Typology of eaters based on conventional and organic food consumption: results from the NutriNet-Santé cohort study

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Abstract

Limited information is available on large-scale populations regarding the socio-demographic and nutrient profiles and eating behaviour of consumers, taking into account both organic and conventional foods. The aims of this study were to draw up a typology of consumers according to their eating habits, based both on their dietary patterns and the mode of food production, and to outline their socio-demographic, behavioural and nutritional characteristics. Data were collected from 28 245 participants of the NutriNet-Santé study. Dietary information was obtained using a 264-item, semi-quantitative, *organic* FFQ. To identify clusters of consumers, principal component analysis was applied on sixteen conventional and sixteen organic food groups followed by a clustering procedure. The following five clusters of consumers were identified: (1) a cluster characterised by low energy intake, low consumption of organic food and high prevalence of inadequate nutrient intakes; (2) a cluster of big eaters of conventional foods with high intakes of SFA and cholesterol; (3) a cluster with high consumption of organic food and relatively adequate nutritional diet quality; (4) a group with a high percentage of organic food consumers, 14% of which were either vegetarians or vegans, who exhibited a high nutritional diet quality and a low prevalence of inadequate intakes of most vitamins except B_{12}; and (5) a group of moderate organic food consumers with a particularly high intake of proteins and alcohol and a poor nutritional diet quality. These findings may have implications for future aetiological studies investigating the potential impact of organic food consumption.

Key words: Nutrient intakes: Profiles of consumers: Clusters: Organic foods: Dietary patterns

Concurrently with the increase in demand for organic food worldwide[1], the last two decades have seen a growing number of research studies investigating the characteristics of organic food consumers[2–15]. However, research on organic food consumption to date has largely focused on differences between frequent users and non-users. Numerous studies have thus investigated the relationships between frequency of organic food consumption/purchase and socio-demographic and lifestyle factors as well as their associated food patterns[3,6,9,12,15]. These studies have suggested that frequent organic food consumption is associated with a higher level of education, vegetarianism or healthier lifestyle and dietary patterns. In these studies, regular or non-organic food users are often considered in single broad categories reflecting the overall frequency of purchase only. These approaches do not take into account the variety of
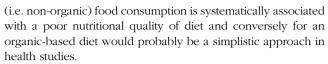
nutritional behaviours and the relative share of organic food intake in the diet. It is, however, likely that the potential effects of an organic diet are associated with the type (i.e. food groups) and the quantity of organic food consumed.

To our knowledge, only one study conducted on males in Germany has attempted to establish a typology of organic and non-organic food purchasers based on their actual consumption of meat, fruits and vegetables[14]. However, in this analysis, men were identified as either organic food purchasers or non-organic food purchasers on the basis of their own statement regarding their purchase of organic food. For future aetiological studies on organic food consumption, a precise understanding of the diversity of profiles taking into account both dimensions (i.e. type and mode of production of the food consumed) is necessary. Indeed, assuming that conventional

(i.e. non-organic) food consumption is systematically associated with a poor nutritional quality of diet and conversely for an organic-based diet would probably be a simplistic approach in health studies.

Therefore, the aims of the present study were to identify a typology of consumers on the basis of a detailed estimation of the consumption of organic and conventional foods in a large sample of French adults from the NutriNet-Santé cohort study and to describe these consumers' groups in terms of socio-demographic, lifestyle, behavioural and nutritional profiles.

Methods

Study population

The NutriNet-Santé study is an ongoing, observational, prospective, open-cohort study, which was launched in 2009 in France[16]. The study aims to investigate the relationships between nutrition and health as well as the determinants of dietary patterns and nutritional status. To be included in the cohort, participants must complete a baseline set of self-administered, web-based questionnaires on dietary intake, as well as health and anthropometric, socio-demographic and lifestyle characteristics. During follow-up, participants were also invited to complete extensive questionnaires related to determinants of dietary behaviour, as well as nutritional and health-related characteristics.

Ethics

This study was conducted in accordance with the Declaration of Helsinki, and all procedures were approved by the Institutional Review Board of the French Institute for Health and Medical Research (IRB INSERM no. 0000388FWA00005831) and the Commission Nationale de l'Informatique et des Libertés (CNIL no. 908450 and no. 909216). All participants provided their informed consent with an electronic signature, and this study is registered in EudraCT (European Union Drug Regulating Authorities Clinical Trials; no. 2013-000929-31).

Data collection and treatment

Dietary intake. To assess usual dietary consumption, participants reported the frequency and portion sizes of consumed foods and beverages by filling out a dedicated 264-item, semi-quantitative, organic FFQ (Org-FFQ). The Org-FFQ was based on a validated FFQ supplemented by a section pertaining to the frequency of organic food consumption (it should be noted that this latter part was not validated)[17]. The Org-FFQ has been described elsewhere[18]. In brief, subjects were asked to report their frequency of consumption and the quantity consumed over the past year for each of the 264 items. In addition, a five-point likert-type scale ranging from never to always was used to estimate the frequency of organic food consumption of each food item. For each food item, the question was as follows: *How often was the product of organic origin?* The term 'organic' referred to European Union-certified organic products. Organic food intake was obtained for each item by applying a weight of 0, 0·25, 0·5, 0·75 and 1 to the five respective categories of frequency (never, rarely, half the time, often and always). Beverage and food items were aggregated into sixteen food groups. The average total daily intake in grams per day of the sixteen food categories was assessed. We separated conventional from organic intake for each food group on the basis of the relative share reported. In other words, for each food group, we calculated organic food intake on the basis of the relative share reported, and conventional food intake was obtained by subtracting the total food intake from the organic food intake.

The proportion of organic food in the whole diet was computed by averaging the total organic food intake (g/d) out of the total intake excluding water (g/d) multiplied by 100.

To estimate nutrient intakes, an *ad hoc* food composition database (regardless of the origin of the products) was developed for the Org-FFQ using the original NutriNet-Santé composition table[19]. As the origin (organic or conventional) of foods was not taken into account, some potential differences in contents reported in the literature resulting from the mode of production were not considered[20–22].

We also computed two *a priori* nutritional diet quality scores: the modified Programme National Nutrition Santé Guidelines Score (mPNNS-GS), which is a thirteen·five-point score that reflects adherence to the French nutritional recommendations[23], and the PANDiet, a 100-point score that reflects the probability of adequate nutrient intake[24]. The prevalence of inadequate intakes of selected nutrients was estimated by the proportion of subjects with intake below the estimated average requirement for the French population[25,26].

Socio-demographic, lifestyle and behavioural characteristics. Upon enrolment and each year thereafter, participants provided information on socio-demographic and lifestyle characteristics including sex, age, education, income, number of children, marital status, place of residence, smoking status and practice of vegetarian or vegan diets. A vegetarian diet was defined as a diet that did not include any meat (the term 'meat' included red meat, processed meat and poultry), whereas a vegan diet was defined as a diet that excluded all foods of animal origin (exclusion of meat, seafood, eggs or dairy products). The question was as follows: *Are you currently following a particular diet? Yes, I am a vegetarian (I do not eat any meat but I can eat products of animal origin). Yes, I am a vegan (I do not eat any meat, seafood, eggs or dairy products).*

The closest available data to the Org-FFQ questionnaire completion date were used. Monthly household income was calculated by household units (HU): 1 HU was attributed for the first adult in the household, 0·5 for other persons aged 14 years or older and 0·3 for children under 14 years[27].

In July 2014, participants were also invited to fill out a questionnaire pertaining to attitudes, perceptions and motivations towards organic food. In particular, subjects were asked to self-report their frequency of organic food consumption (regular/occasional/non-consumption) and to identify the official organic labels among twelve different logos. For a list of conventional and organic food categories, subjects were also asked to report their main place of purchase from among the different alternatives provided. They could also declare that they did not consume the product. For each place of purchase,

a score (in %) was calculated by adding up the number of times this source of supply was selected as a main place of purchase for the different foods and dividing by the number of foods purchased by the participant. Subjects were also asked to provide information concerning whether they engaged (or not) in selected environmentally friendly practices (i.e. practices aimed at reducing consumption of energy and production of waste). The questions were as follows: (1) *Did you consider the energy performance label when purchasing your refrigerator?* (2) *Do you regularly defrost your refrigerator?* (3) *Do you use a lid when heating up water* (4) *Do you recycle organic waste?*

Statistical analyses

The Org-FFQ, an optional questionnaire, was administered over a 5-month period from June to October 2014 to the subjects included in the cohort at that time – that is, 104 080 participants. Of the subjects who completed the Org-FFQ (*n* 33 384), a total of 28 245 were selected (20 980 women and 7265 men). We excluded under-reporting or over-reporting participants with implausible energy intakes (*n* 2097), participants with missing covariates (*n* 2320) or those living overseas (*n* 722). To better characterise the selected sample, we compared participants who completed the Org-FFQ with excluded NutriNet-Santé participants using χ^2 tests and Student *t* tests, as appropriate.

Concerning questions related to recognition of labels, self-reported organic food consumption and environment-friendly practices, a sub-sample was considered with no missing information in terms of these variables. The sample size was thus 23 010. Likewise, for the distribution of places of purchase, the sample size was 22 985.

Under- and over-reporting participants were identified on the basis of their 'energy intake:energy requirement' ratio. Individuals with ratios below or above specific cut-off values previously identified in the FFQ were excluded[17]. BMR was estimated using Schofield equations[28].

To identify different clusters of consumers of conventional and organic products, principal component analysis (PCA) was applied on the sixteen conventional and sixteen organic food group intakes (in g/d, thirty-two variables), thereby taking into account the type of food and the mode of food production (organic or conventional). This method allows the reduction of the initial range of information by maximising variance. In total, six dimensions were retained according to eigenvalues >1, scree test and interpretability of factors[29]. We then performed a two-step clustering procedure by applying Ward's hierarchical clustering using the first six dimensions retained in the PCA, followed by a non-hierarchical, K-means clustering procedure based on the earlier hierarchical clustering. PCA was performed using SAS® PROC PRINCOMP, and the clustering procedure was performed using SAS® PROC CLUSTER and PROC FASTCLUS (version 9.4; SAS Institute Inc.)[29].

We described the clusters in terms of socio-demographic and lifestyle characteristics, dietary profiles and prevalence of inadequate intakes, purchasing behaviours and environmentally friendly practices.

Associations of clusters with the above-listed characteristics were assessed by ANCOVA. We provide mean values and 95 % CI. Dietary characteristics were adjusted for sex, age and total energy intake, and average percentages of place of purchase were adjusted for sex and age. For categorical variables, the *P* value was based on χ^2 test.

Tests of statistical significance were two-sided, and type I error was set at 5 %. Statistical analyses were performed using SAS software (version 9.4; SAS Institute Inc.).

Results

The proportion of men was significantly higher among respondents to the Org-FFQ than among participants excluded from the analysis (26 *v.* 21 %). The respondents were also older than the excluded subjects (53·20 (SD 14·07) *v.* 44·62 (SD 14·20) years old) (data not tabulated).

Cluster description

On the basis of the two-step clustering procedure described above, five clusters were identified, representing, respectively, 39·0 % (cluster 1), 20·6 % (cluster 2), 24·8 % (cluster 3), 10·8 % (cluster 4) and 4·8 % (cluster 5) of the study population. For all variables, *P* values were <0·0001.

According to their main dietary traits, the different clusters are labelled as follows.

Cluster 1: standard conventional food small eaters. Subjects in this cluster were younger compared with other clusters (Table 1). The highest proportion of urban population was found in this group. They had low energy intake, low proportion of organic food in their diet and exhibited intermediate nutritional diet quality (intermediate values of PANDiet and mPNNS-GS scores) (Table 2). The subjects were, for the most part, those with the highest prevalence of inadequate intakes except for vitamin B_{12} and Ca. Their low prevalence of inadequate intakes of Ca is noteworthy (Table 3). The most frequently cited main place of purchase by the subjects was supermarkets followed by retail stores and markets (Table 4).

Cluster 2: unhealthy conventional food big eaters. This group was composed of a third of men and characterised by the highest percentages of individuals with low income and educational levels (Table 1). They had the lowest organic food consumption with high energy intake and an overall poor nutritional diet quality (low PANDiet and mPNNS-GS) with high intakes of cholesterol and SFA (Table 2). For most nutrients, subjects had the lowest prevalence of inadequate intakes except for folate, vitamins C and E, Mg, Fe and Ca (Table 3). The most frequently reported main place of food purchase was the supermarket followed by retail stores and discount stores (Table 4).

Cluster 3: standard organic food small eaters. The lowest proportion of men was found in this cluster (Table 1). Subjects had the second highest proportion of organic food in their diet (Table 2). They had a relatively low energy intake and the second highest intake of fibre and PUFA (Table 2). They exhibited a relatively adequate nutritional diet quality

Table 1. Characteristics of the participants, NutriNet-Santé study, 2014
(Numbers and percentages; mean values and standard deviations; n 28 245)

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	$P*$
n	11·012	5·811	7·007	3·048	1·367	
%	39·0	20·6	24·8	10·8	4·8	
Sex (%)						<0·0001
Female	78·67	67·70	80·22	76·28	31·97	
Male	21·33	32·30	19·78	23·72	68·03	
Age (years)						<0·0001
Mean	51·72	53·91	54·48	53·42	61·18	
SD	14·71	14·05	13·13	13·53	11·19	
Educational level (%)						<0·0001
<High school diploma	21·47	26·07	20·07	17·62	25·68	
High school diploma	15·01	16·74	15·13	13·78	13·97	
Post-secondary graduate	63·52	57·18	64·81	68·60	60·35	
Monthly income per household unit (%)						<0·0001
Refuse to declare	12·76	12·30	13·02	11·38	7·17	
900–1200 euros	11·47	13·23	9·01	13·19	6·51	
1200–1800 euros	21·77	23·83	20·38	21·95	17·70	
1800–2700 euros	25·19	24·68	25·77	25·59	27·87	
>2700 euros	28·81	25·95	31·83	27·89	40·75	
Location (%)						<0·0001
Rural community	19·81	22·44	23·65	24·87	24·43	
Urban unit with a population <20 000 inhabitants	14·79	15·49	15·83	16·50	16·75	
Urban unit with a population between 20 000 and 200 000 inhabitants	17·79	18·38	17·95	17·88	18·07	
Urban unit with a population >200 000 inhabitants	47·60	43·69	42·57	40·75	40·75	
Smoking status (%)						<0·0001
Never smokers	52·03	47·39	48·89	49·93	23·77	
Former smokers	36·58	41·21	41·46	40·52	56·84	
Current smokers	11·39	11·39	9·65	9·55	19·39	
Vegan or vegetarian diet (yes) (%)	1·56	0·67	3·08	14·40	0·73	<0·0001
Recognition of the French label (yes) (%)†	92·58	91·73	93·20	94·69	91·48	<0·0001
Recognition of the European label (yes) (%)†	26·84	22·73	46·82	68·24	28·35	<0·0001
Self-reported organic food consumption (%)†						<0·0001
Non-consumers	17·54	28·50	0·55	0·12	10·17	
Occasional consumers	76·96	69·33	48·11	8·00	73·65	
Regular consumers	5·50	2·17	51·34	91·87	16·17	

* P values are based on the t test or χ^2 test as appropriate.
† Because of missing data, the sample size was 23 010 (cluster 1 = 9003, cluster 2 = 4839, cluster 3 = 5606, cluster 4 = 2412, cluster 5 = 1150).

(high PANDiet and mPNNS-GS) (Table 2). Subjects had intermediate-to-high prevalence of inadequate intakes (Table 3). They reported high diversity in their places of purchase with the supermarket reported as the most frequent place of purchase followed by organic food stores and markets (Table 4). The cluster has the second highest percentage of subjects reporting environmentally friendly practices (Table 5).

Cluster 4: 'green' organic food eaters. This group comprised high organic food consumers, who defined themselves mostly as regular organic food consumers, and had 14 % of vegetarians and vegans (Table 1). They were often highly educated and were largely able to recognise the official labels. The highest proportion of individuals living in rural areas was found in this cluster. Subjects also had the highest contribution of carbohydrate and the lowest contribution of protein to the total energy intake and the highest intakes of PUFA (Table 2). The highest PANDiet and mPNNS-GS scores were found in this cluster. They also exhibited the lowest prevalence of inadequate intakes of folate, vitamin C, vitamin E, Mg and Fe and the highest prevalence of inadequate intake of vitamin B_{12} (Table 3). They also favoured specialised organic food stores and short food supply chains (such as associations supporting small producers) as places of purchase (Table 4). The highest percentage of

subjects with environmentally friendly practices was found in this cluster (Table 5).

Cluster 5: hedonist moderate organic food eaters. This cluster comprised a high proportion of men, individuals with high income and smokers (Table 1). Subjects were also older compared with other clusters. This cluster was mainly characterised by the particularly high intake of proteins and ethanol and a moderate consumption of organic food (Table 2). Overall, they exhibited poor nutritional diet quality with low PANDiet and mPNNS-GS scores. Subjects had the highest prevalence of inadequate intakes of Ca (Table 3). Although this group did the majority of their food purchasing in supermarkets, they also visited retail stores more frequently compared with other groups (Table 4).

Discussion

To our knowledge, no previous study has integrated both food groups and modes of food production in a cluster analysis. In our population, we identify five major groups of consumers: two major groups of low or very low organic food consumers (clusters 1 and 2), two groups of consumers with a high proportion of organic food in their diet (clusters 3 and 4) and a

Table 2. Daily intakes of the thirty-two food groups included in the principal component analysis (PCA) and nutritional profiles across clusters, NutriNet-Santé study, 2014
(Mean values and 95 % confidence intervals; n 28 245)

Labels	Cluster 1 (n 11 012) Standard conventional food small eaters		Cluster 2 (n 5811) Unhealthy conventional food big eaters		Cluster 3 (n 7007) Standard organic food small eaters		Cluster 4 (n 3048) Green organic food eaters		Cluster 5 (n 1367) Hedonist moderate organic food eaters		P*
	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	
Construction variables†											
Organic food intake (g/d or ml/d)											
Fruits and vegetables (including juices and soups)	114·77	110·04, 119·50	89·49‡	82·98, 96·00‡	435·74	429·81, 441·67	819·99‡	811·0, 828·97‡	214·28	200·85, 227·70	<0·0001
Seafood	3·27	2·96, 3·57	2·76‡	2·34, 3·18‡	15·36	14·97, 15·74	17·45‡	16·87, 18·03‡	11·32	10·45, 12·18	<0·0001
Meat, poultry, processed meat	10·93‡	10·35, 11·52‡	11·07	10·26, 11·87	41·16‡	40·43, 41·89‡	40·23	39·12, 41·34	31·81	30·15, 33·46	<0·0001
Eggs	3·65‡	3·48, 3·82‡	4·16	3·93, 4·40	10·05	9·84, 10·26	13·74‡	13·41, 14·06‡	6·68	6·20, 7·16	<0·0001
Dairy products	32·82	30·90, 34·73	24·17‡	21·53, 26·81‡	127·37‡	124·97, 129·77‡	122·84	119·19, 126·48	50·49	45·05, 55·94	<0·0001
Starchy foods	19·77	18·79, 20·75	16·29‡	14·94, 17·63‡	71·16	69·93, 72·38	154·39‡	152·53, 156·26‡	41·17	38·39, 43·95	<0·0001
Whole-grain products	9·52	8·69, 10·35	6·24‡	5·10, 7·38‡	42·48	41·44, 43·52	105·47‡	103·89, 107·05‡	18·33	15·97, 20·68	<0·0001
Oil	3·37	3·18, 3·56	2·53‡	2·27, 2·79‡	13·91	13·67, 14·14	28·36‡	28·00, 28·72‡	7·56	7·02, 8·09	<0·0001
Butter/margarine	0·66	0·60, 0·72	0·57‡	0·49, 0·66‡	3·22	3·15, 3·30	4·62‡	4·51, 4·74‡	1·88	1·71, 2·06	<0·0001
Sweetened foods	6·89	6·55, 7·24	6·25‡	5·77, 6·73‡	26·03	25·60, 26·47	46·75‡	46·09, 47·42‡	14·78	13·80, 15·77	<0·0001
Alcoholic beverages	4·98	4·18, 5·78	4·02‡	2·91, 5·12‡	21·92	20·91, 22·93	47·81	46·29, 49·34	96·57‡	94·29, 98·85‡	<0·0001
Non-alcoholic drinks	96·27	91·11, 101·42	62·90‡	55·80, 70·00‡	384·68	378·21, 391·14	714·27‡	704·47, 724·07‡	170·53	155·89, 185·16	<0·0001
Fast food	1·76	1·55, 1·96	1·52‡	1·24, 1·80‡	9·63	9·37, 9·88	20·38‡	19·99, 20·76‡	5·59	5·02, 6·17	<0·0001
Extra food (including snacks, chips, salted biscuits, dressing and sauces)	1·20	1·05, 1·36	1·20‡	0·98, 1·41‡	6·36	6·16, 6·56	20·18‡	19·88, 20·48‡	3·59	3·14, 4·04	<0·0001
Dairy products and meat substitutes (including soya-based products)	9·21	7·74, 10·67	5·44‡	3·43, 7·46‡	24·56	22·72, 26·39	130·22‡	127·44, 133·00‡	6·31	2·16, 10·47	<0·0001
Other fats (including mayonnaise, fresh cream, vegetable fresh cream)	0·28‡	0·23, 0·32‡	0·33	0·27, 0·39	1·44	1·38, 1·49	4·14‡	4·06, 4·23‡	0·63	0·50, 0·75	<0·0001
Conventional food intake (g/d or ml/d)											
Fruits and vegetables (including juices and soups)	477·17	471·34, 483·00	730·31‡	722·29, 738·34‡	333·67	326·36, 340·98	195·01‡	183·93, 206·09‡	429·67	413·12, 446·22	<0·0001
Seafood	32·76	32·02, 33·49	55·57‡	54·56, 56·59‡	33·91	32·99, 34·83	30·19‡	28·79, 31·59‡	44·83	42·75, 46·92	<0·0001
Meat, poultry, processed meat	85·62	84·43, 86·82	163·02‡	161·37, 164·67‡	56·95	55·45, 58·45	28·67‡	26·40, 30·95‡	122·17	118·77, 125·57	<0·0001
Eggs	4·74	4·59, 4·89	10·46‡	10·25, 10·67‡	1·89	1·70, 2·08	0·85‡	0·56, 1·13‡	5·63	5·20, 6·06	<0·0001
Dairy products	205·75	202·74, 208·77	308·23‡	304·08, 312·38‡	112·54	108·76, 116·32	36·50‡	30·77, 42·23‡	138·77	130·22, 147·33	<0·0001
Starchy foods	129·37	127·80, 130·94	214·41‡	212·24, 216·57‡	78·84	76·87, 80·81	34·90‡	31·91, 37·88‡	142·11	137·65, 146·56	<0·0001
Whole-grain products	30·11	29·27, 30·94	37·92‡	36·77, 39·07‡	24·82	23·77, 25·87	11·03‡	9·44, 12·62‡	34·98	32·61, 37·36	<0·0001
Oil	10·94	10·73, 11·14	20·50‡	20·22, 20·78‡	6·48	6·23, 6·74	2·68‡	2·29, 3·07‡	12·11	11·53, 12·69	<0·0001
Butter/margarine	4·71	4·60, 4·81	9·10‡	8·96, 9·24‡	2·66	2·53, 2·79	0·91‡	0·71, 1·10‡	5·89	5·59, 6·18	<0·0001
Sweetened foods	52·17	51·32, 53·02	93·28‡	92·11, 94·45‡	36·94	35·87, 38·00	22·68‡	21·06, 24·29‡	51·42	49·01, 53·83	<0·0001
Alcoholic beverages	61·41	59·36, 63·45	101·28	98·46, 104·09	55·12	52·56, 57·68	43·94‡	40·05, 47·83‡	427·67‡	421·86, 433·48‡	<0·0001
Non-alcoholic drinks	1525·02	1511·82, 1538·22	1883·29‡	1865·11, 1901·46‡	1383·20	1366·65, 1399·74	1118·82‡	1093·73, 1143·92‡	1413·02	1375·55, 1450·49	<0·0001
Fast food	25·79	25·21, 26·38	44·64‡	43·84, 45·45‡	19·25	18·52, 19·98	13·85‡	12·74, 14·96‡	31·55	29·89, 33·20	<0·0001
Extra food (including snacks, chips, salted biscuits, dressing and sauces)	10·46	10·23, 10·68	22·12‡	21·81, 22·43‡	8·42	8·14, 8·70	6·02‡	5·59, 6·44‡	16·04	15·41, 16·67	<0·0001
Dairy products and meat substitutes (including soya-based products)	6·28	5·68, 6·88	6·84	6·01, 7·67	5·10	4·35, 5·86	9·54‡	8·39, 10·68‡	3·01‡	1·30, 4·72‡	<0·0001

Table 2. *Continued*

Labels	Cluster 1 (n 11 012) Standard conventional food small eaters Mean	95 % CI	Cluster 2 (n 5811) Unhealthy conventional food big eaters Mean	95 % CI	Cluster 3 (n 7007) Standard organic food small eaters Mean	95 % CI	Cluster 4 (n 3048) Green organic food eaters Mean	95 % CI	Cluster 5 (n 1367) Hedonist moderate organic food eaters Mean	95 % CI	P*
Other fats (including mayonnaise, fresh cream, vegetable fresh cream)	2·07	2·00, 2·14	5·15‡	5·06, 5·25‡	1·48	1·39, 1·56	0·76‡	0·63, 0·89‡	2·08	1·88, 2·27	<0·0001
Nutritional descriptive variables§											
Proportion of organic food in the diet (%)‖	13·66	13·31, 14·03	8·59‡	8·14, 9·05‡	50·30	49·89, 50·71	78·53‡	77·98, 79·10‡	25·27	24·5, 26·05	<0·0001
Total energy intake (kJ/d)	7104‡	7050, 7159‡	10 723‡	10 657, 10 786‡	8163	8096, 8226	9895	9811, 9979	9598	9477, 9715	
Total energy intake (kcal/d)	1698‡	1685, 1711‡	2563‡	2547, 2578‡	1951	1935, 1966	2365	2345, 2385	2294	2265, 2322	<0·0001
Lipids (% of total energy intake)	38·86‡	38·68, 39·04‡	40·54	40·31, 40·77	40·43	40·23, 40·64	41·91‡	41·63, 42·19‡	41·77	41·38, 42·17	<0·0001
Carbohydrates (% of total energy intake)	41·78	41·59, 41·98	39·85	39·61, 40·10	40·89	40·67, 41·11	41·87‡	41·57, 42·17‡	38·46‡	38·04, 38·88‡	<0·0001
Total simple carbohydrates (% of total energy intake)	20·71‡	20·55, 20·36‡	19·85	19·64, 20·06	20·55	20·36, 20·73	20·51	20·26, 20·77	17·84‡	17·48, 18·19‡	<0·0001
Protein (% of total energy intake)	18·95	18·86, 19·04	19·21	19·10, 19·33	18·29	18·19, 18·40	15·86‡	15·72, 16·01‡	19·42‡	19·22, 19·62‡	<0·0001
Fibre (g/d)	21·35	21·15, 21·55	19·83	19·57, 20·09	23·89	23·66, 24·13	31·09‡	30·77, 31·41‡	17·21‡	16·77, 17·65‡	<0·0001
PUFA (g/d)	12·93	12·78, 13·07	13·92	13·74, 14·10	14·38	14·22, 14·54	19·89‡	19·67, 20·11‡	12·43‡	12·13, 12·74‡	<0·0001
MUFA (g/d)	32·54	32·31, 32·77	34·17	33·88, 34·46	34·63	34·37, 34·90	38·60‡	38·24, 38·95‡	32·43‡	31·93, 32·92‡	<0·0001
SFA (g/d)	33·19	32·98, 33·40	33·40‡	33·13, 33·67‡	32·00	31·75, 32·24	26·15‡	25·82, 26·48‡	29·68	29·22, 30·14	<0·0001
n-3 Fatty acids (g/d)	1·70	1·67, 1·73	1·70	1·66, 1·74	2·08	2·04, 2·12	3·05‡	3·00, 3·10‡	1·61‡	1·54, 1·68‡	<0·0001
n-6 Fatty acids (g/d)	10·50	10·37, 10·63	11·45	11·29, 11·61	11·59	11·44, 11·73	16·20‡	16·00, 16·40‡	10·12‡	9·85, 10·39‡	<0·0001
Cholesterol (mg/d)	292·83	290·24, 295·41	327·38‡	324·11, 330·66‡	287·33	284·38, 290·28	206·22‡	202·23, 210·22‡	287·69	282·12, 293·25	<0·0001
Ethanol (g/d)	7·41	7·17, 7·66	7·80	7·49, 8·11	7·44	7·17, 7·72	7·40‡	7·02, 7·77‡	40·60‡	40·07, 41·13‡	<0·0001
PANDiet	70·06	69·87, 70·26	68·70‡	68·45, 68·95‡	71·06	70·84, 71·28	73·37‡	73·06, 73·67‡	69·30	68·88, 69·72	<0·0001
mPNNS-GS	8·26	8·22, 8·30	8·22	8·17, 8·27	8·71	8·66, 8·76	8·87‡	8·81, 8·93‡	7·71‡	7·62, 7·80‡	<0·0001

mPNNS-GS, modified Programme National Nutrition Santé Guideline Score.
* ANCOVA was used for testing differences between clusters.
† Thirty-two variables included in the PCA.
‡ Values denote the highest and the lowest values.
§ Adjusted for sex, age and total energy intake.
‖ Proportion of organic food in the diet: average percentages computed by averaging the total organic food intake (g/d) out of the total intake excluding water (g/d) multiplied by 100.

Typology of conventional and organic eaters

Table 3. Prevalence of inadequate intakes based on estimated average requirement (EAR) across clusters, NutriNet-Santé study, 2014 (*n* 28 245)*

Labels	Cluster 1 (*n* 11 012) Standard conventional food small eaters	Cluster 2 (*n* 5811) Unhealthy conventional food big eaters	Cluster 3 (*n* 7007) Standard organic food small eaters	Cluster 4 (*n* 3048) Green organic food eaters	Cluster 5 (*n* 1367) Hedonist moderate organic food eaters	*P*†
Retinol	8·33‡	0·53‡	3·27	1·48	5·41	<0·0001
Thiamin	22·07‡	1·27‡	12·74	2·56	14·41	<0·0001
Riboflavin	9·05‡	0·29‡	6·42	2·92	2·56	<0·0001
Niacin	2·62‡	0·07‡	1·56	0·59	0·66	<0·0001
Pantothenic acid	13·85‡	0·59‡	10·13	3·38	3·15	<0·0001
Vitamin B_6	28·90‡	2·43‡	14·67	3·28	10·53	<0·0001
Folate	14·96‡	1·31	5·24	0·49‡	9·44	<0·0001
Vitamin B_{12}	5·46	0·55‡	5·55	12·03‡	1·39	<0·0001
Vitamin C	31·91‡	12·89	19·37	8·52‡	25·60	<0·0001
Vitamin E	40·21‡	3·70	19·27	2·20‡	24·07	<0·0001
I	17·85‡	1·50‡	9·70	5·87	9·29	<0·0001
Mg	34·65‡	12·01	17·20	3·02‡	17·78	<0·0001
P	1·55‡	0·02‡	1·20	0·13	0·51	<0·0001
Fe	37·71‡	7·06	19·47	3·02‡	3·37	<0·0001
Ca	3·51‡	8·19	29·56	20·95	31·46‡	<0·0001
Zn	4·80‡	0·10‡	3·81	0·89	1·68	<0·0001
K	20·39‡	1·12‡	10·95	2·75	4·17	<0·0001
Se	11·40‡	0·46‡	6·58	2·13	7·10	<0·0001

* Prevalence of inadequate intakes = proportion of the subjects with intake below the EAR.
† *P* values are based on χ^2 test.
‡ Values denote the highest and the lowest values.

group with a moderate consumption of organic food (cluster 5). Their profiles in terms of socio-demographic, behavioural and nutrient characteristics were markedly different, demonstrating a variety of eating habits and patterns. In general, high levels of organic food consumption were associated with an overall better nutritional diet quality. Overall, the total energy intake, the nutritional diet quality, but also the modes of food production emerged as major discriminating components.

Socio-demographic and lifestyle characteristics

Socio-demographic and lifestyle differences between non-organic food consumers and frequent organic food consumers are in line with those observed in other populations[2,3,5,6,13,15] and in the NutriNet-Santé cohort in particular[12]. Our findings also corroborate the fact that, in general, a higher education level seems to be a strong determinant of organic food consumption[4,6,7,10,13]. Unlike previous research showing that organic food consumption tends to be positively related to urbanisation[6,13], the percentage of individuals living in a rural community is highest among the groups with the highest level of organic food consumption. Several hypothesises may explain why high organic food consumers reside more often in rural areas. Country-dwellers (particularly those included in the NutriNet-Santé study) may have a special linkage with food, land and soil, and organic foods have been associated with freshness, tradition and naturalness[30–32]. They may also have high access to short food supply chains, and therefore better access to 'fresh' organic foods.

Regarding lifestyle characteristics, our results are consistent with a recent study showing that frequent organic food consumers exhibit healthier lifestyles with fewer smokers than non-consumers (this study reported 80 % of non-smokers among buyers of organic food *v.* 71 % among non-buyers)[15]. A strong positive association between frequent organic food consumption and vegetarianism has also been reported in the literature[2,13], supported by our findings. In the present study, the proportion of vegetarians and vegans was 14 % among the high organic food consumers (cluster 4), reflecting the fact that very high organic food consumption is probably often related to specific dietary practices.

Dietary profiles and eating-related practices

Across clusters, different eating behaviours are reflected by various levels of nutrient intakes, and thus occurrence of inadequate intakes. The corollary of the low energy intake in cluster 1 is high prevalence of inadequate intakes of most nutrients. The opposite is true for cluster 2 where high energy intake is followed by low prevalence of inadequate intakes of most nutrients. Despite this fact, cluster 2 exhibited the lowest PANDiet score due to their high intakes of cholesterol or SFA.

Unsurprisingly, the highest prevalence of inadequate intakes of vitamin B_{12} was observed in cluster 4, reflecting the plant-based diet of the subjects. Thus, 12 % of subjects had an inadequate intake in this group, which compares with a prevalence of nearly 0 % in the French population[33]. It is also noteworthy that subjects in cluster 4 had the lowest prevalence of inadequate intake of Fe. This can be attributed to their very high consumption of fruits and vegetables, whole-grain products and soya-based products. These results are in line with those of a previous study showing a higher intake of Fe in vegetarians compared with their omnivorous counterparts[34]. For folate, vitamin C or Mg, subjects in cluster 4 had the lowest

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Table 4. Distribution of places of purchase across clusters, NutriNet-Santé study, 2014 (Mean values and 95 % confidence intervals; n 22 985)*†

Labels	Cluster 1 (n 8998) Standard conventional food small eaters		Cluster 2 (n 4833) Unhealthy conventional food big eaters		Cluster 3 (n 5598) Standard organic food small eaters		Cluster 4 (n 2409) Green organic food eaters		Cluster 5 (n 1147) Hedonist moderate organic food eaters		P‡
	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	
Supermarkets	71·09	70·41, 71·77	73·15§	72·34, 73·96§	53·89	53·09, 54·70	34·52§	33·46, 35·58§	64·17	62·71, 65·62	<0·0001
Discount stores	4·00	3·63, 4·37	5·56§	5·11, 6·00§	1·86	1·42, 2·30	0·87§	0·29, 1·45§	3·27	2·48, 4·07	<0·0001
Markets	5·89	5·61, 6·17	4·77§	4·43, 5·10§	8·89§	8·56, 9·23§	8·53	8·09, 8·97	7·71	7·10, 8·31	<0·0001
Associations supporting small producers, box schemes (AMAP)	1·84	1·63, 2·06	1·29§	1·03, 1·54§	4·67	4·42, 4·92	5·99§	5·66, 6·32§	2·62	2·16, 3·07	<0·0001
Retail stores (e.g. bakeries, fisheries, butcheries)	8·19	7·97, 8·42	7·90	7·64, 8·17	8·78	8·52, 9·05	6·41§	6·06, 6·76§	9·67§	9·19, 10·15§	<0·0001
Grocery stores	1·00	0·84, 1·17	0·75§	0·55, 0·95§	1·54§	1·34, 1·74§	1·54§	1·34, 1·74§	1·46	1·28, 1·80	<0·0001
Farms	1·82	1·68, 1·97	1·61§	1·44, 1·79§	2·82§	2·65, 3·00§	2·40	2·17, 2·63	2·26	1·95, 2·58	<0·0001
Self-production	3·08	2·93, 3·24	3·25	3·06, 3·44	3·47§	3·28, 3·06§	2·71§	2·46, 2·95§	3·20	2·85, 3·54	<0·0001
Specialised organic food stores	3·07	2·67, 3·47	1·72§	1·24, 2·20§	14·07	13·59, 14·54	37·03§	36·40, 37·66§	5·65	4·79, 6·52	<0·0001

* Adjusted for sex and age.
† Because of missing data, the sample size was 22 985.
‡ ANCOVA was used for testing differences between clusters.
§ Values denote the highest and the lowest values.

prevalence of inadequate intakes. These three micronutrients are indeed found mainly in 'healthy' foods such as fruits and vegetables largely consumed by subjects in cluster 4. This seems consistent with other studies reporting that frequent organic food consumers had higher intakes of most minerals and vitamins than non-consumers[9,12,13,15].

Cluster 3 can be considered as an *organic* cluster 1. In other words, cluster 3 is an 'organic mirror' of cluster 1. Indeed, cluster 3 showed great similarities to cluster 1, especially for the proportion of women and for subjects with high school diploma. However, subjects in cluster 3 had higher intakes of most nutrients and an overall higher nutritional diet quality than those in cluster 1. In a German study, separate cluster analyses have been carried out for male purchasers and non-purchasers of organic food in order to identify typology of purchasers[14]. Consistent with our findings, the results revealed that, although the same types of consumers were found for both groups, male organic purchasers nevertheless exhibited specific dietary patterns with higher intakes of fruits and vegetables and lower intakes of meat and were more likely to be motivated by sustainability criteria. As also observed in other studies[9,13,15], a positive relationship was found between higher organic food consumption and healthier food habits. In the present study, the highest PANDiet and mPNNS-GS scores are thus found in cluster 3 and cluster 4 – that is, among subjects with the highest level of organic food in their diet. Furthermore, they are more prone to purchasing their foods from a variety of supply chains. The proportion of subjects with environmentally friendly practices was also higher in cluster 3.

Cluster 4 exhibited environmentally friendly behaviours through their choice of products (plant food) and through their choice of the mode of food production (organic instead of conventional), thus fitting with the concept of sustainable diet described by the FAO[35]. Moreover, in our study as in another[36], they also tended to make purchases more frequently from short food supply chains and from small-scale producers than other consumers, thus favouring local production.

These environmentally friendly food behaviours seem to be translated into environmentally friendly practices. For instance, a high percentage of subjects recycle their organic waste, in line with a previous study reporting that increasing organic food consumption was related to environmentally friendly consumption behaviours such as recycling[30]. These 'sustainable habits' are reflected in the ethical reasoning behind organic food consumption[3,11,36].

Cluster 5 gathered a minority of subjects (5 %). They can be seen as a group of 'bon vivants'. They have a traditional diet rich in meat and alcohol with moderate organic food consumption. They have an 'unhealthier' lifestyle overall, as they are more often smokers and have higher alcohol intake.

Our study presents major strengths that include an innovative approach in the implementation of the typology of organic and conventional food consumers, as well as a large participant population allowing for identification of a variety of food habits and practices. Several limitations should also be mentioned. Intake of fruits and vegetables in our study was particularly high compared with the figures of the French National ENNS (Etude nationale nutrition santé) survey[37]. As the Org-FFQ was

Table 5. Environmentally friendly practices across clusters, NutriNet-Santé study, 2014 (*n* 23 010)*

Labels	Cluster 1 (*n* 9003) Standard conventional food small eaters	Cluster 2 (*n* 4839) Unhealthy conventional food big eaters	Cluster 3 (*n* 5606) Standard organic food small eaters	Cluster 4 (*n* 2412) Green organic food eaters	Cluster 5 (*n* 1150) Hedonist moderate organic food eaters	*P*†
Did you consider the energy performance label when purchasing your refrigerator?						<0·0001
Yes	66·17	66·71	74·69	76·53‡	63·04‡	
No	33·83	33·29	25·31	23·47‡	36·96‡	
Do you regularly defrost your refrigerator? (%)						<0·0001
Yes, manually	32·24	31·78	31·97	33·33‡	30·43‡	
Yes, I have an automatic defrost	54·19‡	56·58	57·58	55·10	59·39‡	
No	13·56‡	11·63	10·45	11·57	10·17‡	
Do you use a lid when heating up water? (%)						<0·0001
Yes	79·52	78·30‡	87·60	90·38‡	82·52	
No	20·48	21·70‡	12·40	9·62‡	17·48	
Do you recycle organic waste? (%)						<0·0001
Yes	46·78‡	47·63	63·56	70·36‡	58·43	
No	53·22‡	52·37	36·44	29·64‡	41·57	

* Because of missing data, sample size was 23 010.
† *P* values are based on χ^2 test.
‡ Values denote the highest and the lowest values.

administered between summer and early autumn (from June to October), a possible seasonal effect cannot be ruled out. This is also true for the share of organic food in the whole diet compared with the organic French market[38]. This may be due to the assessment tool itself (Org-FFQ), but it may also be a consequence of the profiles of the NutriNet-Santé participants who are volunteers in a nutrition cohort[39]. They exhibit not only specific socio-demographic characteristics[39] but also probably a higher interest in nutritional and health-related issues. Thus, extrapolation from the results must be done with caution. In addition, respondents to the Org-FFQ were more likely to be interested in sustainability issues. It is noteworthy that the use of a unique composition database to assess nutrient intakes did not allow the consideration of some differences in nutrient contents between organic and conventional foods, as reported in three recent meta-analyses (e.g. content in antioxidant or *n*-3 fatty acids)[20–22].

To conclude, these results indicate that organic or conventional food consumers cannot be considered as two single monolithic groups. Considering that conventional food consumption is systematically associated with a poor quality of diet compared with organic food consumption would be a simplistic approach in aetiological studies on the effects of organic food consumption. This has implications for future studies investigating the potential health impacts of organic food that should take into account all dimensions of dietary patterns. These findings also stress the need to foster the implementation of consistent targeted-group sustainable policies. Notably, in 2015, in France, sales have increased in every supply chain. At the same time, suppliers are seeking to reach out to consumers through diverse channels. As organic supply continues to diversify, so will the consumers. It is therefore crucial to delve further into the understanding of the motivations, perceptions, attitudes and purchase practices of the different types of consumers.

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