Food choice motives and the nutritional quality of diet during the COVID-19 lockdown in France

Lucile Marty, Blandine de Lauzon-Guillain, Maë Labesse, Sophie Nicklaus

Food choice motives and the nutritional quality of diet during the COVID-19 lockdown in France

Lucile Marty[a], Blandine de Lauzon-Guillain[c], Maë Labesse[b], Sophie Nicklaus[b]

[a] Department of Psychological Sciences, University of Liverpool, Eleanor Rathbone Building, Bedford Street South, Liverpool L69 7ZA, UK

[b] Centre des Sciences du Goût et de l'Alimentation, Agrosup Dijon, CNRS, INRAE, Université Bourgogne Franche-Comté, 17 rue Sully, 21065 Dijon Cedex, France

[c] Université de Paris, CRESS, INSERM, INRAE, 16 avenue Paul Vaillant-Couturier, 94807 Villejuif cedex, France

LM is the corresponding author, lucile.marty@liv.ac.uk

Abstract

To limit the transmission of COVID-19, nationwide lockdown was imposed in France between March, 17th and May, 10th 2020. This disruption in individuals' daily routines likely altered food consumption habits. We examined how changes in food choice motives related to changes in nutritional quality during the lockdown compared to before. A convenience sample of 938 French adults completed online questionnaires on the Qualtrics platform at the end of April 2020. Participants were retrospectively asked about their food choice motives and food consumption during the month before and in the first month of the lockdown. The importance of nine food choice motives was assessed: health, convenience, sensory appeal, natural content, ethical concern, weight control, mood, familiarity, and price, scoring from 1 to 4. Food intakes were recorded using a food frequency questionnaire including 110 foods, 12 non-alcoholic beverages and 4 alcoholic beverages. Adherence to the French dietary recommendations before and during the lockdown was estimated using the simplified PNNS-GS2 score, scoring from -17 to 11.5. The nutritional quality of diet was lower during the lockdown compared to before (-0.32, SD 2.28, $p<0.001$). Food choice motives significantly changed and an increase in the importance of weight control was associated with increased nutritional quality ($\beta=0.89$, $p<0.001$, partial $\eta^2=0.032$), whereas an increase in the importance of mood was associated with decreased nutritional quality ($\beta=-0.43$, $p=0.021$, partial $\eta^2=0.006$). The lockdown period in France was related to a decrease in nutritional quality of diet on average, which could be partly explained by changes in food choice motives. The lockdown was indeed related to modification of food choice motives, notably with an increase of weight control, health, natural content and ethical concern.

Keywords: nutritional quality; food choice motives; lockdown; COVID-19

1. Introduction

The world is currently facing the COVID-19 pandemic. To avoid fast-growing transmission of the virus, governmental authorities have had to impose nationwide lockdowns. In France, between March, 17th and May, 10th 2020, most of the population was asked to stay home. In order to limit drastically any human contact, the French were allowed to leave their home only for grocery shopping, medical care, legal obligations, physical activity within a 1 km radius; except for workers from essential sectors (e.g., healthcare, food factories and shops). During this period, all businesses that sold food remained open to the public. However, major disruptions in daily routines caused by the lockdown (e.g., home-working, restaurant closures) were likely to alter food consumption habits in the French population. Moreover, closed borders led to changes in the distribution and availability of food products (Morel, Stroobants, Bran, Iwaniuk, & Hauteville, 2020; Oxfam France, 2020).

A large part of humans' eating behaviours are habits, i.e., automatic associations between specific context cues and responses, which have history of repetition and reward. Habits form as people pursue goals by repeating the same responses in given contexts, and become automatic and hard to change (Wood & Runger, 2016). Because food choices are performed every day and usually in the same context, they likely result from a habitual response; notably, food choices have been shown to be stable in adulthood (Borland, Robinson, Crozier, & Inskip, 2008; Hu et al., 1999; Khani, Ye, Terry, & Wolk, 2004; Weismayer, Anderson, & Wolk, 2006). However, when people are undergoing changes in their environment, their habits are vulnerable to change as they engage in a new non-automatic process of decision making (Verplanken & Wood, 2006). We thus hypothesised that the unusual lockdown period may have caused discontinuities in food choice habits.

In a constructionist perspective, food choice decisions result from one's personal food values that are shaped by life course events, personal and social factors (Furst, Connors,

Bisogni, Sobal, & Falk, 1996; Sobal & Bisogni, 2009). Food values are computed by integrating a set of attributes (food choice motives) based on their importance or salience for an individual at the point of choice (Rangel, 2013). A change in food choice motives may thus lead to a change in food choice decisions. The most important food choice motives have been shown to be taste, cost, nutrition and convenience with a large interindividual variability (Glanz, Basil, Maibach, Goldberg, & Snyder, 1998). We hypothesised that people engaging in a new process of food choice decision making during the lockdown period may have caused changes in food choice motives associated with changes in food choice habits, resulting in modification of the nutritional quality of diet.

The present study aimed to examine the extent of changes in food choice motives during the lockdown and how it related to changes in nutritional quality of diet. We hypothesised that food choice motives and nutritional quality of diet changed during the first month of lockdown (from March, 17th to April, 16th 2020) compared to the month just before the lockdown (from February, 17th to March, 16th 2020). We also hypothesised that changes in food choice motives were associated with changes in nutritional quality. Because poor nutritional quality diet is one of the main risk factors for non-communicable diseases (Afshin et al., 2019), it is of importance to examine the effect of the lockdown on nutritional quality to help anticipating health consequences at a population level. Moreover, this unique nationwide disruption in daily life gives the opportunity to investigate how changes in food choice motives may influence the nutritional quality of diet at an individual level. The results may inform future public health actions that aim at tackling diet related non-communicable diseases by identifying which food choice motives changes may increase or decrease the nutritional quality of diet.

2. **Methods**

2.1. Design and data collection

This was a cross-sectional, pre-registered online experiment conducted in Qualtrics survey platform (www.qualtrics.com). 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). 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 lockdown) and had access to a computer or tablet with an internet connection. 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 during the lockdown and provided consent for their participation. Data were collected on April, 30th and May, 1st 2020. 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. Measures

2.2.1. Participants' characteristics

Participants' characteristics assessment included demographic questions (age, gender, employment status, highest educational qualification, professional situation during the lockdown, living area, type of housing, household composition, financial situation) and food-related behaviours questions (out-of-home eating habits before the lockdown, grocery shopping frequency and time spent cooking during the lockdown, changes in their eating habits during the lockdown, dietary restrictions, dieting status, weight and height at the time of the study). Participants also answered questions about their consumption of organic and local food products (not reported here). As participants were recruited during the COVID-19 pandemic, they were asked if they suspected having or having had COVID-19 and how

worried they were about their health. We also asked for current levels of stress, depression, and loneliness (3 individual items) on a continuous scale from 0 to 100.

2.2.2. Food choice motives

Food choice motives were assessed using a French version of the Food Choice Questionnaire developed in English by (Steptoe, Pollard, & Wardle, 1995) and adapted by (Cottet, Ferrandi, Lichtlé, & Plichon, 2017). The French version included 24 items and nine subscales: health (3 items), convenience (3 items), sensory appeal (3 items), natural content (3 items), ethical concern (2 items), weight control (3 items), mood (3 items), familiarity (2 items), and price (2 items). See Additional file – section 1 for the items in French and in English. Instructions were adapted to assess food choice motives during the month before the lockdown and during the first month of the lockdown simultaneously. For each subscale, two scores were computed by averaging ratings for individual items before and during the lockdown, respectively. The scores ranged from 1 to 4: 1 = Not at all important; 2 = A little important; 3 = Moderately important; 4 = Very important. Δ motives were calculated as the difference of the score for each of the nine subscales during and before the lockdown. Δ motives > 0 indicated higher importance of the motives during the lockdown compared to before.

2.2.3. Food consumption and dietary nutritional quality

Food consumption was retrospectively assessed for the month before the lockdown and the first month of the lockdown simultaneously using a food frequency questionnaire (FFQ) 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 before and during the lockdown were estimated with photos for different food types on a 5-level scale, derived from the SU.VI.MAX portion book (Hercberg,

Deheeger, & Preziosi, 2002), for 72 commonly eaten food items, and by the intermediate portion size for the 38 remaining food items. Participants were also asked the size of the glass or cup they used before and during the lockdown for each non-alcoholic beverage and standard servings were used to estimate alcoholic beverage amounts. Consumption frequency of each item before and during the lockdown was transformed into daily frequency, and daily intake was calculated by multiplying the daily frequency by the estimated portion size. Individual nutrients intakes were calculated before and during the lockdown by multiplying the daily intake of each food item by its nutritional values from the SU.VI.MAX nutrient composition database (Hercberg, 2006).

Adherence to the French dietary recommendations was evaluated during the month before the lockdown and during the first month of the lockdown using the simplified PNNS-GS2 score (sPNNS-GS2), an index previously designed to reflect the 2017 French main dietary recommendations (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). The sPNNS-GS2 calculation has been previously described by Chaltiel et al., 2019. A weight for each component is defined according to the level of evidence of the association between food groups consumption and health status. sPNNS-GS2 scores were computed for each participant before and during the lockdown (range: -17 to 11.5). Slight modifications were brought to the calculation of the score. The sPNNS-GS2 originally included bonus points for added fat below 16% of energy intake (Chaltiel et al., 2019). The FFQ did not make it possible to calculate the percentage of energy intake accounted for added fat and this component was excluded from the score calculation.

However, a modified version of the sPNNS-GS2 including an added fat component based on the ratio of plant over animal fat was also calculated. The main analysis was performed on this indicator and results were similar (see Additional file – section 2). In addition, the only whole grain food included in the used FFQ was whole grain bread. To obtain an estimation of other whole grain foods consumption frequency as required by the sPNNS-GS2 calculation, we calculated the ratio whole grain bread/(whole grain bread + white bread) and multiplied the consumption frequency of other grains (pasta, rice and semolina) by this ratio.

2.3. Outcome

The primary outcome, Δ quality, was the difference in nutritional quality of diet (sPNNS-GS2) between during and before the lockdown. Δ quality > 0 indicated better nutritional quality during the lockdown compared to before.

2.4. Statistical analyses

Hypotheses were specified before the data were collected and we followed an analytic plan that was pre-registered before data analysis (https://osf.io/gwfdb/). 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. ≥ 500 kcal/day and ≤ 3500 kcal/day for women, and ≥ 800 kcal/day and ≤ 4000 kcal/day for men (Banna, McCrory, Fialkowski, & Boushey, 2017; Willett, 2013).

For descriptive purposes, we compared food choice motives scores and sPNNGS-2 components scores before and during the lockdown using paired T-tests. As exploratory analyses, we also examined whether changes in food choice motives or nutritional quality during the lockdown compared to before differed across population subgroups using one-way ANOVAs: people who are younger vs. older, male vs. female, normal-weight vs. overweight, lower vs. higher educational level, facing financial difficulties vs. people who were not, living

alone during the lockdown vs. with others, living in a city vs. in the countryside, usually having meal out of home at least four times a week vs. less than 4 times a week, infected by the corona virus vs. not infected. We then examined the influence of changes in food choice motives during and before the lockdown on the difference in nutritional quality of diet by running a multiple linear regression including the nine Δ motives as predictors and Δ quality as the dependant variable (main model). Sensitivity analyses were conducted to examine whether the pattern of results from the main model differed: 1/ including age, gender, highest educational level and reported BMI as covariates (adjusted model), 2/ excluding participants who declared that they did not make any noticeable change in their diet during the lockdown, 3/ excluding participants who declared that they often did not find in store what they wanted to buy during the lockdown, as change in diet quality could be due more to external constraints than to personal motives, 4/ excluding participants who declared that they went to work as normal during the lockdown. As an additional exploratory analysis, we also adjusted the main model for the variables with significant effects on Δ motives or Δ quality in the exploratory one-way ANOVAs.

All statistical analyses were performed using SAS version 9.3 (SAS Institute, Inc., 2012 SAS® 9.3. Cary, NC). The level of significance was set at $p < 0.05$ applying Bonferroni correction for multiple comparisons where appropriate.

2.5. Sample size calculation

We aimed to recruit a sample size of 1,000 participants to detect small differences in food choice motives scores and sPNNS-GS2 score before and during the lockdown using paired t-tests (d = 0.1) and small effects of Δ motives on Δ quality in a multiple linear regression including nine predictors ($f^2 = 0.016$) at power 0.80 and level of significance 0.05 (GPower 3.1).

3. **Results**

3.1. Participants

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 **Table 1**. Eighteen participants declared that they suspected having COVID-19 when they completed the study and 59 declared that they suspected having had COVID-19 before. Six hundred participants (64%) declared being slightly to very worried about their health. On average levels of stress, depression, and loneliness were 26 (SD 28), 23 (SD 25), and 34 (SD 28) respectively on a scale from 0 to 100.

Table 1. Participants' characteristics, n=938

Age, *years*, mean (SD)	38.7 (11.6)
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)
Situation during the lockdown, n (% of workers)	
(several possible answers)	
Going to workplace	194 (20.7)
Working from home	418 (57.6)

Furloughed	122 (13.0)
Other	91 (9.7)
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)
Type of housing, n (%)	
House	498 (53.1)
Flat	440 (46.9)
Household composition, n (%)	
1 adult	206 (22.0)
2 adults	246 (26.2)
> 2 adults	138 (14.7)
2 adults with children (<14 years old)	220 (23.5)
Other	128 (13.6)
Financial situation, n (%)	
Stable	660 (70.4)
Precarious	272 (29.0)
Chose not to answer	6 (0.6)
Eating out of home before the lockdown, n (%)	
3 times per month or less	378 (40.3)
Once to 3 times a week	241 (25.7)
4 to 6 times a week	280 (29.9)
7 times per week or more	39 (4.1)
Grocery shopping frequency during the lockdown, n (%)	

Twice a week or more	157 (16.7)
Once a week	493 (52.6)
Less than once a week	288 (30.7)
Difficulties to find food during the lockdown, n (%)	
Often	104 (11.1)
Sometimes	465 (49.6)
Rarely	272 (29.0)
Never	97 (10.3)
Increase in time spent cooking during the lockdown, n (%)	780 (83.2)
Changes in eating habits during the lockdown, *yes,* n (%)	747 (79.6)
Dietary restrictions, *none*, n (%)	834 (88.9)
Dieting status, *yes*, n (%)	132 (14.1)
Reported BMI, kg/m^2, mean (SD)	24.5 (4.88)
Implausible[a], n (%)	10 (1.1)

[a]Excluding weight < 30 kg or > 250 kg, height < 1.45 m or > 3 m (Hardy, Johnson, & Park, 2016; Miller, 2003)

3.2. Food choice motives and nutritional quality of diet before and during the lockdown

Food choice motives changed significantly during the lockdown compared to before (**Table 2**). In particular, 48% of the participants declared that mood was more important in their food choices during the lockdown compared to before and 48% declared that convenience was less important. Health and weight control were more important during the lockdown compared to before for 26 and 29% of the participants, respectively.

Table 2. Food choice motives before and during the lockdown, n=938

	Before lockdown	**During lockdown**	**Difference during vs.**	**p-value[b]**	**Increased during vs.**	**Unchanged during vs.**	**Decrease during vs.**

	mean (SD)[a]	mean (SD)[a]	before		before[c] n (%)	before[d] n (%)	before[e] n (%)
Δ Weight control	2.29 (0.71)	2.43 (0.80)	0.14 (0.53)	<.001	275 (29.3)	546 (58.2)	117 (12.5)
Δ Mood	2.21 (0.71)	2.46 (0.75)	0.25 (0.41)	<.001	453 (48.3)	426 (45.4)	59 (6.3)
Δ Health	2.74 (0.69)	2.85 (0.71)	0.12 (0.38)	<.001	247 (26.3)	619 (66.0)	72 (7.7)
Δ Sensory appeal	3.32 (0.54)	3.34 (0.56)	0.02 (0.25)	0.004	128 (13.7)	730 (77.8)	80 (8.5)
Δ Familiarity	2.55 (0.73)	2.44 (0.77)	-.12 (0.52)	<.001	113 (12.1)	592 (63.1)	233 (24.8)
Δ Price	2.86 (0.61)	2.81 (0.70)	-.05 (0.53)	0.003	152 (16.2)	591 (63.0)	195 (20.8)
Δ Ethical concern	2.83 (0.82)	2.91 (0.82)	0.07 (0.45)	<.001	196 (20.9)	644 (68.7)	98 (10.4)
Δ Natural content	2.89 (0.80)	2.95 (0.80)	0.06 (0.36)	<.001	176 (18.8)	673 (71.7)	89 (9.5)
Δ Convenience	2.51 (0.82)	2.10 (0.78)	-.41 (0.75)	<.001	93 (9.9)	400 (42.6)	445 (47.5)

Cronbach's α before: Health (0.71), Convenience (0.89), Sensory appeal (0.67), Natural content (0.86), Ethical concern (0.66), Weight control (0.81), Mood (0.65), Familiarity (0.64), Price (0.63). Cronbach's α during: Health (0.72), Convenience (0.85), Sensory appeal (0.66), Natural content (0.86), Ethical concern (0.64), Weight control (0.84), Mood (0.64), Familiarity (0.64), Price (0.67).

[a] range: 1 to 4, [b] paired t-tests, Bonferroni corrected alpha level: 0.006, [c] corresponds to participants with Δ motives > 0, [d] Δ motives = 0, [e] Δ motives < 0

On average, the participants consumed 1700 kcal/day (SD 596) during the month before the lockdown and 1935 kcal/day (SD 656) during the first month of lockdown and this increase was statistically significant (paired t-test: $t(937) = 13.57$, $p < 0.001$). Overall, the nutritional quality of diet significantly decreased during the first month of the lockdown compared to the month before (**Table 3**). Despite an increase in fruit and vegetables, pulses, fish and seafood consumption, the sharp increase in processed meat, sweet-tasting beverages and alcoholic beverages consumption negatively affected the sPNNS-GS2 score.

Table 3. Comparison of the nutritional quality of diet before and during the lockdown

	Recommendation	Before lockdown mean (SD)	During lockdown mean (SD)	p-value[a]
sPNNS-GS2 score[b]		1.2 (2.5)	0.8 (2.8)	<.001
Score components				
Fruit and vegetables (frequency/day)	At least 5 servings/day	2.6 (1.6)	3.2 (1.8)	<.001
Pulses (frequency/week)	At least 2 servings/week	0.7 (1.1)	0.9 (1.3)	<.001
Whole-grain foods (frequency/day)	Every day	0.5 (0.6)	0.6 (0.7)	0.019
Nuts (g/day)	A handful/day[c]	2.8 (5.2)	2.7 (5.8)	0.371
Dairy products (frequency/day)	2 servings/day	2.3 (1.4)	2.5 (1.4)	<.001
Fish and seafood (frequency/week)	2 servings/week	1.6 (1.5)	1.7 (1.5)	0.002
Red meat (g/week)	<500 g/week	292 (266)	302 (280)	0.154
Processed meat (g/week)	<150 g/week	113 (133)	145 (172)	<.001
Sugary foods (% EIWA)	<10% EIWA	11.6 (7.1)	12.5 (7.9)	<.001
Sweet-tasting beverages (ml/day)	0 ml/day	177 (376)	213 (413)	<.001
Alcoholic beverages (g of alcohol/week)	<100 g of alcohol/week	30 (59)	39 (72)	<.001
Salt (g/day)	<8 g/day	2.9 (1.1)	3.2 (1.2)	<.001

249 EIWA, energy intake without alcohol.

[a] paired t-tests, Bonferroni corrected alpha level: 0.004, [b] without added fat component, range from -17 to 11.5. [c] one serving/handful of nuts = 30g (Chaltiel et al., 2019).

We explored whether changes in food choice motives and nutritional quality during the lockdown compared to before differed across population subgroups and found relatively few significant differences (see Additional file – section 3).

When examining the influence of changes in food choice motives on changes of the nutritional quality of diet during the lockdown compared to before, we found that increased importance of weight control motives was associated with increased nutritional quality and that increased importance of mood motives was associated with decreased nutritional quality in both raw and adjusted multiple linear regressions (**Table 4**). Changes in other food choice motives were not associated with changes in the nutritional quality of diet. In the other three multiple linear regressions testing the influence of changes in food choice motives on changes of the nutritional quality conducted as sensitivity analyses (i.e., excluding participants who declared that they did not have made any noticeable change in their diet during the lockdown, excluding participants who declared that they often did not find in store what they wanted to buy during the lockdown, excluding participants who declared that they went to work as normal during the lockdown), Δ weight control and Δ mood remained significant or marginally significant predictors of Δ quality (see Additional file – section 4). In addition, the exploratory adjusted model, including the variables from exploratory analyses for which we found differences in Δ motives or Δ quality, also led to similar results (see Additional file – section 4).

Table 4. Influence of Δ motives on the difference in nutritional quality of diet between during and before the lockdown, dependant variable: Δ quality

	Raw model (n=938) $R^2 = 0.057$			**Adjusted model[a] (n=927)** $R^2 = 0.076$		
	β estimate	**p-value**	**partial η^2**	**β estimate**	**p-value**	**partial η^2**
(Intercept)	-.39	<.001		0.24	0.656	
Δ Weight control	0.89	<.001	0.032	0.99	<.001	0.043
Δ Mood	-.43	0.021	0.006	-.42	0.035	0.006
Δ Health	0.31	0.227	0.002	0.29	0.285	0.002
Δ Sensory appeal	0.21	0.491	0.001	0.27	0.418	0.001
Δ Familiarity	-.15	0.312	0.001	-.14	0.391	0.001
Δ Price	-.11	0.427	0.001	-.20	0.197	0.002
Δ Ethical concern	-.09	0.621	<.001	-.30	0.155	0.003
Δ Natural content	-.07	0.811	<.001	0.17	0.573	<.001
Δ Convenience	0.01	0.895	<.001	0.04	0.765	<.001

Variance inflation factor: Δ Health (1.72), Δ Convenience (1.23), Δ Sensory appeal (1.17), Δ Natural content (1.80), Δ Ethical concern (1.40), Δ Weight control (1.37), Δ Mood (1.08), Δ Familiarity (1.18), Δ Price (1.08). Δ quality is the difference in sPNNS-GS2 score during the lockdown compared to before. Δ quality > 0 indicated better nutritional quality during the lockdown compared to before. Δ motives > 0 indicated higher importance of the motives during the lockdown compared to before.

[a] Control variables: age, gender, BMI, highest educational qualification.

4. Discussion

To our knowledge, this is the first study that investigated changes in food choice motives associated with nutritional changes during the lockdown in France. Significant changes in food choice motives during the lockdown were observed with an increase in the

importance of health, weight control, ethical concern, natural content, sensory appeal, and mood, and a significant decrease in the importance of convenience, familiarity, and price. The participants reported a 14% increase in energy intake and a decrease in nutritional quality of their diet during the lockdown compared to before. An increase in the importance of weight control during the lockdown was associated with increased nutritional quality, whereas an increase in the importance of mood was associated with decreased nutritional quality. Changes in the importance of other food choice motives were not associated with changes in nutritional quality of diet.

Increase in energy intake and unhealthier dietary patterns during the lockdown compared to before were also described in a study conducted among 37,252 French adults from the web-based NutriNet-Santé cohort (Deschasaux-Tanguy et al., 2020). The authors found an energy intake of 1942 kcal/day during the lockdown, which is similar to the reported energy intake reported during the lockdown in the present study (1935 kcal/day on average). The authors highlighted weight gain for 35% of the sample and increased consumption of sweets, biscuits, and cakes. Consistently, despite the fact that the participants of the present study increased their intake of fruit and vegetables, pulses, fish and seafood, they also increased their consumption of processed meat, sugary foods, sweet-tasting beverages and alcoholic beverages leading to a decrease in nutritional quality of their diet on average. These changes in food consumption patterns echo studies showing increased snacking during the lockdown (Deschasaux-Tanguy et al., 2020; Sanchez & Moreno, 2020), as fatty-sweet products and sweet-tasting beverages (including fruit juices) are usually consumed during snacking episodes by French adults (Si Hassen et al., 2018). In addition, a survey on 3,000 French adults reported that 42% declared having pre-meal drinks ("*apéritif*") more often during than before the lockdown (Darwin Nutrition & IFOP, 2020). Pre-meal drinks are usually the first part of a meal, opening a social eating time and are often accompanied by

311 finger foods (Danesi, 2018). The deterioration of nutritional quality during the lockdown may
312 be partly due to increased number of social and festive eating occasions within the home,
313 associated with consumption of low-nutritional-quality foods (e.g., sweet-tasting beverages
314 and alcoholic beverages, processed meat, sugary foods). Changes in health, ethical concern,
315 natural content, sensory appeal, and price food choice motives during the lockdown are in line
316 with the results of a survey conducted among a representative sample of 1,005 French adults
317 where the participants declared changes in their perception of the ecological (49%), social
318 (47%) and economical (57%) values of the food during the lockdown (YouGov, 2020). The
319 decrease in the importance of convenience for 48% of our sample mirrored that 83% declared
320 that they increased their time spent cooking during the lockdown. Collectively, these changes
321 in food choice motives may reflect a growing awareness of the importance of the
322 sustainability of food choices where preserving health and pleasure from eating, protecting the
323 environment and guaranteeing decent wages to farmers are equally important (FAO & WHO,
324 2019).

325 Increase in the importance of weight control (29% of the participants) and mood (48%
326 of the participants) food choice motives were prominent and associated with opposite changes
327 in nutritional quality of diet. Stress, feeling of emptiness and boredom management by eating
328 were common behaviours in the French population during the lockdown with 63%, 63%, and
329 57% prevalence in a 1,092 sample of French adults, respectively (Cherikh et al., 2020).
330 Occasional emotion regulation by eating is associated with the consumption of sweet foods
331 (De Lauzon et al., 2004; Macht & Simmons, 2011) which may explain the negative
332 relationship between changes in mood food choice motive and nutritional quality of diet. On
333 the contrary, increased importance of weight control led to increased nutritional quality,
334 suggesting that participants engaging in weight management behaviour successfully stuck
335 with their goal by managing their food intake during the first month of the lockdown. In line

with our results, a study investigating eating behaviour during the lockdown in 2,364 UK adults showed that 35% of the participants declared eating a more healthy and balanced diet during the lockdown compared to before (Robinson et al., unpublished results). It is worth noticing that in the present study increased importance of health as a food choice motive was not significantly correlated with increased nutritional quality; whereas people more motivated by health were reported to adopt healthier diet than people less motivated by health (Konttinen, Sarlio-Lähteenkorva, Silventoinen, Männistö, & Haukkala, 2012; Naughton, McCarthy, & McCarthy, 2015). Moreover, we would have expected an increase in nutritional quality when price became less important because of the positive association between price and nutritional quality across individual food items (Andrieu, Darmon, & Drewnowski, 2006; Marty et al., 2015; Rehm, Monsivais, & Drewnowski, 2011), but this is not supported by these data. Similarly, we would have expected an increase in nutritional quality when convenience became less important because the degree of food processing and convenience were shown to be negatively associated with nutritional quality (Martínez Steele, Popkin, Swinburn, & Monteiro, 2017; Poti, Mendez, Ng, & Popkin, 2015). Our results suggest that choosing more expensive and less convenient foods (i.e., requiring more effort and time to prepare) did not necessarily translate into better nutritional quality of diet. Overall, the difference in the measured food choice motives only explained 5.7% of the variance of the change in the nutritional quality during compared to before the lockdown. Nutritional quality is multidimensional by nature; food choices are complex decisions and various other variables may have influenced what people chose to eat and the resulting nutritional quality of their diet during the lockdown, for instance the availability of food products.

Strengths and limitations

We were able to collect detailed information about food consumption during the month before the lockdown and during the first month of the lockdown in a large sample of

French adults. Our study was timely as the data were collected two weeks after the end of the first month of the lockdown. However, the participants retrospectively reported their food consumption which is a clear limitation of this study. We could not anticipate the lockdown and organise a measurement point before the lockdown. Participants were asked to report simultaneously for each food item their consumption before and during the lockdown which made it easier reporting differences in consumption frequency, even if a recall bias could have affected the responses for the period before the lockdown. In other respects, due to this exceptional situation, we compared food consumption in March (before the lockdown, end of winter) and in April (during the lockdown, beginning of spring). We could have expected a season effect in our data, with an improvement of the nutritional quality of diet in April compared to March due to increased availability of fresh fruit and vegetables, although access to fresh product may have been limited by the lockdown (Oxfam France, 2020). Finally, due to unexpectedly high numbers of participants who failed an attention check or reported implausible energy intake (16.4% of the eligible participants who completed the study), we did not reach the sample size of 1,000 participants we aimed for. However, a sample size of 938 participants still allowed to detect small effects of Δ motives on Δ quality in a multiple linear regression including nine predictors ($f^2 = 0.017$) at power 0.80 and level of significance 0.05 (GPower 3.1). A limitation of this study is that the sample was not representative of the French population and included more women and individuals with higher educational level. This is often the case in studies with volunteers on this topic (Deschasaux-Tanguy et al., 2020). In addition, the participants were recruited from a population registered in the Chemosens Platform's PanelSens database, gathering individuals who agreed to be contacted to take part in research studies exploring eating behaviours. Thus, it is likely that our sample was biased towards individuals with an interest in food. However, this can also be viewed as a strength as these individuals were more likely to have paid attention to what they ate before

and during the lockdown and consequently to have cautiously reported their food consumption.

Future research

In a follow-up study, it would be interesting to investigate whether changes in food choice motives and nutritional quality remain stable overtime. Moreover, we analysed the nutritional quality, but the lockdown may also have influenced other characteristics of diet (e.g., proportion of organic and local products). A secondary objective of this online survey was to compare consumption of organic and locally produced food before and during the lockdown and to examine how it related to nutritional quality of diet. The collected data about consumption of organic and local food products before and during the lockdown will be analysed separately. An unanswered question is how diet of more disadvantaged populations was modified during the lockdown and specific studies are needed to describe food choices and eating behaviours among these populations. Finally, only increased weight control food choice motive significantly predicted a better nutritional quality of diet. The increase in health food choice motive did not translate into better nutritional quality of diet. Yet, numbers of public health actions aim at increasing motivation towards health to encourage the individuals to make healthier food choices (Capewell & Capewell, 2017; Frieden, 2010). Our results suggest that increasing the importance of health as a food choice motive might not be sufficient to increase the nutritional quality of diet, maybe because of a lack of nutritional knowledge. From this perspective, making nutritional information easy to understand and directly accessible by consumers at the point of choice should be prioritised, e.g., the front-of-pack nutrition label Nutriscore (Egnell et al., 2018).

Conclusion

409 The lockdown period in France was related to a decrease in nutritional quality of diet
410 on average which could be partly explained by changes in food choice motives. The lockdown
411 was indeed related to modification of food choice motives in this sample. For instance,
412 whereas the importance of convenience and price motives decreased, the importance of
413 health, natural content and ethic motives increased, suggesting a growing awareness of the
414 importance of sustainable food choices.

415

416 **Acknowledgments**

417 We thank the ChemoSens platform for the help with data collection, in particular C. Martin
418 and F. Durey; and V. Feyen for her help with participant management. This work was
419 supported by grants from ANR (ANR-15-CE21-0014, PUNCH grant to SN), the Conseil
420 Régional Bourgogne, Franche-Comte (PARI grant) and the FEDER (European Funding for
421 Regional Economic Development). The funders had no role in planning, conducting, or
422 interpreting the study.

423

424 **Author contributions**

425 LM and SN designed the study and were responsible for data collection. LM and ML
426 analysed the data. BLG developed the food frequency questionnaire and assisted in data
427 analyses. LM was responsible for initial drafting of the paper, and all authors read and
428 approved the final manuscript.

429

430 **References**

431 Afshin, A., Sur, P. J., Fay, K. A., Cornaby, L., Ferrara, G., Salama, J. S., … Murray, C. J. L.

(2019). Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet*, *393*(10184), 1958–1972. http://doi.org/10.1016/S0140-6736(19)30041-8

Andrieu, E., Darmon, N., & Drewnowski, A. (2006). Low-cost diets: more energy, fewer nutrients. *European Journal of Clinical Nutrition*, *60*(3), 434–6. http://doi.org/10.1038/sj.ejcn.1602331

Banna, J. C., McCrory, M. A., Fialkowski, M. K., & Boushey, C. (2017). Examining Plausibility of Self-Reported Energy Intake Data: Considerations for Method Selection. *Frontiers in Nutrition*, *4*(September), 1–6. http://doi.org/10.3389/fnut.2017.00045

Borland, S. E., Robinson, S. M., Crozier, S. R., & Inskip, H. M. (2008). Stability of dietary patterns in young women over a 2-year period. *European Journal of Clinical Nutrition*, *62*(1), 119–126. http://doi.org/10.1038/sj.ejcn.1602684

Capewell, S., & Capewell, A. (2017). An effectiveness hierarchy of preventive interventions: Neglected paradigm or self-evident truth? *Journal of Public Health*, *40*(2), 350–358. http://doi.org/10.1093/pubmed/fdx055

Chaltiel, D., Adjibade, M., Deschamps, V., Touvier, M., Hercberg, S., Julia, C., & Kesse-Guyot, E. (2019). Programme national nutrition santé - Guidelines score 2 (pnns-gs2): Development and validation of a diet quality score reflecting the 2017 French dietary guidelines. *British Journal of Nutrition*, *122*(3), 331–342. http://doi.org/10.1017/S0007114519001181

Cherikh, F., Frey, S., Bel, C., Attanasi, G., Alifano, M., & Iannelli, A. (2020). Behavioral Food Addiction During Lockdown: Time for Awareness, Time to Prepare the Aftermath. *Obesity Surgery*, 3–5. http://doi.org/10.1007/s11695-020-04649-3

455 Cottet, P., Ferrandi, J., Lichtlé, M., & Plichon, V. (2017). La compréhension des moteurs des
456 comportements alimentaires : une approche par le food choice questionnaire. In *12ème*
457 *Journée du Marketing Agroalimentaire* (hal-01900329). Montpellier, France.

458 Danesi, G. (2018). A cross-cultural approach to eating together: Practices of commensality
459 among French, German and Spanish young adults. *Social Science Information*, *57*(1),
460 99–120. http://doi.org/10.1177/0539018417744680

461 Darwin Nutrition, & IFOP. (2020). Quel est l'impact du confinement sur le poids et les
462 habitudes alimentaires des Français ? Retrieved July 28, 2020, from https://www.darwin-
463 nutrition.fr/actualites/alimentation-francais/

464 De Lauzon, B., Romon, M., Deschamps, V., Lafay, L., Borys, J. M., Karlsson, J., … Charles,
465 M. A. (2004). The Three-Factor Eating Questionnaire-R18 is able to distinguish among
466 different eating patterns in a general population. *Journal of Nutrition*, *134*(9), 2372–
467 2380. http://doi.org/10.1093/jn/134.9.2372

468 Deschasaux-Tanguy, M., Druesne-Pecollo, N., Esseddik, Y., Szabo de Edelenyi, F., Alles, B.,
469 Andreeva, V. A., … Touvier, M. (2020). Diet and physical activity during the COVID-
470 19 lockdown period (March-May 2020): results from the French NutriNet-Sante cohort
471 study. *MedRxiv*, (June), preprint. http://doi.org/10.1101/2020.06.04.20121855

472 Egnell, M., Ducrot, P., Touvier, M., Allès, B., Hercberg, S., Kesse-Guyot, E., & Julia, C.
473 (2018). Objective understanding of Nutri-Score Front-Of-Package nutrition label
474 according to individual characteristics of subjects: Comparisons with other format labels.
475 *PLoS ONE*, *13*(8), 1–16. http://doi.org/10.1371/journal.pone.0202095

476 FAO, & WHO. (2019). *Sustainable healthy diets - Guiding principles*. Rome.

477 Frieden, T. R. (2010). A framework for public health action: The health impact pyramid.

American Journal of Public Health, *100*(4), 590–595. http://doi.org/10.2105/AJPH.2009.185652

Furst, T., Connors, M., Bisogni, C. A., Sobal, J., & Falk, L. W. (1996). Food choice: A conceptual model of the process. *Appetite*, *26*, 247–265. http://doi.org/10.1006/appe.1996.0019

Glanz, K., Basil, M., Maibach, E., Goldberg, J., & Snyder, D. (1998). Why Americans eat what they do: Taste, nutrition, cost, convenience and weight control concerns as influences on food consumption. *J Am Diet Assoc*, *98*, 1118–1126.

Hercberg, S. (2006). *Table de composition des aliments SU.VI.MAX* (Economica).

Hercberg, S., Deheeger, M., & Preziosi, P. (2002). *SU.VI.MAX. Portions alimentaires : manuel photos pour l'estimation des quantités*. Paris.

Hu, F. B., Rimm, E., Smith-Warner, S. A., Feskanich, D., Stampfer, M. J., Ascherio, A., … Willett, W. C. (1999). Reproducibility and validity of dietary patterns assessed with a food- frequency questionnaire. *American Journal of Clinical Nutrition*, *69*(2), 243–249. http://doi.org/10.1093/ajcn/69.2.243

Kadawathagedara, M., Kersuzan, C., Wagner, S., Tichit, C., Gojard, S., Charles, M. A., … de Lauzon-Guillain, B. (2017). Adéquation des consommations alimentaires des femmes enceintes de l'étude ELFE aux recommandations du Programme national nutrition santé. *Cahiers de Nutrition et de Dietetique*, *52*(2), 78–88. http://doi.org/10.1016/j.cnd.2016.12.001

Khani, B. R., Ye, W., Terry, P., & Wolk, A. (2004). Reproducibility and Validity of Major Dietary Patterns among Swedish Women Assessed with a Food-Frequency Questionnaire. *The Journal of Nutrition*, *134*(6), 1541–1545.

http://doi.org/10.1093/jn/134.6.1541

Konttinen, H., Sarlio-Lähteenkorva, S., Silventoinen, K., Männistö, S., & Haukkala, A. (2012). Socio-economic disparities in the consumption of vegetables, fruit and energy-dense foods: The role of motive priorities. *Public Health Nutrition*, *16*(5), 873–882. http://doi.org/10.1017/S1368980012003540

Macht, M., & Simmons, G. (2011). Emotional Eating. In I. Nyklíček, A. Vingerhoets, & M. Zeelenberg (Eds.), *Emotion Regulation and Well-Being*. New York, NY: Springer. http://doi.org/10.1017/CBO9781107415324.004

Martínez Steele, E., Popkin, B. M., Swinburn, B., & Monteiro, C. A. (2017). The share of ultra-processed foods and the overall nutritional quality of diets in the US: Evidence from a nationally representative cross-sectional study. *Population Health Metrics*, *15*(1), 1–11. http://doi.org/10.1186/s12963-017-0119-3

Marty, L., Dubois, C., Gaubard, M. S., Maidon, A., Lesturgeon, A., Gaigi, H., & Darmon, N. (2015). Higher nutritional quality at no additional cost among low-income households: Insights from food purchases of "positive deviants." *American Journal of Clinical Nutrition*, *102*(1). http://doi.org/10.3945/ajcn.114.104380

Morel, S., Stroobants, J.-P., Bran, M., Iwaniuk, J., & Hauteville, J.-M. (2020). Coronavirus : la pénurie de saisonniers paralyse l'agriculture européenne. Retrieved July 28, 2020, from https://www.lemonde.fr/economie/article/2020/04/07/coronavirus-la-penurie-de-saisonniers-paralyse-l-agriculture-europeenne_6035779_3234.html

Naughton, P., McCarthy, S. N., & McCarthy, M. B. (2015). The creation of a healthy eating motivation score and its association with food choice and physical activity in a cross sectional sample of Irish adults. *International Journal of Behavioral Nutrition and Physical Activity*, *12*(1), 1–10. http://doi.org/10.1186/s12966-015-0234-0

525 Oxfam France. (2020). Coronavirus : derrière la crise sanitaire, la crise alimentaire guette.
526 Retrieved July 28, 2020, from https://www.oxfamfrance.org/agriculture-et-securite-
527 alimentaire/coronavirus-derriere-crise-sanitaire-crise-alimentaire-guette/

528 Poti, J. M., Mendez, M. A., Ng, S. W., & Popkin, B. M. (2015). Is the degree of food
529 processing and convenience linked with the nutritional quality of foods purchased by US
530 households? *American Journal of Clinical Nutrition*, *101*(6), 1251–1262.
531 http://doi.org/10.3945/ajcn.114.100925

532 Rangel, A. (2013). Regulation of dietary choice by the decision-making circuitry. *Nature*
533 *Neuroscience*, *16*(12), 1717–24. http://doi.org/10.1038/nn.3561

534 Rehm, C. D., Monsivais, P., & Drewnowski, A. (2011). The quality and monetary value of
535 diets consumed by adults in the United States. *The American Journal of Clinical*
536 *Nutrition*, *94*, 1333–9. http://doi.org/10.3945/ajcn.111.015560.1

537 Robinson, E., Boyland, E., Chisholm, A., Harrold, J., Maloney, N. G., Marty, L., …
538 Hardman, C. A. (unpublished results). Obesity, eating behavior and physical activity
539 during COVID-19 lockdown: A study of UK adults.

540 Sanchez, J., & Moreno, N. (2020). How COVID-19 is impacting our eating & drinking habits.
541 In *Kantar Worldpanel Webminar*.

542 Si Hassen, W., Castetbon, K., Tichit, C., Péneau, S., Nechba, A., Ducrot, P., … Méjean, C.
543 (2018). Energy, nutrient and food content of snacks in French adults. *Nutrition Journal*,
544 *17*(1), 1–9. http://doi.org/10.1186/s12937-018-0336-z

545 Sobal, J., & Bisogni, C. A. (2009). Constructing food choice decisions. *Annals of Behavioral*
546 *Medicine*, *38*(SUPPL.). http://doi.org/10.1007/s12160-009-9124-5

547 Steptoe, A., Pollard, T. M., & Wardle, J. (1995). Development of a Measure of the Motives

548 Underlying the Selection of Food: the "Food Choice Questionnaire." *Appetite*, *25*, 267–
549 284.

550 Verplanken, B., & Wood, W. (2006). Interventions to Break and Create Consumer Habits.
551 *American Marketing Association*, *25*(1), 90–103. http://doi.org/10.1007/978-1-4020-
552 5908-7_18

553 Weismayer, C., Anderson, J. G., & Wolk, A. (2006). Changes in the Stability of Dietary
554 Patterns in a Study of Middle-Aged Swedish Women. *The Journal of Nutrition*, *136*(6),
555 1582–1587. http://doi.org/10.1093/jn/136.6.1582

556 Willett, W. (2013). *Nutritional Epidemiology* (3rd ed.). Oxford University Press.

557 Wood, W., & Runger, D. (2016). Psychology of habits. *Annual Review of Psychology*, *67*,
558 289–314. http://doi.org/10.1146/annurev-psych-122414-033417

559 YouGov. (2020). Confinement : la valeur économique, écologique et sociale de la nourriture a
560 évolué en France. Retrieved July 28, 2020, from
561 https://fr.yougov.com/news/2020/05/28/confinement-la-valeur-de-la-nourriture-a-evolue/

562

563