicole Darmon. 2018. 'Nutritional Quality of School Meals in France: Impact of Guidelines and the Role of Protein Dishes'. *Nutrients* 10 (2): 205. https://doi.org/10.3390/nu10020205.

Vieux, Florent, Louis-Georges Soler, Djilali Touazi, and Nicole Darmon. 2013. 'High Nutritional Quality Is Not Associated with Low Greenhouse Gas Emissions in Self-Selected Diets of French Adults'. *The American Journal of Clinical Nutrition* 97 (3): 569–83. https://doi.org/10.3945/ajcn.112.035105.

Wagner, Barbara, Benjamin Senauer, and C. Ford Runge. 2007. 'An Empirical Analysis of and Policy Recommendations to Improve the Nutritional Quality of School Meals'. *Review of Agricultural Economics* 29 (4): 672–88.

Westhoek, Henk. 2014. 'Food Choices, Health and Environment: Effects of Cutting Europe's Meat and Dairy Intake'. *Global Environmental Change*, 10.

Wickramasinghe, K K, M Rayner, M Goldacre, N Townsend, and P Scarborough. 2016. 'Contribution of Healthy and Unhealthy Primary School Meals to Greenhouse Gas Emissions in England: Linking Nutritional Data and Greenhouse Gas Emission Data of Diets'. *European Journal of Clinical Nutrition* 70 (10): 1162–67. https://doi.org/10.1038/ejcn.2016.101.

Wickramasinghe, Kremlin, Mike Rayner, Michael Goldacre, Nick Townsend, and Peter Scarborough. 2017. 'Environmental and Nutrition Impact of Achieving New School Food Plan Recommendations in the Primary School Meals Sector in England'. *Open Access*, 9.

Woods, Julie, Alex Bressan, Corrina Langelaan, Angela Mallon, and Claire Palermo. 2014. 'Australian School Canteens: Menu Guideline Adherence or Avoidance?: School Canteen Menu Compliance'. *Health Promotion Journal of Australia* 25 (2): 110–15. https://doi.org/10.1071/HE14009.