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# The motivational roots of sustainable diets: Analysis of food choice motives associated to health, environmental and socio-cultural aspects of diet sustainability in a sample of French adults

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ABSTRACT

Achieving sustainable healthy diets for all will require substantial changes in individuals' food choices. Motivation plays a central role in behaviour change, yet little is known about the relationship between food choice motives and sustainability of the overall diet. The present study explored the relationship between food choice motives and different facets of diet sustainability in order to emphasize individuals' motivational supports and barriers regarding diet sustainability. We analysed food choice motives and dietary data collected through online questionnaires in 938 French adults (79% female, mean age = 39y (SD = 12)). The importance of nine food choice motives was assessed and three overarching motivational dimensions were derived from a principal component analysis on food choice motives: 'health and sustainability, 'ease and accessibility' and 'pleasure'. Food intakes were recorded using a food frequency questionnaire and six indicators of diet sustainability were calculated: nutritional quality, environmental impact, adherence to the EAT-Lancet diet, organic food consumption, local food consumption and ready-to-eat meals consumption. 'Health and sustainability' motives were consistently positively associated with diet sustainability indicators. On the contrary, 'ease and accessibility' motives were consistently negatively associated with diet sustainability. Associations between 'pleasure' motives and diet sustainability were mixed. Based on these results, it seems equally important to promote individuals' awareness of health and environmental impacts of food as to increase the accessibility of convenient sustainable healthy food products to support individuals' food choices towards sustainable diets.

## 1. Introduction

The EAT-Lancet Commission has outlined targets on achieving healthier and more environmentally friendly diets, providing guidelines on what and how much to eat at an individual level (Willett et al., 2019). The nutritional routes towards sustainable diets in Western countries are thus well-known: lowering amounts of animal-based foods, diversifying plant-based foods, avoiding unhealthy and highly processed foods that contain high levels of saturated fat and added sugars. However, the psychological routes to achieve these goals, i.e. what would it take for individuals to shift from their current diet to this alternative diet, remain to be investigated (Editorial, 2019; Nielsen et al., 2020). Part of the answer may reside in examining food choice motives that drive or impede diet sustainability. In the present study, we investigated the relationship between a wide range of food choice motives and sustainability of the overall diet including the health, environmental and sociocultural aspects (FAO and WHO, 2019).

Motivation is a central component of most theories of behaviours (Davis et al., 2015; Michie et al., 2011). From a constructionist perspective, motivation to perform a behaviour results from one's personal food values that are shaped by life course events, personal and social factors (Furst et al., 1996; Sobal and Bisogni, 2009). Food decisions are then computed by integrating a set of attributes based on the importance or salience of the corresponding value for an individual at the point of choice (Rangel, 2013). For instance, the nutritional quality may affect food decisions to a large extent in individuals who value health, and greenhouse gas emissions (GHGEs) associated with a food product may influence food decisions to a large extent in individuals who value

*Abbreviations:* GHGEs, Greenhouse gas emissions.

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environmental protection. The measure of food choice motives characterises the importance of different values for an individual in a context of food decision making (Steptoe et al., 1995). Previous studies identified taste, cost, nutrition and convenience as the most important food choice motives, although with a large interindividual variability (Glanz et al., 1998; Roininen et al., 1999; Steptoe et al., 1995). More recently, a growing interest in ethics and sustainability as food choice motives has been observed (Guiné et al., 2020; Lindeman and Väänänen, 2000; Sautron et al., 2015; Verain et al., 2021).

Little is known about the relationship between food choice motives and sustainability of the overall diet. To date, studies that have investigated the relationship between food choice motives and dietary consumption either reported a range of motives and their association with specific food consumption, e.g. fruit and vegetables (Brown et al., 2009; Konttinen et al., 2013), traditional foods (Pieniak et al., 2009), organic foods (Baudry et al., 2017; Kesse-Guyot et al., 2013), or reported overall diet sustainability indicators but linked with specific motives, e.g. association between nutritional quality and attitudes towards organic, local and sustainable foods (Pelletier et al., 2013) or attitudes towards healthy eating (Lê et al., 2013). One recent study investigated associations between a broad range of food choice motives and dietary patterns, but without reporting specific indicators of diet sustainability (Allès et al., 2017). Diet sustainability implies both a tight balance in what and how much is consumed and trade-offs between several food choice motives (Tobler et al., 2011; Verain et al., 2015). Yet, there is a gap in knowledge regarding how a broad range of food choice motives are related to the overall diet analysed through different dimensions of sustainability which would emphasize individuals' motivational supports and barriers concerning all the aspects of diet sustainability separately.

This study aims at analysing whether food choice motives are related to the different aspects of the diet sustainability, characterized as broadly as possible. The underlying hypotheses is that food choice motives are at the root of dietary behaviour and likely to be significantly linked with sustainability indicators; but that such associations could be specific to the considered sustainability indicator. To the best of our knowledge, this is the first study that investigated how a broad range of food choice motives related to the sustainability of the overall diet described through a set of six indicators covering the health, environmental and sociocultural aspects of sustainability: nutritional quality, adherence to the EAT-Lancet diet, GHGEs, organic food consumption, local food consumption and ready-to-eat meals consumption (see Seconda et al., 2019 for a review of indicators of diet sustainability).

## 2. Material and methods

### 2.1. Data collection

Analyses reported in this paper consist in secondary use of data collected as part of a cross-sectional, pre-registered online survey (https://osf.io/gwfdb/). The primary study aimed to investigate food choice motives and food consumption before and during the first COVID-19 lockdown in France (Marty et al., 2021). In the present study, we specifically used data on food choice motives and food consumption during the month before the first lockdown that were retrospectively recorded during the first lockdown, on April, 30th and May 1st, 2020.

Participants were recruited by emailing individuals from a population registered in the Chemosens Platform's PanelSens database at Centre des Sciences du Goût et de l'Alimentation (Dijon, France). This database was declared to the relevant authority (Commission Nationale Informatique et Libertés; CNIL; n°1148039). Eligible participants were aged over 18, had been residing in France at least since February 17th, 2020 (i.e., one month before the first lockdown) and had access to a computer or tablet with an internet connection. When the study was launched, it was aimed to include 1000 participants. Eligible participants who completed the study received compensation in return for their participation (15€ Amazon voucher). The study was approved by the ethical evaluation committee for research of INSERM (reference: n°20–683, delivered on April 27th, 2020). All participants were informed that the purpose of the study was to investigate food choices before and during the first lockdown and provided consent for their participation. Three attention check questions (e.g., 'How many times have you visited the planet Mars?') were included in various parts of the questionnaire.

### 2.2. Dietary data

Participants were asked to report food consumption during the previous month using a validated food frequency questionnaire including 110 foods, 12 non-alcoholic drinks and 4 alcoholic drinks with frequency assessed by a 6-item scale from "Never" to "Several times a day" (Kadawathagedara et al., 2017). Usual portion sizes were estimated with photos for different food types on a 5-level scale, derived from the SU.VI.MAX portion book (Hercberg et al., 2002) or using average portion size (Kadawathagedara et al., 2017). The consumption frequency of each item was transformed into daily frequency, and daily intake was calculated by multiplying the daily frequency by the estimated portion size. Individual nutrient intakes were calculated by multiplying the daily intake of each food item by its nutritional values from the SU.VI.MAX nutrient composition database (Hercberg, 2006).

Participants also answered questions about their consumption frequency of organic and local food products for 12 food categories on a 3-point scale: 2 = "Most of the time", 1 = "Occasionally" and 0 = "Never". The 12 categories were: fruit, vegetables, dairy products, meat and fish, eggs, grains, bread, oil, ready-to-eat meals, biscuits, tea and coffee, wine and beers. Organic and local food consumption questions were adapted from a previously published questionnaire that assessed organic food consumption and included 18 food or non-food products categories (Baudry et al., 2015); we excluded the six categories that were not part of the food frequency questionnaire.

### 2.3. Indicators of diet sustainability

#### 2.3.1. Indicators selection

According to FAO and WHO definition, sustainable diets "are dietary patterns that promote all dimensions of individuals' health and well-being; have low environmental pressure and impact; are accessible, affordable, safe and equitable; and are culturally acceptable" (FAO and WHO, 2019). This definition encompasses three different aspects of diets: their impact on health, on the environment and their sociocultural role. These aspects rely on broadly different concepts which poses methodological challenges regarding how to assess diet sustainability as a whole. Several attempts have been made to develop an index that reflects diet sustainability at the individual level but they often considered only a small number of indicators and focused on GHGEs and nutritional quality thus not covering all the aspects of the definition (Jones et al., 2016). Seconda et al. (2019) described a multicriteria approach to assess individuals' diet sustainability. Based on the available scientific literature in September 2017, the authors provided a list of indicators recommended in previous studies that covered at least one of the diet sustainability definition aspects and could be computed at an individual level (Seconda et al., 2019). Based on this list and on data that were available for the studied population, we selected two indicators for each diet sustainability aspect: nutritional quality and adherence to the EAT-Lancet diet for the health aspect, GHGEs and organic food consumption for the environmental aspect, local food consumption and ready-to-eat meals consumption for the sociocultural aspect.

#### 2.3.2. Nutritional quality

The nutritional quality is linked to the health aspect of a sustainable diet (FAO and WHO, 2019). Adherence to the French dietary guidelines was evaluated using the simplified PNNS-GS2 (sPNNS-GS2, Chaltiel et al., 2019). The sPNNS-GS2 builds on the distinction between malus components (less healthy food groups which consumption should be

limited, carrying a negative score, i.e., red meat, processed meat, sugary foods, sweet-tasting beverages, alcoholic beverages, salt) and bonus components (healthier food groups carrying a positive score, i.e., fruits and vegetables, nuts, legumes, whole-grain food, milk and dairy products, fish and seafood) reflecting established knowledge on the relationship between food groups consumption and non-communicable disease risk factors. sPNNS-GS2 was computed for each participant with slight modifications to the calculation compared to the initial definition (range: -17 to 11.5). See Marty et al., 2021 for a detailed description of the calculation.

#### 2.3.3. Adherence to the EAT-Lancet diet

Adherence to the EAT-Lancet diet (i.e., a "healthy diet from sustainable food system") as defined by Willett et al., (2019) pertains both to health and environmental aspects of a sustainable diet (FAO and WHO, 2019). It was characterised by calculating the EAT-Lancet diet index (ELD-I) developed by Kesse-Guyot et al. (2021). This score measures how close a diet is to the EAT-Lancet reference for 14 food groups: grains, potatoes and tubers, vegetables, fruit, dairy foods, beef, lamb and pork, chicken and other poultry, eggs, fish, legumes, nuts, saturated oil, unsaturated oils and sweeteners. For sweeteners component, intake of added sugars was used. For saturated and unsaturated oil components, intakes of saturated and unsaturated fatty acids were used, which differed from Kesse-Guyot et al., (2021). Cut-offs for each component are presented in supplementary materials, Supplementary Table S1. All the items of the food frequency questionnaire were associated with one of the EAT-Lancet food groups, except ready-to-eat meals that could not be assigned to a unique food group and sweets, biscuits and pastries that are not part of the EAT-Lancet diet. The ELD-I calculation is energy-adjusted (reference for energy: 2500 kcal). It allocates positive points if the consumption of food groups to promote is above the reference, and if the consumption of food groups to limit is below the reference. Conversely, it allocates negative points if the consumption of food groups to promote is below the reference, and if the consumption of food groups to limit is above the reference. The score of a diet that meets the reference is zero.

#### 2.3.4. Greenhouse gas emissions (GHGEs)

GHGEs in kg $CO_2$eq/kg is one way of qualifying the environmental impact of diet (FAO and WHO, 2019). GHGEs are the primary driver of climate change and to date, the most reliable environmental indicator available in food databases (ADEME, 2020; Vermeulen et al., 2012). Hence, it is often used to measure the environmental impact of diets (Broekema et al., 2020; Mertens et al., 2019; Willits-Smith et al., 2020). GHGEs were derived from the French food environmental impact database Agribalyse 3.0 drawn up by the French Agency for Ecological Transition that includes GHGEs values for 2480 food items (ADEME, 2020), based on Life Cycle Analyses of food products. The items of the food frequency questionnaire were associated to all the corresponding food items from Agribalyse 3.0. GHGEs of each item of the food frequency questionnaire were calculated as the average GHGEs of individual foods from Agribalyse 3.0 associated to each item. GHGEs of participants' daily diets were calculated by multiplying the daily intake of each food item by its associated GHGEs per kg.

#### 2.3.5. Organic and local food consumption

Organic and local food consumption address both environmental and sociocultural aspects of a sustainable diet (FAO and WHO, 2019). An organic food consumption score (organic score) and a local food consumption score (local score) were calculated as the mean from the participants' responses across the 12 food categories (Cronbach's alphas: 0.95 for organic score, 0.86 for local score).

#### 2.3.6. Ready-to-eat meals consumption

By reducing cooking time and standardising recipes, ready-to-eat meals consumption minimises the transmission of culinary practices and local food cultures that are parts of the sociocultural aspects of a sustainable diet (FAO and WHO, 2019). The frequency per week of ready-to-eat meals consumption was derived from the following 13 items of the food frequency questionnaire: pastries, quiches, sandwiches, pizzas, baked pasta, burgers, *cassoulet*, couscous, paella, *choucroute*, chili con carne, fish-based dishes, low-fat dishes which all are mixed dished commonly sold as ready-to-eat meals at French supermarkets. Ready-meals in italic are untranslated names of typical French mixed dishes.

### 2.4. Food choice motives

Food choice motives were assessed using a French version of the Food Choice Questionnaire developed in English by Steptoe et al. (1995) and adapted and validated in French by Cottet et al. (2017). The French version included 24 items and nine subscales: health (3 items, Cronbach's α: 0.91), convenience (3 items, Cronbach's α: 0.89), sensory appeal (3 items, Cronbach's α: 0.67), natural content (3 items, Cronbach's α: 0.86), ethical concern (2 items, Cronbach's α: 0.66), weight control (3 items, Cronbach's α: 0.81), mood (3 items, Cronbach's α: 0.65), familiarity (2 items, Cronbach's α: 0.64), and price (2 items, Cronbach's α: 0.63). For each subscale, a score was computed by averaging ratings for individual items. The scores ranged from 1 to 4: 1 = Not at all important; 2 = A little important; 3 = Moderately important; 4 = Very important.

### 2.5. Sociodemographic characteristics

Participants were asked for their age, gender, employment status, highest educational qualification, living area, dietary restriction (e.g., dairy-free, vegan), weight and height at the time of completion of the online survey. Self-reported body mass index (BMI) was calculated in kg/$m^2$.

### 2.6. Statistical analyses

Only participants who completed the study were included in the analyses. Participants who failed at least one attention check were excluded. We analysed data from participants who reported plausible energy intake, i.e. $\geq$ 500 kcal/day and $\leq$3500 kcal/day for women, and $\geq$800 kcal/day and $\leq$4000 kcal/day for men (Banna et al., 2017; Willett, 2013). Participants with missing values were only excluded from analyses using the variable where a value was missing.

Principal component analysis (PCA) was performed on the nine subscales scores of the Food Choice Questionnaire to assess the possibility to define overarching motivational dimensions in order to increase the interpretability of the associations between food choice motives and diet sustainability indicators. The dimensions identified by PCA are new independent variables resulting from linear combinations of original food choice motives that maximise variance. Three principal components representing three independent motivational dimensions were identified according to their interpretability and percentage of variance explained. Food choice motives with standardized regression coefficients >0.4 in absolute value were considered to contribute significantly to the motivational dimension. All participants have a score on each motivational dimension which can be interpreted as the importance of the motivational dimension for the participant.

For descriptive purposes, associations across diet sustainability indicators were investigated using Pearson's correlations. These correlations were adjusted for energy intake as GHGEs are primarily correlated to the amount of food consumed (e.g., Masset et al., 2014). Pearson's correlation coefficients of the six indicators of diet sustainability with total energy intake can be found in supplementary materials, Supplementary Table S2.

The association between food choice motives and the six indicators of diet sustainability was assessed by running six linear regressions with each indicator of diet sustainability as dependant variable. In each model, the three factors from the principal component analysis

corresponding to the three motivational dimensions were considered simultaneously as independent variables. We chose to test the three motivational dimensions simultaneously in the models because they coexist in the food decision process and likely interplay with each other at the point of choice. In order to control for confounding effects of gender, age, education, BMI and total energy intake, these variables were also included in each model. As sensitivity analyses, we also ran linear regressions considering simultaneously the nine subscales scores from the Food Choice Questionnaire instead of the three PCA patterns.

To further explore the relationships between adherence to the EAT-Lancet diet and motivational dimensions, we derived consumption in g/2500 kcal for each food group of the EAT-Lancet reference from the food frequency questionnaire and linear regressions were run to test the association between the consumption of each food group and motivational dimensions. Models were adjusted for gender, age, education, BMI and total energy intake.

The substantial variability in food choice motives and nutritional quality observed in a previous study based on the same dataset (Marty et al., 2021) confirmed the relevance of investigating the relationship between food choice motives and indicators of diet sustainability based on the present sample of individuals (n = 938). All statistical analyses were performed using SAS version 9.4 (SAS Institute, Inc. 2013 SAS® 9.4. Cary, NC). The level of significance was set at $p < 0.05$ unless otherwise specified.

## 3. Results

### 3.1. Participants' characteristics

A total of 1353 participants consented to participate. Participants who were not eligible (n = 110), did not complete the study (n = 121), failed at least one attention check (n = 84) or reported implausible energy intake (n = 100) were excluded and data from 938 participants were analysed. Participants' characteristics are presented in Table 1.

### 3.2. Description of diet sustainability

The average total energy intake was 1700 kcal/day (SD 596). A graphical description of diet sustainability indicators is presented in Fig. 1. The nutrition quality of the sample diets evaluated with sPNNS-GS2 was 1.2 (SD 2.5) and the environmental impact estimated by GHGEs was 4.8 kg $CO_2$eq/day (SD 2.1). The mean of the ELD-I was -16.0 (SD 37.1). The organic and local scores were 0.64 (SD 0.49) and 0.59 (SD 0.43), respectively and participants consumed ready-to-eat meals 2.29 (SD 1.79) times a week accounting for 6.0% (SD 4.5) of total energy intake on average.

**Table 1**
Participants' characteristics, n = 938.

| | |
|---|---|
| Age, *years*, mean (SD) [range] | 39 (12) [18–65] |
| **Gender,** *female*, n (%) | 736 (78.5) |
| **Employment status,** n (%) | |
| *Full or part-time* | 726 (77.4) |
| *Student* | 66 (7.1) |
| *Retired* | 48 (5.1) |
| *Looking for a job* | 65 (6.9) |
| *Looking after home* | 12 (1.3) |
| *Other* | 21 (2.2) |
| **Highest educational qualification,** n (%) | |
| *< High-school + 2 years diploma* | 227 (24.2) |
| *High-school + 2 years diploma* | 197 (21.0) |
| *High-school + 3 or + 4 years diploma* | 230 (24.5) |
| *≥ High-school + 5 years diploma* | 284 (30.3) |
| **Living area, n (%)** | |
| *Countryside* | 243 (25.9) |
| *Suburban area* | 213 (22.7) |
| *City centre* | 482 (51.4) |
| **Dietary restrictions,** *none*, n (%) | 834 (88.9) |
| **Reported BMI,** kg/m$^2$, mean (SD) [range] | 24.5 (4.88) [14.9–45.3] |
| *Implausible weight or height*[a], n (%) | 10 (1.1) |

[a] Values are considered implausible if weight <30 kg or >250 kg, height <1.45 m or > 3 m (Hardy et al., 2016; Miller, 2003).

Pearson's correlations matrix of the six indicators of diet sustainability adjusted for energy intake is presented in Table 2. Adherence to the EAT-Lancet diet (ELD-I) was positively associated to nutritional quality (sPNNS-GS2) and negatively to environmental impact (GHGEs) consistently with the results a previous study showing that adherence to the EAT-Lancet recommendations led to lower environmental impacts and better nutritional quality (Kesse-Guyot et al., 2021). Nutritional quality and environmental impact were however not significantly associated with one another which highlights a potential conflict in achieving both better nutritional quality and lower environmental impacts for the consumers. However, both organic and local scores were positively associated to nutritional quality (sPNNS-GS2) and adherence to the EAT-Lancet diet (ELD-I). Higher ready meals consumption was associated to poorer nutritional quality (sPNNS-GS2) and higher environmental impact (GHGEs) and a weaker adherence to the EAT-Lancet diet (EDL-I) suggesting that individuals who consumed the highest amounts of ready-to-eat-meals had overall unsustainable dietary patterns.

### 3.3. Description of motivational dimensions

Three motivational dimensions explaining 59% of the total variance in food choice motives were derived from the PCA: the importance of 'health and sustainability' motives, of 'ease and accessibility' motives and of 'pleasure' motives (Table 3). Only mood motives did not contribute significantly to any of the three motivational dimensions.

### 3.4. Relationship between diet sustainability and motivational dimensions

The results of the linear regressions testing the associations between each of the six indicators of diet sustainability: nutritional quality (sPNNS-GS2), environmental impact (GHGEs), adherence to the EAT-Lancet diet (ELD-I), organic food consumption (organic score), local food consumption (local score), weekly frequency of ready-to-eat meals consumption, and the three motivational dimensions are reported in Table 4.

Across the six models, 'health and sustainability' motives were positively associated with four indicators of diet sustainability and at least one per sustainability aspect: nutritional quality and adherence to the EAT-Lancet diet for the health aspect; organic score for the environmental aspect; local score for the sociocultural aspects. It suggests that 'health and sustainability' motives are motivational support to adopt a sustainable diet as they translated in a diet that consistently reflects individuals' drive for sustainable food choices encompassing all the aspects of diet sustainability. On the contrary, 'ease and accessibility' motives were negatively associated with five indicators of sustainability covering all of its aspects. 'Ease and accessibility' motives seem thus to be motivational barriers regarding the adoption of a sustainable diet. Finally, 'Pleasure' motives were negatively related to health aspects but positively with environmental and sociocultural aspects of diet sustainability. This latest result highlights that a single motivation can have contradictory effects on diet sustainability by favouring one aspect to the detriment of another one.

Similar findings were found when considering the nine subscales scores from the Food Choice Questionnaire (Supplementary Table S3): we found an overall positive association between diet sustainability and motives related to health and sustainability and an overall negative association between diet sustainability and motives related to ease and accessibility.

Additional insights on the relationship between adherence to the EAT-Lancet diet and food choice motives are provided in Table 5 that shows consumption by food groups of the EAT-Lancet reference diet and associations with the three motivational dimensions. It is worth noting that only 18% of the participants were in the reference range for beef,

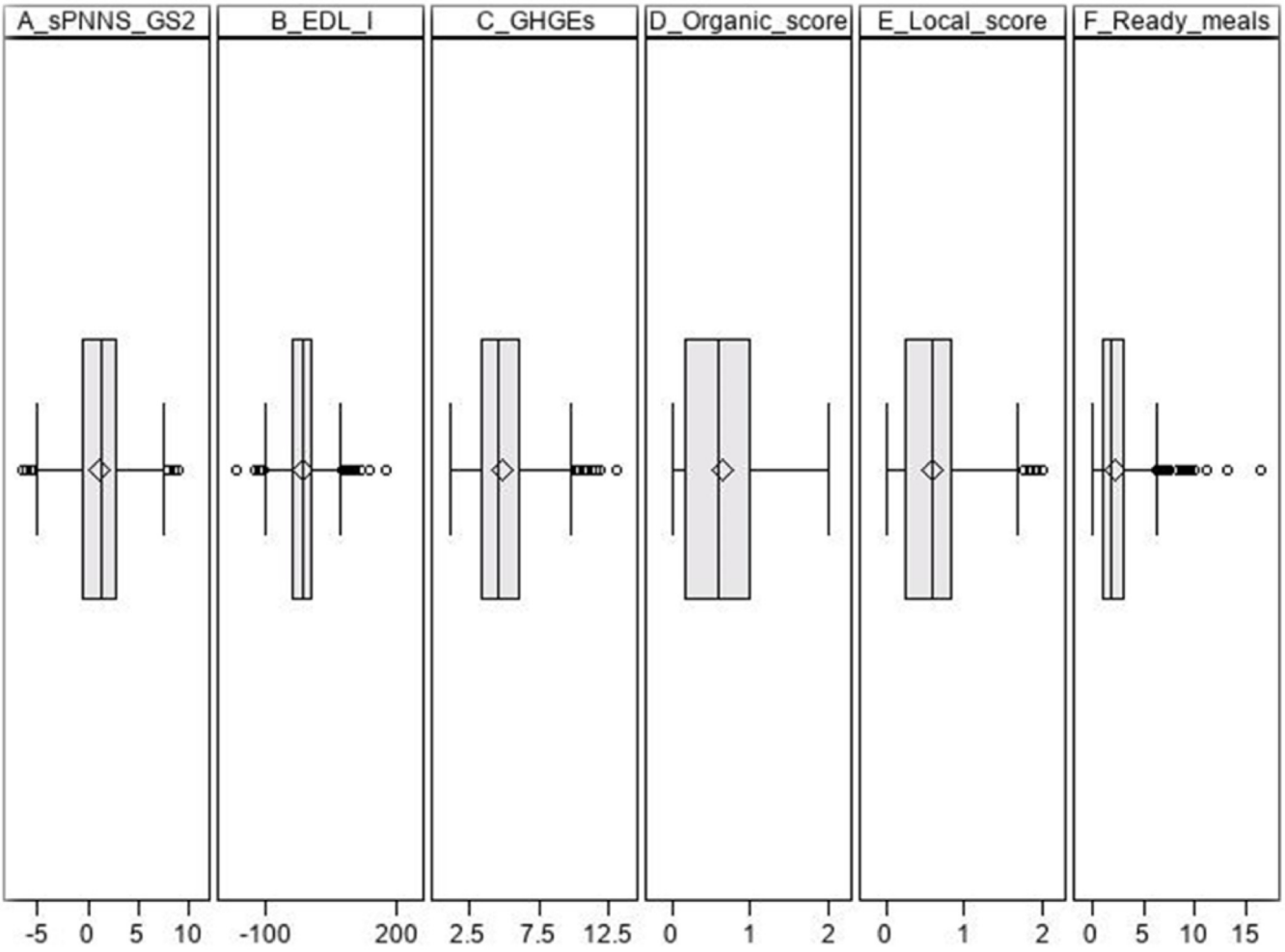


**Fig. 1.** Boxplots for the six diet sustainability indicators (n = 938).
**A**: sPNNS-GS2, adherence to the French dietary recommendations score, from -17 to 11.5. **B**: ELD-I, EAT-Lancet diet index, adherence to the EAT-Lancet diet. **C**: GHGEs, greenhouse gas emissions of the diet in kg $CO_2$eq/day. **D** and **E**: Organic and local scores, consumption frequency of organic and local food products from 0 = "Never" to 2 = "Most of the time". **F**: Ready meals, frequency per week of ready-to-eat meals consumption.

lamb and pork consumption, the others exceeding recommended consumption, and that only 34% and 51% were in the range for fruit and vegetables consumption, respectively. 'Health and sustainability' motives were positively associated with fruit, vegetables, legumes and nuts consumption and negatively with beef, lamb and pork consumption which explains the positive relationship observed between 'health and sustainability' motives and nutritional quality. On the contrary, 'ease and accessibility' motives were negatively associated with fruit, vegetables and legumes consumption and 'pleasure' motives were negatively associated with vegetables consumption which explains their negative associations with nutritional quality.

## 4. Discussion

In this study, we examined the relationships between three independent food choice motivational dimensions ('health and sustainability', 'ease and accessibility', 'pleasure') and indicators of diet sustainability. 'Health and sustainability' motives were consistently positively associated with diet sustainability indicators, in the cases of nutritional quality, adherence to the EAT-Lancet diet and organic and local food consumption. On the contrary, 'ease and accessibility' motives were consistently negatively associated with diet sustainability as we found negative associations with nutritional quality, adherence to the EAT-Lancet diet and organic and local food consumption and a positive association with ready-to-eat meals consumption. Results regarding 'pleasure' motives were mixed, showing a negative association with nutritional quality but also a negative association with environmental impact (i.e., a higher importance of 'pleasure' motives was associated with lower environmental impact) and positive associations with organic and local food consumption.

As in previous studies, we found that higher 'health and sustainability' motives (i.e., health, natural content and ethical concern) were expectedly associated with the higher nutritional quality of the diet (Allès et al., 2017; Konttinen et al., 2013; Pelletier et al., 2013) and with higher consumption of organic food products (Baudry et al., 2017). In a broader perspective we found that 'health and sustainability' motives were positively associated with indicators of health (nutritional quality), environmental (organic food consumption) and sociocultural (local food consumption) impacts of the diet highlighting that in the case of a high motivation for health and sustainability, individuals appear able to act on their motivation through their food choices. Conversely, 'ease and accessibility' motives (i.e., convenience, familiarity and price) were negatively associated with indicators of all aspects of diet sustainability. In line with previous research, we showed that higher 'ease and accessibility' motives were associated with lower nutritional quality (Allès et al., 2017; Konttinen et al., 2013) and lower consumption of organic

**Table 2**
Pearson's correlations matrix of indicators of diet sustainability adjusted for energy intake, n = 938.

| | sPNNS-GS2 | ELD-I | GHGEs | Organic score | Local score |
|---|---|---|---|---|---|
| **GHGEs** | $r$ = -0.03 $p$ = 0.347 | | | | |
| **ELD-I** | $r$ = 0.35 $p$ < 0.001 | $r$ = -0.44 $p$ < 0.001 | | | |
| **Organic score** | $r$ = 0.22 $p$ < 0.001 | $r$ = 0.17 $p$ < 0.001 | $r$ = -0.08 $p$ = 0.020 | | |
| **Local score** | $r$ = 0.16 $p$ < 0.001 | $r$ = 0.10 $p$ = 0.003 | $r$ = -0.01 $p$ = 0.835 | $r$ = 0.46 $p$ < 0.001 | |
| **Ready meals** | $r$ = -0.08 $p$ = 0.012 | $r$ = -0.13 $p$ < 0.001 | $r$ = 0.09 $p$ = 0.009 | $r$ = -0.05 $p$ = 0.132 | $r$ = -0.03 $p$ = 0.354 |

sPNNS-GS2, adherence to the French dietary recommendations score, from -17 to 11.5. ELD-I, EAT-Lancet diet index, adherence to the EAT-Lancet diet. GHGEs, greenhouse gas emissions of the diet in kg $CO_2$eq/day. Organic and local scores, consumption frequency of organic and local food products respectively, from 0 = "Never" to 2 = "Most of the time". Ready meals, frequency per week of ready-to-eat meals consumption.

**Table 3**
Motivational dimensions derived from principal component analysis of nine food choice motives (n = 938).

| Food choice motives[a] | 'Health & Sustainability' | 'Ease & accessibility' | 'Pleasure' |
|---|---|---|---|
| Health | **0.49** | -0.15 | -0.18 |
| Convenience | 0.11 | **0.48** | -0.05 |
| Sensory appeal | 0.28 | 0.18 | **0.69** |
| Natural content | **0.46** | -0.36 | 0.03 |
| Ethical concern | **0.41** | -0.36 | 0.17 |
| Weight control | 0.36 | 0.14 | **-0.52** |
| Mood | 0.34 | 0.26 | 0.01 |
| Familiarity | 0.15 | **0.45** | 0.31 |
| Price | 0.17 | **0.42** | -0.31 |
| **Variance explained (%)** | 29 | 20 | 10 |

[a] Dimensions from the food choice questionnaire (Steptoe et al., 1995; Cottet et al., 2017). Values are standardized regression coefficients. Values in bold (>0.4) indicate food choice motives contributing to the interpretation of the dimension.

foods (Baudry et al., 2017). In addition, we found a positive association between 'ease and accessibility' motives and ready-to-eat meals consumption which is consistent with previous studies showing that individuals' key motives for choosing ready meals are convenient and time-saving (Ahlgren et al., 2005; Costa et al., 2007). It is noteworthy that ready-to-eat meals consumption was also negatively correlated with nutritional quality and positively with the environmental impact of diet. As ready meals contributed only for 6% of total energy intake on average in our sample, these associations may be explained by a range of food choice behaviours associated with ready-to-eat meals consumption that negatively influence nutritional quality and environmental impact of the overall diet.

Neither 'health and sustainability' motives nor 'ease and accessibility' motives were associated with GHGEs. On the one hand, this result suggests a lack of information about GHGEs of food products impeding the process of choosing environmentally friendly food products (Camilleri et al., 2019). On the other hand, it demonstrates that lower 'ease and accessibility' motives do not particularly favour lower GHGEs diets compared to higher 'ease and accessibility' motives. On the contrary, 'pleasure' motives can be in favour of more environmentally friendly diets (less GHGEs, more organic consumption). However, it seems to be a driver of unhealthier food choices and in particular of a lower consumption of vegetables.

**Table 4**
Parameters estimates from the six linear regressions testing the relationship between motivational dimensions and each of the six indicators of diet sustainability, n = 927.

| | | Independent variables: PCA patterns of food choice motives | | |
|---|---|---|---|---|
| | | 'Health & sustainability' | 'Ease & accessibility' | 'Pleasure' |
| Sustainability aspects | Dependant variables | β [95% IC][a] | β [95% IC][a] | β [95% IC][a] |
| Health | **Model 1:** sPNNS-GS2 | **0.36** [0.27; 0.45] | **-0.23** [-0.35; -0.12] | **-0.31** [-0.46; -0.16] |
| | **Model 2:** ELD-I | **4.81** [3.40; 6.23] | **-4.04** [-5.80; -2.28] | -0.70 [-3.04; 1.64] |
| Environment | **Model 3:** GHGEs | -0.01 [-0.06; 0.04] | 0.05 [-0.01; 0.11] | **-0.15** [-0.23; -0.07] |
| | **Model 4:** Organic score | **0.10** [0.08; 0.12] | **-0.14** [-0.16; -0.11] | **0.03** [0.01; 0.06] |
| Sociocultural | **Model 5:** Local score | **0.06** [0.05; 0.08] | **-0.10** [-0.12; -0.08] | **0.03** [0.01; 0.06] |
| | **Model 6:** Ready meals | -0.04 [-0.11; 0.02] | **0.16** [0.08; 0.24] | -0.02 [-0.12; 0.09] |

sPNNS-GS2, adherence to the French dietary recommendations score, from -17 to 11.5. ELD-I, EAT-Lancet diet index, adherence to the EAT-Lancet diet. GHGEs, greenhouse gas emissions of the diet in kg $CO_2$eq/day. Organic and local scores, consumption frequency of organic and local food products respectively, from 0 = "Never" to 2 = "Most of the time". Ready meals, frequency per week of ready-to-eat meals consumption.

[a] Parameters estimates and 95% confidence intervals from linear regressions adjusted for gender (1 missing value/938), age, education, BMI (10 missing values/938) and total energy intake. One model was run for each indicator of diet sustainability. In each model, the three dimensions of food choice motives were considered simultaneously. In bold: parameters significantly different from zero at α = 0.05.

The present study investigated for the first time the motivational roots of adherence to the EAT-Lancet diet. Only 18% of our sample were in the range of recommended intake for beef, lamb and pork that are foods with the worst impacts on health and the environment (Clark et al., 2019) and that contribute the most to European diets GHGEs (Mertens et al., 2019). We observed a significant negative association between 'health and sustainability' motives and beef, lamb and pork consumption but, in this sample, meat consumption was quite high compared to the reference value of the EAT-Lancet diet. This suggests a deficit of information regarding the extent of the environmental impact of meat or highlight barriers to reduce meat consumption that are beyond food choice motives (e.g., habits). In support with these hypotheses, a recent systematic review of 38 articles on consumer perception regarding sustainable protein consumption concluded that consumer awareness of the environmental impact of meat production was low in European countries (Hartmann and Siegrist, 2017); only 35% of European citizens consider eating a sustainable healthy diet involves eating meat less often (European Commission, 2020). Beside the lack of awareness on the environmental impact of meat consumption, resistance to the idea of reducing meat consumption has also been related to people associating eating meat with pleasure, and social, personal and cultural values around eating meat (Macdiarmid et al., 2016). Consistently, meat was recently shown to be central in meal composition in French consumers (Melendrez-Ruiz et al., 2019b).

In our sample, 34% and 51% were in the range of recommended

**Table 5**
Consumption of EAT-Lancet food groups (per 2500 kcal of diet) and parameters estimates from linear regressions testing the relationship between motivational dimensions and food groups consumption, n = 927.

| | | | | Independent variables: PCA patterns of food choice motives[†] | | |
|---|---|---|---|---|---|---|
| | | | | 'Health & Sustainability' | 'Ease & Accessibility' | 'Pleasure' |
| **Dependent variables: Food groups** | **EAT-lancet reference (possible range) *g/2500 kcal** | **% in the possible range** | **Median (IQR) g/ 2500 kcal** | β [IC 99.9%] | β [IC 99.9%] | β [IC 99.9%] |
| Grains | 464[+] (0–60% of energy) | 100 | 197 (131–274) | -0.82 [-9.57; 7.94] | 1.03 [-9.82; 11.88] | 7.42 [-7.06; 21.91] |
| Potatoes and tubers | 50 (0–100) | 61 | 80 (45–132) | 3.88 [-1.02; 8.78] | -2.30 [-8.37; 3.77] | -2.91 [-11.0; 5.20] |
| Vegetables | 300 (200–600) | 51 | 258 (155–434) | **31.5** [14.3; 48.8] | **-27.9** [-49.2; -6.46] | **-34.5** [-63.0; -5.90] |
| Fruit | 200 (100–300) | 34 | 155 (70–291) | **30.0** [16.2; 43.8] | **-23.6** [-40.7; -6.42] | -16.2 [-39.0; 6.74] |
| Dairy foods | 250 (0–500) | 91 | 183 (101–324) | -0.08 [-14.2; 14.0] | 12.2 [-5.30; 29.7] | -2.42 [-25.7; 20.9] |
| Beef, lamb, pork | 14 (0–28) | 18 | 77 (39–122) | **-5.50** [-9.56; -1.44] | 2.49 [-2.53; 7.52] | -3.13 [-9.84; 3.59] |
| Chicken, poultry | 29 (0–58) | 85 | 28 (9–47) | -0.08 [-2.51; 2.35] | 0.91 [-2.10; 3.96] | -1.93 [-5.94; 2.09] |
| Eggs | 13 (0–25) | 41 | 31 (16–53) | 2.57 [-0.94; 6.08] | -0.43 [-4.78; 3.91] | -5.37 [-11.2; 0.44] |
| Fish | 28 (0–100) | 94 | 26 (10–51) | 1.24 [-1.39; 3.88] | -0.66 [-3.92; 2.61] | -3.31 [-7.67; 1.05] |
| Legumes | 50[+] (0–100) | 93 | 12 (6–42) | **5.96** [2.03; 9.90] | **-4.90** [-9.77; -0.02] | -3.75 [-10.3; 2.75] |
| Nuts | 25 (0–75) | 99 | 5 (0–12) | **2.12** [1.08; 3.17] | -0.85 [-2.15; 0.44] | -1.44 [-3.17; 0.28] |

*After Willett et al., 2019. [†]Parameters estimates and 99.9% confidence intervals from linear regressions adjusted for gender (1 missing value/938), age, education, BMI (10 missing values/938) and total energy intake. One model was run for each food group. In each model, the three dimensions of food choice motives were considered simultaneously. In bold: parameters significantly different from zero at α = 0.001 to control for multiple testing. [+]After Knuppel et al., 2019, reference diet refers to dry, raw weight. IQR: values for quartiles 1 and 3. One model was run for each food group and within each model, the three dimensions of food choice motives were considered simultaneously.

intake for fruit and vegetables, respectively. Consumption of fruit and vegetables was strongly associated with food choice motives: positively with 'health and sustainability' motives and negatively with 'ease and accessibility' motives. Despite 20 years of pervasive public health messages to encourage fruit and vegetables consumption in France (Hercberg et al., 2008), we observed that there is still room for improvement which is in line with the results of the latest national food consumption survey (ANSES, 2017). The negative association of fruit, vegetables and legumes consumption with 'ease and accessibility' motives suggests that they may be perceived as expensive and time-consuming to prepare which has also been described in previous studies (e.g., Chapman et al., 2017; McMorrow et al., 2017; Melendrez-Ruiz et al., 2019a; Pinho et al., 2018).

### 4.1. Policy and practical implications

Collectively, the present results regarding the relationship between diet sustainability and food choice motives highlight rooms and promising routes for interventions to drive food choice change towards more sustainable and healthier diets based on individuals' motivational profiles. The positive association between several indicators of diet sustainability and 'health and sustainability' motives suggests that these later should be enhanced at a population level. As proposed by the Institute for Public Policy Research (UK) in a report entitled Building a Food System that works for Everyone, "consistent local and national messaging on what constitutes a healthy sustainable diet" seems necessary to raise global awareness regarding the link between individuals' diets and their health and environmental impacts (P. Coleman et al., 2021). In addition, the gap between 'health and sustainability' motives and GHGEs highlights a deficit in information related to GHGEs of food products. One strategy to address this gap in consumer knowledge would be to develop and display an environmental label across all food categories which may encourage a switch towards more-environmentally friendly food options as suggested in a recent systematic review (Potter et al., 2021).

Besides better informing individuals, our results on the negative association between several indicators of diet sustainability and 'ease and accessibility' motives suggest the need of an additional strategy that would aim at reshaping the food environment to make healthy and sustainable food choices easier. Increasing the availability and convenience of healthy and sustainable food products could help individuals that are more motivated by the ease and accessibility of food products to switch to a healthier and more environmentally-friendly diet at no convenience cost. For instance, it has been shown that increasing the proportion of vegetarian options, lowering their price or reordering menu items increased the choice of vegetarian options at university cafeterias (Garnett et al., 2019, 2020, 2021). These strategies could be encouraged across other catering systems and in particular in public institutions where local and national governments have the greatest influence (Coleman et al., 2021). In addition, innovations from the food industry aiming at creating healthier and more environmentally friendly ready-to-eat meals based on familiar recipes should be encouraged to achieve diet transition for consumers who value convenience and familiarity in their food choices (Remnant and Adams, 2015; Schmidt Rivera and Azapagic, 2019).

### 4.2. Strengths and limitations

To the best of our knowledge, the present research work is the first study that investigated associations between a broad range of food choice motives and overall diet indicators related to all the aspects of diet sustainability, i.e. related to health, environment, and socio-cultural aspects (FAO and WHO, 2019). We used previously developed and validated tools to assess food choice motives (Cottet et al., 2017; Steptoe et al., 1995), food consumption (Kadawathagedara et al., 2021) and organic

food consumption (Baudry et al., 2015). Only the questions regarding local food consumption were developed for the purpose of the present study using the same items and scale as for assessing organic food consumption. This score showed good internal validity. The sPNNS-GS2 and EDL-I calculations were adapted to the data available from the food frequency questionnaire resulting in minor deviations from the original score calculations. The added fat component was removed from sPNNS-GS2 calculation which may have led to overestimating the nutritional quality of the diet in our sample. The saturated and unsaturated oils intakes were replaced by saturated and unsaturated fatty acids intakes in EDL-I calculation that may have led to overestimating the deviation from the EAT-Lancet reference diet in our sample. In the former study calculating the EDL-I in a French sample (n = 29 210) the median was 26.3 compared to -17.0 in the present sample (Kesse-Guyot et al., 2021). We estimated the environmental impact of the diets by calculating GHGEs which is not the unique indicator of environmental impact but has been shown to act as a proxy of wider environmental impacts such as acidification and eutrophication potential or land use, notably in the case of meat production (Röös et al., 2013). Moreover, ready-to-eat meals consumption may have been overestimated because the participants may have as well cooked the mixed dishes from scratch, even though they all are very common ready-to-eat meals recipes.

The results are based on secondary analyses of dietary data that were retrospectively reported and a recall bias could have affected the responses. Data were collected during the first COVID-19 lockdown in France and participants were asked about their food choice motives and food consumption before and during the first lockdown (Marty et al., 2021). Here, we specifically analysed data on food choice motives and food consumption before the first lockdown. In a previous study on the same sample of participants, we found that the first lockdown led to changes in food choice motives. However, only changes in two food choice motives were linked with changes in dietary patterns: an increase in weight control motives was associated with an increase in nutritional quality and an increase in mood motives with a decrease in nutritional quality. In another study conducted one-year after the beginning of the pandemic, we found very limited sustained changes in food choice motives (Marty et al., 2022) meaning that the pre-pandemic associations described in the present study likely remained the same post-pandemic.

Another limitation of this study is that our sample was not representative of the general population as we included voluntary participants from a population who registered to take part in research studies on food, which limits the generalisation of the results. In particular, our sample included 79% of female respondents and 76% of individuals with higher education diploma. These characteristics have been associated to higher importance of health and sustainability motives and lower importance of ease and accessibility (Allès et al., 2017; Konttinen et al., 2021). However, it is hard to hypothesize how this over-representation may have affected the associations between food choice motives and diet sustainability found in the present study.

### 4.3. Conclusions

This study highlighted three major motivational dimensions regarding food choices: 'health and sustainability, 'ease and accessibility' and 'pleasure'. Two of these dimensions were unambiguously related to health, environmental and socio-cultural aspects of diet sustainability. 'Health and sustainability' motives were associated with more sustainable diets, whereas 'ease and accessibility' motives were associated with less sustainable diets. These motivational roots of sustainable diets are worth considering to trigger global diet change. In order to promote food transition for all, policy makers must elaborate strategies that specifically target individuals with low health and sustainability motives, by promoting consistent messaging on what constitutes a sustainable diet, and individuals with high ease and accessibility motives, by reshaping the food environment to make sustainable food choices easier.

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## Authors contributions

LM: conceptualization, investigation, formal analysis, writing – original draft;
BLG: methodology, software, writing – review and editing;
SC: conceptualization, writing – review and editing;
SN: conceptualization, investigation, writing – review and editing.

## Declaration of competing interest

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

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## Appendix A. Supplementary data

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