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

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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

38 1. Introduction

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

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

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

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

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

86 2. Methods

87 2.1. Design and data collection

88 This was a cross-sectional, pre-registered online experiment conducted in Qualtrics
89 survey platform (www.qualtrics.com). Participants were recruited by emailing individuals
90 from a population registered in the Chemosens Platform's PanelSens database at Centre des
91 Sciences du Goût et de l'Alimentation (Dijon). This database was declared to the relevant
92 authority (Commission Nationale Informatique et Libertés; CNIL; n°1148039). Eligible
93 participants were aged over 18, had been residing in France at least since February 17th, 2020
94 (i.e., one month before the lockdown) and had access to a computer or tablet with an internet
95 connection. Eligible participants who completed the study received compensation in return for
96 their participation (15€ Amazon voucher). The study was approved by the ethical evaluation
97 committee for research of INSERM (reference: n°20-683, delivered on April 27th, 2020). All
98 participants were informed that the purpose of the study was to investigate food choices
99 during the lockdown and provided consent for their participation. Data were collected on
100 April, 30th and May, 1st 2020. Three attention check questions (e.g., 'How many times have
101 you visited the planet Mars?') were included in various parts of the questionnaire.

102 2.2. Measures

103 2.2.1. Participants' characteristics

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

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

115 2.2.2. Food choice motives

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

130 2.2.3. Food consumption and dietary nutritional quality

131 Food consumption was retrospectively assessed for the month before the lockdown
132 and the first month of the lockdown simultaneously using a food frequency questionnaire
133 (FFQ) including 110 foods, 12 non-alcoholic drinks and 4 alcoholic drinks with frequency
134 assessed by a 6-item scale from “Never” to “Several times a day” (Kadawathagedara et al.,
135 2017). Usual portion sizes before and during the lockdown were estimated with photos for
136 different food types on a 5-level scale, derived from the SU.VI.MAX portion book (Herberg,

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

146 Adherence to the French dietary recommendations was evaluated during the month
147 before the lockdown and during the first month of the lockdown using the simplified PNNS-
148 GS2 score (sPNNS-GS2), an index previously designed to reflect the 2017 French main
149 dietary recommendations (Chaltiel et al., 2019). The sPNNS-GS2 builds on the distinction
150 between malus components (less healthy food groups which consumption should be limited,
151 carrying a negative score, i.e., red meat, processed meat, sugary foods, sweet-tasting
152 beverages, alcoholic beverages, salt) and bonus components (healthier food groups carrying a
153 positive score, i.e., fruits and vegetables, nuts, legumes, whole-grain food, milk and dairy
154 products, fish and seafood). The sPNNS-GS2 calculation has been previously described by
155 Chaltiel et al., 2019. A weight for each component is defined according to the level of
156 evidence of the association between food groups consumption and health status. sPNNS-GS2
157 scores were computed for each participant before and during the lockdown (range: -17 to
158 11.5). Slight modifications were brought to the calculation of the score. The sPNNS-GS2
159 originally included bonus points for added fat below 16% of energy intake (Chaltiel et al.,
160 2019). The FFQ did not make it possible to calculate the percentage of energy intake
161 accounted for added fat and this component was excluded from the score calculation.

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

169 *2.3. Outcome*

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

173 *2.4. Statistical analyses*

174 Hypotheses were specified before the data were collected and we followed an analytic
175 plan that was pre-registered before data analysis (<https://osf.io/gwfdb/>). Only participants who
176 completed the study were included in the analyses. Participants who failed at least one
177 attention check were excluded. We analysed data from participants who reported plausible
178 energy intake, i.e. ≥ 500 kcal/day and ≤ 3500 kcal/day for women, and ≥ 800 kcal/day and \leq
179 4000 kcal/day for men (Banna, McCrory, Fialkowski, & Boushey, 2017; Willett, 2013).

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

186 alone during the lockdown vs. with others, living in a city vs. in the countryside, usually
187 having meal out of home at least four times a week vs. less than 4 times a week, infected by
188 the corona virus vs. not infected. We then examined the influence of changes in food choice
189 motives during and before the lockdown on the difference in nutritional quality of diet by
190 running a multiple linear regression including the nine Δ motives as predictors and Δ quality
191 as the dependant variable (main model). Sensitivity analyses were conducted to examine
192 whether the pattern of results from the main model differed: 1/ including age, gender, highest
193 educational level and reported BMI as covariates (adjusted model), 2/ excluding participants
194 who declared that they did not make any noticeable change in their diet during the lockdown,
195 3/ excluding participants who declared that they often did not find in store what they wanted
196 to buy during the lockdown, as change in diet quality could be due more to external
197 constraints than to personal motives, 4/ excluding participants who declared that they went to
198 work as normal during the lockdown. As an additional exploratory analysis, we also adjusted
199 the main model for the variables with significant effects on Δ motives or Δ quality in the
200 exploratory one-way ANOVAs.

201 All statistical analyses were performed using SAS version 9.3 (SAS Institute, Inc.,
202 2012 SAS® 9.3. Cary, NC). The level of significance was set at $p < 0.05$ applying Bonferroni
203 correction for multiple comparisons where appropriate.

204 2.5. Sample size calculation

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

210 3. Results

211 3.1. Participants

212 A total of 1353 participants consented to participate. Participants who were not
 213 eligible (n=110), did not complete the study (n=121), failed at least one attention check
 214 (n=84) or reported implausible energy intake (n=100) were excluded and data from 938
 215 participants were analysed. Participants' characteristics are presented **Table 1**. Eighteen
 216 participants declared that they suspected having COVID-19 when they completed the study
 217 and 59 declared that they suspected having had COVID-19 before. Six hundred participants
 218 (64%) declared being slightly to very worried about their health. On average levels of stress,
 219 depression, and loneliness were 26 (SD 28), 23 (SD 25), and 34 (SD 28) respectively on a
 220 scale from 0 to 100.

221

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

Age, years, mean (SD)	38.7 (11.6)
Gender, female, n (%)	736 (78.5)
Employment status, n (%)	
<i>Full or part-time</i>	726 (77.4)
<i>Student</i>	66 (7.1)
<i>Retired</i>	48 (5.1)
<i>Looking for a job</i>	65 (6.9)
<i>Looking after home</i>	12 (1.3)
<i>Other</i>	21 (2.2)
Situation during the lockdown, n (% of workers)	
(several possible answers)	
<i>Going to workplace</i>	194 (20.7)
<i>Working from home</i>	418 (57.6)

<i>Furloughed</i>	122 (13.0)
<i>Other</i>	91 (9.7)
Highest educational qualification, n (%)	
<i>< High-school +2 years diploma</i>	227 (24.2)
<i>High-school +2 years diploma</i>	197 (21.0)
<i>High-school +3 or +4 years diploma</i>	230 (24.5)
<i>≥ High-school +5 years diploma</i>	284 (30.3)
Living area, n (%)	
<i>Countryside</i>	243 (25.9)
<i>Suburban area</i>	213 (22.7)
<i>City centre</i>	482 (51.4)
Type of housing, n (%)	
<i>House</i>	498 (53.1)
<i>Flat</i>	440 (46.9)
Household composition, n (%)	
<i>1 adult</i>	206 (22.0)
<i>2 adults</i>	246 (26.2)
<i>> 2 adults</i>	138 (14.7)
<i>2 adults with children (<14 years old)</i>	220 (23.5)
<i>Other</i>	128 (13.6)
Financial situation, n (%)	
<i>Stable</i>	660 (70.4)
<i>Precarious</i>	272 (29.0)
<i>Chose not to answer</i>	6 (0.6)
Eating out of home before the lockdown, n (%)	
<i>3 times per month or less</i>	378 (40.3)
<i>Once to 3 times a week</i>	241 (25.7)
<i>4 to 6 times a week</i>	280 (29.9)
<i>7 times per week or more</i>	39 (4.1)
Grocery shopping frequency during the lockdown, n (%)	

<i>Twice a week or more</i>	157 (16.7)
<i>Once a week</i>	493 (52.6)
<i>Less than once a week</i>	288 (30.7)
Difficulties to find food during the lockdown, n (%)	
<i>Often</i>	104 (11.1)
<i>Sometimes</i>	465 (49.6)
<i>Rarely</i>	272 (29.0)
<i>Never</i>	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/m², mean (SD)	24.5 (4.88)
<i>Implausible^a, n (%)</i>	10 (1.1)

223 ^aExcluding weight < 30 kg or > 250 kg, height < 1.45 m or > 3 m (Hardy, Johnson, & Park, 2016; Miller, 2003)

224

225 3.2. Food choice motives and nutritional quality of diet before and during the lockdown

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

231

232 **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)

233 Cronbach's α before: Health (0.71), Convenience (0.89), Sensory appeal (0.67), Natural content (0.86), Ethical
234 concern (0.66), Weight control (0.81), Mood (0.65), Familiarity (0.64), Price (0.63). Cronbach's α during: Health
235 (0.72), Convenience (0.85), Sensory appeal (0.66), Natural content (0.86), Ethical concern (0.64), Weight control
236 (0.84), Mood (0.64), Familiarity (0.64), Price (0.67).

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

239

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

247

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

		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

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

252

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

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

272

273 **Table 4.** Influence of Δ motives on the difference in nutritional quality of diet between during
 274 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

275 Variance inflation factor: Δ Health (1.72), Δ Convenience (1.23), Δ Sensory appeal (1.17), Δ Natural content
 276 (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
 277 quality is the difference in sPNNS-GS2 score during the lockdown compared to before. Δ quality > 0 indicated
 278 better nutritional quality during the lockdown compared to before. Δ motives > 0 indicated higher importance of
 279 the motives during the lockdown compared to before.

280 ^a Control variables: age, gender, BMI, highest educational qualification.

281

282 4. Discussion

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

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

294 Increase in energy intake and unhealthier dietary patterns during the lockdown
295 compared to before were also described in a study conducted among 37,252 French adults
296 from the web-based NutriNet-Santé cohort (Deschasaux-Tanguy et al., 2020). The authors
297 found an energy intake of 1942 kcal/day during the lockdown, which is similar to the reported
298 energy intake reported during the lockdown in the present study (1935 kcal/day on average).
299 The authors highlighted weight gain for 35% of the sample and increased consumption of
300 sweets, biscuits, and cakes. Consistently, despite the fact that the participants of the present
301 study increased their intake of fruit and vegetables, pulses, fish and seafood, they also
302 increased their consumption of processed meat, sugary foods, sweet-tasting beverages and
303 alcoholic beverages leading to a decrease in nutritional quality of their diet on average. These
304 changes in food consumption patterns echo studies showing increased snacking during the
305 lockdown (Deschasaux-Tanguy et al., 2020; Sanchez & Moreno, 2020), as fatty-sweet
306 products and sweet-tasting beverages (including fruit juices) are usually consumed during
307 snacking episodes by French adults (Si Hassen et al., 2018). In addition, a survey on 3,000
308 French adults reported that 42% declared having pre-meal drinks (“*apéritif*”) more often
309 during than before the lockdown (Darwin Nutrition & IFOP, 2020). Pre-meal drinks are
310 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

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

358 *Strengths and limitations*

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

361 French adults. Our study was timely as the data were collected two weeks after the end of the
362 first month of the lockdown. **However, the participants retrospectively reported their food**
363 **consumption which is a clear limitation of this study. We could not anticipate the lockdown**
364 **and organise a measurement point before the lockdown.** Participants were asked to report
365 simultaneously for each food item their consumption before and during the lockdown which
366 made it easier reporting differences in consumption frequency, even if a recall bias could have
367 affected the responses for the period before the lockdown. In other respects, due to this
368 exceptional situation, we compared food consumption in March (before the lockdown, end of
369 winter) and in April (during the lockdown, beginning of spring). We could have expected a
370 season effect in our data, with an improvement of the nutritional quality of diet in April
371 compared to March due to increased availability of fresh fruit and vegetables, although access
372 to fresh product may have been limited by the lockdown (Oxfam France, 2020). Finally, due
373 to unexpectedly high numbers of participants who failed an attention check or reported
374 implausible energy intake (16.4% of the eligible participants who completed the study), we
375 did not reach the sample size of 1,000 participants we aimed for. However, a sample size of
376 938 participants still allowed to detect small effects of Δ motives on Δ quality in a multiple
377 linear regression including nine predictors ($f^2 = 0.017$) at power 0.80 and level of significance
378 0.05 (GPower 3.1). A limitation of this study is that the sample was not representative of the
379 French population and included more women and individuals with higher educational level.
380 This is often the case in studies with volunteers on this topic (Deschasaux-Tanguy et al.,
381 2020). In addition, the participants were recruited from a population registered in the
382 Chemosens Platform's PanelSens database, gathering individuals who agreed to be contacted
383 to take part in research studies exploring eating behaviours. Thus, it is likely that our sample
384 was biased towards individuals with an interest in food. However, this can also be viewed as a
385 strength as these individuals were more likely to have paid attention to what they ate before

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

388 *Future research*

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

408 *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

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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

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