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Association between positive psychological traits and changes in dietary behaviour related to first COVID-19 lockdown: a general population-based study

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1 **ABSTRACT**

2 **Background:** The spread of the coronavirus disease (COVID-19) led many countries to
3 implement lockdown measures, which resulted in changes in dietary behaviours that could
4 persist over the long term and have associated health consequences. Psychological traits may
5 impact these changes given their known association with dietary behaviours. We aimed to
6 investigate in a population-based study, whether positive psychological traits were associated
7 with changes of snacking behaviour and food consumption observed during the first COVID-
8 19 lockdown period.

9 **Design:** In 2016, levels of optimism, resilience, self-esteem, satisfaction with life, mindfulness
10 and mastery were assessed in 33,766 adults of the French NutriNet-Santé cohort. Snacking and
11 food group consumption were assessed in April-May 202. Association between psychological
12 traits and changes (no change, increase, decrease) in snacking and food group consumption
13 were assessed using logistic regressions. Multiple correspondence analysis followed by
14 ascending hierarchical classification were used to derive clusters of dietary behaviours.
15 Covariance analyses were used to compare mean scores of psychological traits between
16 clusters. Analyses were adjusted for sociodemographic and lifestyle characteristics, anxiety and
17 depressive symptomatology.

18 **Results:** Participants with higher levels of optimism, resilience, self-esteem, satisfaction with
19 life, mindfulness or mastery were less likely to change their snacking behaviour and food group
20 consumption of various food groups. Individuals with lower levels were more likely to make
21 changes, with either unhealthy (e.g., less fruits and vegetables, more processed meat) or healthy
22 (e.g., more pasta/rice (whole-grain)) changes. Overall, individuals showed higher levels of
23 positive psychological traits in the “no change” cluster, followed by the “healthy” and the
24 “unhealthy” cluster (all $P < 0.05$).

25 **Conclusions:** Individuals with higher levels of optimism, resilience, self-esteem, satisfaction
26 with life, mindfulness or mastery were less impacted by the lockdown in terms of dietary
27 behaviours.

28

29 **Keywords:** positive psychology; snacking behaviour; food consumption; dietary behaviours;
30 COVID-19

31 **Abbreviations:** BMI, Body Mass Index; BRS, Brief Resilience Scale; CI, Confidence Interval;
32 CU, Consumption Unit; FFMQ, Five Facets Mindfulness Questionnaire; GAD-7, General
33 Anxiety Disorder 7 scale; LOT-T, Life Orientation Test – Revised; OR, Odds Ratio; PHQ-9,
34 Patient Health Questionnaire 9 scale; PMS, Pearlin Mastery Scale; SES, Self-Esteem Scale;
35 SWLS, Satisfaction With Life Scale.

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44 **Author contributions:** M.R conducted the literature review and drafted the manuscript. M.R.
45 performed analyses. M.R., M.D.T, R.S, N.D.P., Y.E., F.S.D., J.B., P.G., S.H., M.T., and S.P.
46 were involved in interpreting results and critically reviewed the manuscript. M.T., P.G. S.H.
47 and S.P. and SAPRIS study group were responsible for developing the design and protocol of
48 the study. M.R., M.D.T, R.S, N.D.P., Y.E., F.S.D., J.B., P.G., S.H., M.T., and S.P. report no
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75 **BACKGROUND**

76 In 2019, a novel corona virus disease (COVID-19) leading to severe acute respiratory syndrome
77 emerged in China and quickly spread all over the globe. On March 12, 2020, the World Health
78 Organization (WHO) declared COVID-19 as a global pandemic (1), which has led the national
79 authorities of many countries to implement a nationwide lockdown to constrain the transmission
80 of the virus. In France, the first lockdown entered into force on March 17, 2020 and was
81 loosened on May 11, 2020. Under that situation, social distancing was advocated and French
82 people could leave their home only for grocery shopping, medical care, legal obligation and
83 physical activity within a 1 km radius (2). Only workers from what was called “essential”
84 sectors (healthcare, medical research, food and drug manufactures and supplies, garbage
85 collection, city cleaning, vehicle and technology maintenance) maintained their usual activity
86 (2). All other non-essential public spaces including school and universities, workplaces, open
87 spaces, recreational spaces and non-food spaces were closed (2). As a result, a vast majority of
88 the population either was asked to telework from home or became partially unemployed, and
89 parents had to relay school teachers at home (2).

90 Studies conducted among the general population showed changes in the diet during the first
91 COVID-19 lockdown but with contrasted results. Both positive changes were observed, with
92 an increase in consumption of fruit and vegetables (3–6), whole grains (4), legumes and nuts
93 (3), and a reduced consumption of confectionery and salty snacks (4), ice cream (4) and alcohol
94 (5), and negative changes, characterised by an increase in snacking (3,7,8), chocolate (3,5), ice
95 cream (4,5), salty snack (5,9), processed meat (6), sugary food (6) and alcohol (6,9), and a
96 decrease in fruits and vegetables (3,4,9), fish (4,9), whole grain products (4,9). Other behaviours
97 such as a decrease in physical activity (3,8,10–12), an increase in sedentary time (3), and an
98 increase in tobacco consumption (10) were also observed.

99 Given the impact of dietary behaviours on chronic diseases (13) and their potential impact on
100 the immune response (14), it is important to understand their determinants. More specifically,
101 a better understanding of these determinants may help prevent unhealthy changes in dietary
102 behaviour in potential future similar crises such as the COVID-19 pandemic. This is particularly
103 important since negative dietary behaviour resulting from the lockdown may last thereafter, as
104 nutritional behaviours have been shown to be relatively stable over time (15).

105 Individual psychological resources may have had an impact on the lockdown experience, and
106 in particular on changes in dietary behaviour, given the recognised influence of psychological
107 traits on dietary behaviours in general (16,17). For example, individuals in a cluster
108 characterised by higher neuroticism, insecurity, stress and ‘type A’ personality (i.e. more
109 competitive and ambitious) reported more negative impact of the lockdown on their lifestyle
110 behaviour, and in particular on their diet (18). Positive psychological resources are of specific
111 interest since focusing on building competencies rather than correcting weakness could be a
112 step forward in health promotion (19). Optimism (20), satisfaction with life (21), self-esteem
113 (22), resilience (23), mindfulness (24) and mastery (25) are all positive psychological resources
114 that have previously been associated with a healthier diet. Therefore, it is likely that these traits
115 may have played a role in the way individuals experienced the lockdown, and more specifically
116 their overall dietary behaviour during this period.

117 The aim of the present study was therefore to assess the association between several positive
118 psychological traits (optimism, satisfaction with life, self-esteem, resilience, mindfulness and
119 mastery), and changes in snacking behaviour, food group consumption and overall dietary
120 behaviours related to the first COVID-19 lockdown period in a large population-based sample.

121

122 **METHODS**

123 **Study population and design**

124 This study was conducted within the NutriNet-Santé Study, an ongoing web-based prospective
125 cohort launched in 2009, the aims of which being to explore the relations between nutrition and
126 health, as well as the determinants of eating behaviours and nutritional status. The rationale,
127 design and methods have been described (26). Participants are volunteers aged ≥ 18 years
128 from the general French population. At inclusion, they are asked to complete a set of self-
129 reported web-based questionnaires to assess their diet, health status, physical activity,
130 anthropometric data, socio-economic conditions and lifestyle characteristics. In addition,
131 optional questionnaires related to eating behaviour determinants and specific health-related
132 outcomes are sent each month.

133 The NutriNet-Santé study was conducted in accordance with the Declaration of Helsinki, and
134 all procedures were approved by the Institutional Review Board of the French Institute for
135 Health and Medical Research (IRB Inserm n° 0000388FWA00005831) and the Commission
136 Nationale de l'Informatique et des Libertés (CNIL n° 908450 and n° 909216). Electronic
137 informed consent was obtained from all participants. The study was registered at
138 clinicaltrials.gov as #NCT03335644.

139

140 **Assessment of positive psychological traits**

Dispositional optimism

141 Dispositional optimism is defined as the general expectation that good things, rather than bad
142 things, will occur in one's future (27). It was assessed with the French version (28) of the Life
143 Orientation Test - Revised (LOT-R) (29), which was administered between October and
144 December 2016. This validated questionnaire consists of 6 items: 3 positively worded (e.g.,
145 "I'm always optimistic about my future") and 3 negatively worded (e.g., "I hardly ever expect
146 things to go my way"), rated on a 5-point Likert scale ranging from 0 (strongly disagree) to 4

147 (strongly agree). The scoring for the negatively worded items was reversed. Item scores were
148 summed up and divided by the number of items, leading to a final score ranging from 0 (low
149 optimism) to 4 (high optimism). The scale showed good internal consistency (Cronbach's $\alpha =$
150 0.84).

151

Satisfaction with life

152 Satisfaction with life is defined by a global assessment of a person's quality of life according
153 to his/her chosen criteria (30). It was evaluated by the validated French version (31) of the
154 Satisfaction With Life Scale (SWLS) (32) between October and December 2016. The SWLS is
155 composed of 5 items (e.g., "The conditions of my life are excellent") rated on a 7-point Likert
156 scale ranging from 1 (strongly disagree) to 7 (strongly agree). The items scores were summed
157 up and the score was divided by the number of items leading to a final score ranging from 1
158 (low satisfaction with life) to 7 (high satisfaction with life). The scale displayed good internal
159 consistency (Cronbach's $\alpha = 0.89$).

160

Self-esteem

161 Self-esteem refers to an individual's evaluation of their own worth (33). It was assessed with
162 the French version (34) of the Rosenberg Self-Esteem Scale (R-SES) (33) which was completed
163 by participants between October and December 2016. This validated questionnaire is composed
164 of 10 items: 5 positively worded (e.g., "I feel I have a number of good qualities") and 5
165 negatively worded (e.g., "At times I think I am no good at all"). All items are rated on a 4-point
166 Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree). The scoring for the
167 negatively worded items was reversed. The scores were summed and then divided by the
168 number of items. The final score of self-esteem was ranging from 1 (low self-esteem) to 4 (high
169 self-esteem). The scale showed good internal consistency (Cronbach's $\alpha = 0.88$).

170

171 *Resilience*

172 Resilience, the ability to bounce back or recover from stress (35), was assessed with the French
173 version of the Brief Resilience Scale (BRS) (35) between January and July 2017. This validated
174 questionnaire consists of 3 items positively worded (e.g., “I tend to bounce back quickly after
175 hard times”) and 3 items negatively worded (e.g., “I have a hard time making it through stressful
176 events”), each rated on a 5-points Likert scale, ranging from 1 (strongly disagree) to 5 (strongly
177 agree). The scoring for the negatively worded items was reversed. Item scores were summed
178 and divided by the number of items, leading to a final score ranging from 1 (low resilience) to
179 5 (high resilience). The scale showed good internal consistency (Cronbach’s $\alpha = 0.84$).

180

181 *Mindfulness*

182 Mindfulness reflects the propensity to be mindful in daily life (36). It was assessed with the
183 French version (36) of the Five Facets Mindfulness Questionnaire (FFMQ) (37), between
184 January and June 2013. This validated questionnaire is composed of 39 items: 20 positively
185 worded (e.g., “While walking, I am aware of the sensations in my body”) and 19 negatively
186 worded (e.g., “I am easily distracted”) rated on a 5-points Likert scale ranging from 1 (never or
187 very rarely true) to 5 (very often or always true). The score of the negative worded items were
188 reversed before summing all items. This score was divided by the number of items, leading to
189 a final overall score ranging from 1 (low degree of mindfulness) to 5 (high degree of
190 mindfulness). The scale displayed good internal consistency (Cronbach’s $\alpha = 0.89$).

191

192 *Mastery*

193 Mastery is defined as the extent to which individuals perceive having control over important
194 circumstances of their lives (38). This psychological trait was measured with the Pearlin

195 Mastery Scale (PMS) (39) between May and November 2014, which is a 7-item validated
196 questionnaire: 3 positively worded (e.g., “What happens to me in the future mostly depends on
197 me”) and 5 negatively worded (e.g., “There is really no way I can solve some of the problems
198 I have”) rated on a 7-point Likert scale ranging from 1 (strongly agree) to 7 (strongly disagree).
199 The items scored were summed and then divided by the number of items. The score was ranging
200 from 1 (low mastery) to 7 (high mastery). The scale displayed good internal consistency
201 (Cronbach’s $\alpha = 0.84$).

202

203 **Assessment of changes in snacking behaviour and food group consumption**

204 During the first lockdown period, a set of lockdown related questionnaires was sent to all
205 participants between April 1 and May 13, 2020. The set included a self-report questionnaire
206 assessing participants’ exposure to SARS-CoV2 infection and experience of the lockdown, as
207 part of a national multi-cohort project (*Health, Practices, Relationships and Social inequalities*
208 *in the general population during the COVID-19 crisis*, SAPRIS), and a questionnaire to
209 qualitatively assess changes in physical activity, food supply, weight and dietary habits. Access
210 to the questionnaire are on supplementary material 1. To assess changes in snacking behaviour,
211 participants were asked to choose an answer between the following statements: “Compared to
212 the situation before lockdown: I snack more, I snack less, I snack neither more nor less”. To
213 assess potential changes in dietary habits, participants were also asked to choose an answer
214 between the following statements: “Check the answer that best describe your situation for each
215 food group: I increased my consumption, I decreased my consumption, I did not change my
216 consumption, I do not consume this food group”. Among the 48 food groups assessed in the
217 questionnaire, we selected 17 groups according to two criteria. Since multiple correspondence
218 analysis requires that there are no low frequency modalities for each variable (40) we removed
219 food groups that were mostly non-consumed. In addition, we selected food groups that were of

220 particular interest from a nutritional perspective, and in particular groups targeted by the French
221 National Nutrition and Health Program (PNNS) (41). Selected groups were: whole-grain bread,
222 whole-grain pasta and rice, fresh fruits, fresh vegetables, legumes, fresh fish and shellfish, fresh
223 red meat, processed meat, sandwiches, pizzas and savoury pies, yoghurt and cottage cheese,
224 sweets and chocolate, biscuits and cakes, butter, sugar, honey and marmalade, sugary drinks
225 and sodas, and alcoholic drinks.

226

227 **Covariates**

228 Socio-demographic, anthropometric and lifestyle data were self-reported each year, using a set
229 of web-based questionnaires that have been validated against traditional methods (42,43). We
230 used the latest data available prior to baseline (October 2016). Collected information included:
231 age (years), gender (men, women), educational level (primary, secondary, undergraduate, and
232 postgraduate), occupational status (unemployed, student, self-employed and farmer, employee
233 and manual worker, intermediate profession, managerial staff and intellectual profession, and
234 retired), monthly income per household unit, smoking status (never, former smokers, and
235 current smokers), physical activity, body mass index (BMI), dietary energy intake (including
236 alcohol), general anxiety disorders (General Anxiety Disorder-7 scale) and depressive
237 symptomatology (Patient Health Questionnaire-9). Monthly income per household unit was
238 calculated using information about income and household composition. The number of people
239 in the household was converted into a number of consumption units (CU) according to the
240 OECD (Organisation for Economic Cooperation and Development) equivalence scale: one CU
241 is attributed for the first adult in the household, 0.5 for other persons aged 14 or older and 0.3
242 for children under 14 (44). Categories of monthly income were defined as follows: <1,200;
243 1,200-1,799; 1,800-2,299; 2,300-2,699; 2,700-3,699; and $\geq 3,700$ euros per household unit as
244 well as “unwilling to answer”. Physical activity was assessed with the short form of the French

245 version of the International Physical Activity Questionnaire (45). Weekly energy expenditure,
246 expressed in Metabolic Equivalent of Task in minutes per week (MET in minutes/week), was
247 estimated and three levels of physical activity were constituted: low (< 30 min/day), moderate
248 (30–60 min/day), and high (\geq 60 min/day). BMI was calculated on the basis of self-reported
249 height and weight. Energy intake (kcal) was assessed with a set of three 24-hr-dietary records
250 which participants are asked to complete every 6 months. Participants reported all food and
251 beverages consumed in a day, using standard measurements and/or validated photographs when
252 reporting portion sizes (46). Nutrient intakes were estimated by using the published NutriNet-
253 Santé food composition database. Mean daily food intake (in grams per day) was weighted
254 according to the day of the week (weekday or weekend). In addition, various covariates were
255 collected between April 1 and May 13, 2020 (first lockdown period) as part as the SAPRIS
256 questionnaire. Data on professional activity during lockdown (working outside home, partially
257 unemployed, fully working from home, partially working from home, student, and other), and
258 the presence of children or grandchildren <18 years at home during the lockdown (yes, no) were
259 collected. In addition, data on anxiety and depressive symptomatology were collected. Anxiety
260 was assessed with the French version of the General Anxiety Disorder 7 (GAD-7) scale (47).
261 The GAD-7 scale is a 7-item questionnaire assessing general anxiety disorders, with each item
262 rated on a 4-point scale, leading to a 0-21 range. A score \geq 10 indicates the presence of anxiety
263 disorders (47). Depressive symptomatology was assessed with the French version of the Patient
264 Health Questionnaire-9 (PHQ-9) scale (48). The PHQ-9 scale is a 9 items questionnaire
265 assessing depressive symptomatology. Its items are rated on a 4-point scale leading to a 0-27
266 range. A score \geq 10 indicates the presence of depressive symptoms (48).

267

268 **Statistical analyses**

269 We used chi-square test and student *t* test to compare included with excluded participants,
270 as appropriate. Individual characteristics, changes in snacking behaviour and food group
271 consumption were described with frequencies or mean \pm standard deviation. Relationship
272 between individual characteristics and positive psychological traits levels were described with
273 Pearson correlations for continuous variables and Student *t* test and variance analysis (ANOVA)
274 for categorical variables.

275 We used multinomial logistic regression models to assess the link between positive
276 psychological traits (independent variables) and changes in snacking behaviour and food group
277 consumption (dependent variables). Three levels of change in snacking behaviour and food
278 group consumption were defined: increased, decreased and no change (reference). Participants
279 who do not consume the food group of interest were excluded from the analyses for this specific
280 food group. The strength of all associations was determined by computing odds ratios (ORs)
281 and 95% confidence intervals (CI).

282 We applied a multiple correspondence analysis (MCA), a data reduction procedure, to derive
283 clusters of dietary behaviours from changes in snacking and food group consumption. Changes
284 in snacking behaviour and all 17 food groups were included in the MCA as active variables.
285 Two dimensions were kept based on inertia decomposition and the relevance and
286 interpretability of the obtained profiles (40) (explaining respectively 7.7% and 5.7% of the
287 variation). Coordinates of changes in snacking and food groups along these dimensions are
288 shown in **Supplementary Table 1**. We then performed an ascending hierarchical classification
289 (AHC) on the scores of participants along these two dimensions to define clusters of participants
290 displaying similar dietary behaviours. Dietary behaviours were classified as “healthy” or
291 “unhealthy”, following the French nutritional recommendations (PNNS) (41). Covariance
292 analysis (ANCOVA) were used to compare mean scores of each psychological trait between

293 clusters. We then computed post-hoc pairwise comparisons using Bonferroni's test to account
294 for multiple comparisons. We provided adjusted mean values and 95% CI.
295 Potential confounders were selected based on variables shown in the literature to be associated
296 with positive psychological traits (49–53) and diet (52,54,55). Then, confounders associated
297 with the different psychological traits, changes in snacking behaviour, food group consumption
298 and dietary behaviour at the $P < 0.2$ level were retained in multivariable logistic regressions
299 and covariance analyses. We performed 3 different model: Model 1 was adjusted for age,
300 gender, educational level, occupational status, professional activity during lockdown, monthly
301 household income, presence of children or grandchildren <18 years during lockdown, smoking
302 status, physical activity, BMI and dietary energy intake. Model 2 was: Model 1 + general
303 anxiety disorders and depressive symptoms during lockdown. In addition, a raw model was
304 presented in **supplementary table 2**. Analysis were not stratified by gender or BMI as the
305 interactions between the positive psychological traits and gender or BMI were non-significant
306 for most food groups and clusters of dietary behaviours ($P > 0.2$).
307 Missing data with regard to confounders were handled with multiple imputations by fully
308 conditional specification (20 imputed data sets). All tests of statistical significance were 2-
309 sided, and significance was set at 5%. The MCA and the ACH were performed using the
310 FactoMineR package version 1.34 (56) (R-software). All other statistical analyses were
311 performed using SAS version 9.4 software (SAS Institute, Inc.).

312

313 **RESULTS**

314 **Characteristics of the sample**

315 A total of 40,550 participants completed the optional questionnaire on dietary and snacking
316 behaviour during the first COVID-19 lockdown. Among them, 23,400 participants completed
317 the LOT-R (among which 52 were excluded because they had an acquiescence bias, meaning
318 they agreed to all question without consideration of the reverse items), 23,455 completed the

319 SWLS (N = 0 with an acquiescence bias), 23,435 completed the R-SES (N = 18 with an
320 acquiescence bias), 25,965 completed the BRS (N = 58 with an acquiescence bias), 29,179
321 completed the FFMQ (N = 14 with an acquiescence bias), and 17,058 participants completed
322 the PMS (N = 57 with an acquiescence bias). Compared with excluded participants, included
323 participants (the 33,766 individuals who had completed the COVID-19 lockdown questionnaire
324 and at least one psychological trait questionnaire) were older (53.4 ± 13.8 years for included
325 participants vs. 48.8 ± 15.2 years for excluded participants, $P < 0.0001$) and included a higher
326 proportion of men (24.1% vs 20.1%, $P < 0.0001$), individuals with university education (70.1%
327 vs. 66.9%, $P < 0.0001$), individuals with high incomes ($> 2,700\text{€}$ monthly income) (32.8% vs
328 22.8%, $P < 0.0001$), and a lower proportion of current or former smoker (49.4 vs 50.7,
329 $P < 0.0001$).

330 **Table 1.** shows individuals characteristics of the sample and their associations with the positive
331 psychological traits. Overall, positive psychological traits were higher in men, in participants
332 with higher education level (except for resilience), income, physical activity, and in individuals
333 reporting no symptoms of anxiety disorders or depressive symptomatology (except for
334 optimism). Psychological traits were positively correlated with age (except for mastery). Levels
335 of psychological traits were higher in managerial staff and intellectual professions (for
336 optimism, satisfaction with life, mindfulness, self-esteem) or self-employed and farmer (for
337 resilience, mastery, self-esteem). Associations with smoking were mixed: individuals with
338 greater optimism, satisfaction with life and self-esteem were more often smokers or former
339 smokers, while those with greater resilience, mindfulness and mastery were more often never
340 smokers. Psychological trait levels were higher in participants with children or grandchildren
341 at home during the lockdown (except for satisfaction with life and mastery). Finally, all
342 psychological traits correlated negatively with BMI (except for resilience).

343 **Table 2.** shows the distribution of participants who declared increasing, decreasing or not
344 having changed their snacking behaviour and food group consumption. The proportion of
345 participants who did not change their consumption was greater than 50% for every food group
346 considered, except for sugary drinks and sodas (20.4%).

347 A large proportion of participants increased their intake, and in particular more than 10%
348 reported an increase in snacking (19.5%), and in the consumption of fresh fruits (13.3%), fresh
349 vegetables (14.8%), legumes (14.7%), sweets and chocolate (20.7%), biscuits and cakes
350 (19.8%) and alcoholic drinks (14.1%). In addition, more than 10% reported a decrease in their
351 consumption of whole-grain bread (10.3%), fresh fruits (17.5%), fresh vegetables (17.8%),
352 fresh fish or shellfish (35.4%), fresh red meat (22.8), processed meat (13.6%), sandwich, pizzas
353 and savoury pies (14.8%), and alcoholic drinks (10.3%).

354

355 **Association between positive psychological traits and changes in snacking behaviour and** 356 **food group consumption during the first lockdown period**

357 **Table 3** present the results of the multinomial logistic regression models assessing the
358 association between the different positive psychological traits (i.e. optimism, satisfaction with
359 life, self-esteem, resilience, mindfulness and mastery), and changes in snacking behaviour and
360 food group consumption related to the first lockdown period.

361 Results of model 1 showed that participants with a higher level of any of the positive
362 psychological traits assessed were less likely to increase (ORs ranges from 0.67 (95% CI: 0.62,
363 0.72) to 0.95 (95% CI: 0.91, 0.98)), but also decrease (ORs ranges from 0.81 (95% CI: 0.73,
364 0.89) to 0.95 (95% CI: 0.90, 1.0)), their snacking behaviour compared with individuals with
365 lower levels of positive psychological traits.

366 In addition, participants with higher positive psychological traits were less likely (ORs ranges
367 from 0.62 (95% CI: 0.51, 0.76) to 0.95 (95% CI: 0.92, 0.99)) to increase their consumption of
368 whole-grain bread, whole-grain pasta and rice (except for mastery), fresh fruits and vegetables

369 (only for satisfaction with life), legumes (except for optimism, mindfulness and mastery), fresh
370 fish or shellfish (only for satisfaction with life), fresh red meat (except for optimism, resilience
371 and mastery), processed meat, sandwich, pizzas and savoury pies, yoghurt and cottage cheese
372 (except for mastery), sweets and chocolate (except for mastery), biscuits and cakes, butter
373 (except for optimism), sugar, honey and marmalade, sugary drinks and sodas (except for
374 mastery), and alcoholic drinks.

375 Participants with higher positive psychological traits were also less likely (ORs ranges from
376 0.74 (95%CI: 0.69, 0.80) to 0.95 (95%CI: 0.93, 0.98)) to decrease their consumption of whole-
377 grain bread (except for optimism and mindfulness), fresh fruits, fresh vegetables, legumes (only
378 for satisfaction with life and mastery), fresh fish and shellfish, fresh red meat, processed meat
379 (only for satisfaction with life), sandwich, pizzas and savoury pie (except for mindfulness),
380 yoghurt and cottage cheese, sweets and chocolate (except for mindfulness), biscuits and cakes
381 (except for mindfulness), butter (except for mindfulness), sugar, honey and marmalade (only
382 for satisfaction with life and mastery), sugary drinks and sodas (only for satisfaction with life),
383 and alcoholic drinks (only for satisfaction with life).

384 Finally, they were more likely (OR = 1.26 (95% CI: 1.11, 1.44)) to decrease their consumption
385 of honey and marmalade (only for mindfulness).

386 The raw model (supplemental data) showed very few differences with model 1. In addition,
387 analyses with further adjustment for anxiety and depressive symptomatology (model 2) showed
388 similar results overall compared with model 1, although some associations were weakened.

389

390 **Association between positive psychological traits and changes in overall dietary** 391 **behaviours during the first lockdown period**

392 **Table 4** presents the distribution of dietary behaviour change related to the lockdown across
393 the clusters derived from the AHC. We identified three clusters. Cluster 1 included 43.89% of
394 the participants and was composed of individuals who mainly reported no change in their food

395 consumption during the lockdown period. Cluster 2 included 28.74% of the participants. This
396 cluster mainly corresponded to “Healthy changes” and was characterised by a noticeable
397 decrease in snacking and consumption of unhealthier food groups: fresh red meat, processed
398 meat, sandwich, pizza and savoury pies, sweets and chocolate, biscuits and cakes, butter, sugar,
399 honey and marmalade, sugary drinks and sodas, and alcoholic drinks, with an increase in
400 consumption of legumes. A decrease in consumption of whole-grain bread, and fresh fish and
401 shellfish was also observed. Conversely, cluster 3, which was composed of 13.74% of the
402 participants, was mainly characterised by “Unhealthy changes”, i.e. an increase in snacking and
403 consumption of several unhealthier food groups: processed meat, sweets and chocolate, biscuits
404 and cakes, butter, sugar, honey and marmalade, and alcoholic drinks, with a decreased
405 consumption of healthier food groups: fresh fruits, fresh vegetables and fresh fish and shellfish.
406 This cluster was also characterised by an increased consumption of whole-grain pasta and rice,
407 legumes, and yoghurt and cottage cheese.

408 **Table 5** present the results of the ANCOVA comparing mean scores of each psychological trait
409 level between clusters. Mean scores of all psychological traits considered were significantly
410 different across clusters of dietary behaviour (all $P < 0.05$). Scores for positive psychological
411 traits were higher in cluster 1 followed by cluster 2 and then cluster 3. In the first model, all
412 pairwise comparisons were significant with the exception of cluster 1 vs 2 for optimism and
413 mindfulness. Overall, results were similar in model 2, except for cluster 1 vs 2 that became non-
414 significant in the case of resilience and cluster 1 vs 2 that became significant in the case of
415 mindfulness.

416

417 **DISCUSSION**

418 This large population-based study is, to our knowledge, the first to investigate the association
419 between positive psychological traits and the changes in snacking behaviour, food group

420 consumption and overall dietary behaviour related to the first COVID-19 lockdown period in
421 France. Our results showed that participants with higher optimism, satisfaction with life, self-
422 esteem, resilience, mindfulness or mastery scores were less likely to change their snacking
423 behaviour, food group consumption and overall dietary behaviour during the lockdown.
424 Individuals who scored lower in terms of these positive psychological traits were more likely
425 to display unhealthy changes and, to a lower extent, healthy changes.

426

427 **Association between higher levels of positive psychological traits and no change in overall**
428 **dietary behaviour**

429 We found that participants with higher positive psychological traits levels were less likely to
430 make changes in their snacking behaviour, food group consumption and overall dietary
431 behaviour during the lockdown compared to individuals with lower psychological scores. In
432 particular, they were less likely to decrease, but also less likely to increase their snacking and
433 food group consumption. To our knowledge, no previous study has investigated the link
434 between psychological traits and dietary changes during lockdown, but several studies reported
435 an overall change in dietary behaviour during this period (3,4,6,9,10). In a study conducted in
436 the same population as ours, reasons mentioned included changes in lifestyle (change of routine,
437 spending more time cooking) and food supply (buying less fresh products, difficulty going to
438 usual stores or finding usual products), voluntary changes (trying to avoid weight gain,
439 opportunity to balance weight gain) and emotional reasons (eating out of boredom, out of
440 anxiety) (3). Various hypotheses can be made to explain our results. Previous studies have
441 shown that participants with a higher level of self-esteem, resilience and satisfaction with life
442 best adapted to lockdown situation and tended to have more positive attitudes and behaviours,
443 compared with participants with lower levels (57). Other studies showed overall greater coping
444 strategies in individuals with higher optimism (58,59), satisfaction with life (60), mindfulness
445 (61,62), and mastery (51). A greater sense of personal control was also observed in individuals

446 with higher positive psychological traits levels, and in particular life satisfaction (63). Finally,
447 more deliberate and less affective choices could be observed in individuals with higher levels
448 of mastery (25). These data would suggest that greater coping, positive attitudes and less
449 affective choices in individuals with higher positive psychological traits levels may have
450 resulted in greater adaptation during lockdown, and thus led to fewer changes in dietary
451 behaviour. Previous studies indicated that women were particularly affected by lockdown, as
452 they reported increased stress (64), which is an initiator of dietary changes (65). Therefore,
453 differences between men and women could have been expected. Yet, interestingly, interactions
454 between psychological traits and sex were non-significant for most food groups in our study,
455 suggesting a similar effect of psychological traits on changes in snacking and overall dietary
456 behaviour in men and women.

457

458

459 **Association between lower levels of positive psychological traits and unhealthy changes in**
460 **overall dietary behaviour**

461 Our study showed that individuals with lower positive psychological traits levels were more
462 likely to display unhealthy changes in their dietary behaviour. Though there is no similar data
463 existing in the literature, previous studies reported that individuals with lower levels of positive
464 psychological traits were less likely to have a healthier diet (20–25), which is consistent with
465 our results. Potential explanation of our findings could involve the fact that individuals with
466 higher positive psychological traits levels were less impacted by lockdown side-effects, such
467 as an increase in stress (due to work interruption, fear of contracting COVID-19, low
468 satisfaction with health information received, etc.), anxiety and depression (10,66–68),
469 loneliness (69), isolation and boredom as emotional reactions to social distancing (70), and
470 sleep disturbances (71). Indeed, in the literature, higher levels of optimism (72), satisfaction
471 with life (73,74), self-esteem (75), resilience (76,77), mindfulness (78,79), and mastery (80,81)

472 have been negatively associated with anxiety, stress or depression. In addition, higher levels of
473 satisfaction with life (82) and mindfulness (83,84) have been associated with less loneliness,
474 while higher levels of optimism and self-esteem were associated with greater declared social
475 support (85). Finally, lower optimism (86), satisfaction with life (87), and mindfulness (88,89)
476 were associated, though indirectly, to greater sleep disturbance. These lockdown side-effects
477 could have had an impact on the diet during the lockdown. For instance, anxiety and depression
478 are known to be associated with unhealthy changes in nutritional behaviours (54,55), and
479 negative changes in mental state was reported to be a reason of eating practices modifications
480 during the COVID-19 lockdown (3,6,10). Loneliness, boredom and sleep disturbances have
481 also been previously associated with deleterious food choices (90–94). These results suggest
482 that participants with lower positive psychological traits levels could have been more exposed
483 to anxiety, depression, loneliness, boredom or sleep disturbances during lockdown and were
484 therefore more likely to engage in unhealthy dietary behaviours. In particular, our results
485 showing a weakening of the association between the psychological traits and dietary behaviours
486 when controlling for anxiety and depressive symptomatology, support the fact that part of the
487 associations could be due to these mental states.

488

489 **Association between lower levels of positive psychological traits and healthy changes in** 490 **overall dietary behaviour**

491 Healthy dietary changes were also observed in individuals with lower positive psychological
492 traits levels, although to a lesser extent. As previously mentioned, lower levels in positive
493 psychological traits are associated with greater stress and anxiety (72,73,76,78,81,95). In
494 addition, individuals with lower levels of optimism (96), resilience (97), self-esteem (57), and
495 mindfulness (98) specifically reported greater fear of COVID-19. It is possible that fear of
496 COVID-19 has led these individuals to improve their dietary behaviours in order to remain in
497 good health, reinforce their immune system (14) and prevent the development of certain

498 diseases such as overweight or cardiovascular diseases, which are risk factor for COVID-19-
499 related mortality (88,99).

500

501 **Differences between psychological traits**

502 Overall, similar results were observed for all positive psychological traits considered in our
503 study, although some specificity could be observed. Satisfaction with life was the psychological
504 trait most consistently associated with dietary behaviour since it was significantly associated
505 with each food group. In contrast, mindfulness and mastery were associated with a more limited
506 number of food groups. This suggests that mechanisms underlying the associations between
507 positive psychological traits and dietary behaviour during lockdown could differ from trait to
508 trait.

509

510 **Application**

511 Our results suggest that positive psychological traits may have a protective effect on changes
512 in eating behaviour during major life events, such as the COVID-19 lockdown. Various
513 interventions have been shown to be effective in increasing optimism (100), self-esteem (101),
514 resilience (102) gratitude (103) or mindfulness (104). These interventions could target the
515 general population or focus on individuals with lower levels of positive psychological traits
516 identified using self-declared questionnaires (29,32,33,35,37,39). Interventions could be set in
517 various settings such as health care, professional or academic environments. Components of
518 these interventions could also be part of more general public health messages.

519

520 **Strengths and limitations**

521 This study is particularly original as, to our knowledge, no other study has previously
522 investigated the link between positive psychological traits and changes in dietary behaviours
523 during the COVID-19 lockdown. An important strength of our study is its large sample size

524 with participants of various socio-demographic characteristics and nutritional status. Although
525 we adjusted for a wide range of potential confounders, we cannot rule out the existence of
526 residual confounding due to other environmental or residual factors such as the housing type,
527 exposure to COVID-19 or modifications of food supply. Due to the design of the NutriNet-
528 Santé study, positive psychological traits were assessed between 2013 and 2017, i.e. seven to
529 three years prior to lockdown. The longitudinal design of this study is a strength since it gives
530 indications about the direction of the association. However, the large time gap is a limit of our
531 methodology since psychological traits might have changed during this period. However,
532 psychological traits have been shown to be relatively stable over time (105). In addition,
533 depressive symptomatology (PHQ-9) and anxiety disorders (GAD-7) were assessed during the
534 lockdown, along with the food groups, and used as confounders in our models. Another strength
535 is that positive psychological traits were measured with validated questionnaires (24,27,30–
536 32,51), and each displayed good internal consistency in our sample. The main limitation of our
537 study is the self-assessment nature of the questionnaires assessing changes in snacking
538 behaviour and food group consumption. In addition, the NutriNet -Santé study is a prospective
539 cohort focusing on nutrition and health based on voluntary recruitment, implying that our
540 participants are more likely to have a higher interest in nutrition and health, and therefore to
541 have a healthier diet. In addition, participants were more educated and had a higher income and
542 professional status than the overall French population (106). Caution is needed when
543 extrapolating our results to the whole French population.

544

545 **CONCLUSION**

546 This study examined the associations between optimism, satisfaction with life, self-esteem,
547 resilience, mindfulness and mastery, and changes in snacking behaviour, food group
548 consumption and overall dietary behaviours in a large population-based sample during the

549 COVID-19 lockdown period in France compared with before the lockdown. We found that the
550 lockdown seemed to have had a lower impact on the dietary behaviour of participants with
551 higher levels of positive psychological traits. On the contrary, individuals with lower levels
552 tended to modify their dietary behaviour, some towards unfavourable changes and some others,
553 to a lesser extent, towards favourable changes. Further population-based studies are needed to
554 confirm our results, and in particular longitudinal studies to assess whether the observed
555 changes will last after the pandemic and over a longer period and have later health
556 consequences. Our results underline that it is important to consider positive psychological traits
557 in policies aiming to prevent behavioural changes during specific periods, such as global
558 pandemics or important life events.

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Table 1. Individual characteristics of the 33,766 participants and comparison of the positive psychological score according to these characteristics (NutriNet-Santé Study, 2016-2020).

	% or Mean \pm SD	Optimism (LOT-R) ¹	<i>P</i> value ²	Satisfaction with life (SWLS) ¹	<i>P</i> value ²	Self-esteem (R-SES) ¹	<i>P</i> value ²	Resilience (BRS) ¹	<i>P</i> value ²	Mindfulness (FFMQ) ¹	<i>P</i> value ²	Mastery (PMS) ¹	<i>P</i> value ²
All													
Data collected at baseline													
Age (years)	53.39 \pm 13.82 ³	0.05 (0.03, 0.06)	<.0001	0.04 (0.02, 0.05)	<.0001	0.07 (0.06, 0.08)	<.0001	0.1 (0.09, 0.11)	<.0001	0.1 (0.09, 0.11)	<.0001	-0.09 (-0.11, -0.08)	<.0001
Gender (%)			<.0001		<.0001		<.0001		0.017		<.0001		<.0001
Men	24.07	3.15 \pm 0.59		5.28 \pm 1.02		3.26 \pm 0.42		3.49 \pm 0.67		3.38 \pm 0.39		5.05 \pm 1.04	
Women	75.93	3.12 \pm 0.64		5.14 \pm 1.11		3.18 \pm 0.47		3.27 \pm 0.68		3.33 \pm 0.43		4.87 \pm 1.16	
Educational level (%)			0.0016		<.0001		<.0001		0.0008		<.0001		<.0001
Primary	1.85	3.09 \pm 0.53		4.98 \pm 1.15		3.16 \pm 0.45		3.38 \pm 0.7		3.26 \pm 0.43		4.59 \pm 1.23	
Secondary	27.29	3.11 \pm 0.6		4.99 \pm 1.14		3.15 \pm 0.45		3.33 \pm 0.69		3.28 \pm 0.41		4.71 \pm 1.17	
Undergraduate	31.66	3.13 \pm 0.64		5.18 \pm 1.07		3.2 \pm 0.45		3.3 \pm 0.69		3.34 \pm 0.42		4.9 \pm 1.13	
Postgraduate	38.43	3.14 \pm 0.65		5.33 \pm 1.04		3.24 \pm 0.47		3.34 \pm 0.67		3.39 \pm 0.43		5.07 \pm 1.07	
Missing data	0.77												
Occupational status (%)			<.0001		<.0001		<.0001		<.0001		<.0001		<.0001
Unemployed	8.68	3.05 \pm 0.68		4.75 \pm 1.38		3.08 \pm 0.54		3.18 \pm 0.76		3.31 \pm 0.46		4.63 \pm 1.27	
Student	1.27	3.05 \pm 0.7		5.24 \pm 1.13		3.04 \pm 0.52		3.13 \pm 0.65		3.27 \pm 0.4		5.06 \pm 1.04	
Self-employed, farmer	1.70	3.3 \pm 0.71		5.27 \pm 1.1		3.26 \pm 0.47		3.48 \pm 0.69		3.4 \pm 0.43		5.23 \pm 1.02	
Employee, manual worker	13.47	3.05 \pm 0.62		4.83 \pm 1.21		3.12 \pm 0.49		3.21 \pm 0.71		3.25 \pm 0.41		4.79 \pm 1.15	
Intermediate professions	15.33	3.11 \pm 0.64		5.14 \pm 1.07		3.18 \pm 0.46		3.28 \pm 0.67		3.32 \pm 0.42		4.95 \pm 1.09	
Managerial staff, intellectual profession	24.70	3.17 \pm 0.66		5.36 \pm 1.02		3.26 \pm 0.46		3.37 \pm 0.67		3.38 \pm 0.42		5.16 \pm 1.02	
Retired	33.43	3.15 \pm 0.59		5.27 \pm 0.98		3.22 \pm 0.42		3.4 \pm 0.66		3.36 \pm 0.42		4.81 \pm 1.15	

Missing data	1.42												
Monthly household income (%)			<.0001		<.0001		<.0001		<.0001		<.0001		<.0001
< 1200 €	9.13	3.04 ± 0.68		4.6 ± 1.37		3.08 ± 0.53		3.24 ± 0.73		3.29 ± 0.45		4.56 ± 1.25	
1200 - 1799 €	19.44	3.08 ± 0.62		4.97 ± 1.14		3.15 ± 0.48		3.29 ± 0.69		3.31 ± 0.42		4.81 ± 1.14	
1800 - 2299 €	15.33	3.11 ± 0.63		5.07 ± 1.1		3.18 ± 0.46		3.31 ± 0.68		3.32 ± 0.42		4.89 ± 1.13	
2300 - 2699 €	10.01	3.15 ± 0.62		5.25 ± 0.99		3.22 ± 0.44		3.36 ± 0.68		3.33 ± 0.42		4.9 ± 1.09	
2700 - 3699 €	18.46	3.16 ± 0.62		5.39 ± 0.94		3.25 ± 0.43		3.37 ± 0.66		3.37 ± 0.41		5.06 ± 1.06	
> 3700 €	14.36	3.22 ± 0.66		5.54 ± 0.9		3.3 ± 0.43		3.44 ± 0.66		3.41 ± 0.41		5.19 ± 1.02	
Unwilling to answer	11.43	3.11 ± 0.6		5.17 ± 1.05		3.18 ± 0.46		3.26 ± 0.69		3.34 ± 0.44		4.79 ± 1.17	
Missing data	1.85												
Smoking status (%)			0.0001		<.0001		0.0065		<.0001		<.0001		<.0001
Never	50.50	3.1 ± 0.66		5.03 ± 1.18		3.18 ± 0.48		3.35 ± 0.69		3.36 ± 0.43		5.03 ± 1.1	
Former	38.99	3.15 ± 0.62		5.18 ± 1.06		3.21 ± 0.45		resili		3.35 ± 0.42		4.93 ± 1.13	
Current	10.39	3.12 ± 0.63		5.2 ± 1.09		3.2 ± 0.47		3.29 ± 0.69		3.33 ± 0.42		4.87 ± 1.14	
Missing data	0.12												
Physical activity (%)			<.0001		<.0001		<.0001		<.0001		<.0001		<.0001
High	36.33	3.18 ± 0.63		5.28 ± 1.03		3.23 ± 0.45		3.41 ± 0.68		3.38 ± 0.42		4.96 ± 1.13	
Moderate	40.36	3.12 ± 0.63		5.18 ± 1.08		3.19 ± 0.46		3.3 ± 0.67		3.34 ± 0.42		4.92 ± 1.12	
Low	22.90	3.07 ± 0.63		5 ± 1.18		3.16 ± 0.48		3.23 ± 0.7		3.27 ± 0.42		4.8 ± 1.16	
Missing data	0.41												
Body Mass Index (kg/m²)	24.13 ± 4.49	-0.03 (-0.04, -0.02)	<.0001	-0.12 (-0.13, -0.1)	<.0001	-0.02 (-0.03, 0)	0.0177	0.02 (0, 0.03)	0.0142	-0.05 (-0.06, -0.04)	<.0001	-0.08 (-0.09, -0.06)	<.0001
Dietary energy intake (Kcal)	1837.57 ± 484.89	0 (-0.01, 0.02)	0.7308	0.05 (0.03, 0.06)	<.0001	0.04 (0.03, 0.05)	<.0001	0.02 (0.01, 0.04)	0.0002	-0.01 (-0.03, 0)	0.0145	0.03 (0.02, 0.05)	<.0001
Snacking frequency (%)			<.0001		<.0001		<.0001		<.0001		<.0001		<.0001
Never	22.55	3.19 ± 0.66		5.28 ± 1.08		3.25 ± 0.46		3.43 ± 0.71		3.41 ± 0.43		5 ± 1.18	
< once a week	17.90	3.16 ± 0.61		5.26 ± 1.03		3.22 ± 0.44		3.36 ± 0.66		3.37 ± 0.42		4.95 ± 1.08	
≥ once a week and < once a day	32.70	3.11 ± 0.62		5.2 ± 1.06		3.2 ± 0.45		3.3 ± 0.67		3.33 ± 0.42		4.93 ± 1.09	

≥ once a day	26.85	3.07 ± 0.63	4.99 ± 1.15	3.14 ± 0.48	3.23 ± 0.69	3.27 ± 0.42	4.78 ± 1.16
General anxiety disorders (GAD-7) (%)		0.0403	<.0001	<.0001	<.0001	<.0001	<.0001
No	89.93	3.16 ± 0.62	5.23 ± 1.05	3.22 ± 0.45	3.36 ± 0.67	3.36 ± 0.42	4.96 ± 1.1
Yes	7.18	2.75 ± 0.6	4.46 ± 1.33	2.91 ± 0.54	2.86 ± 0.72	3.12 ± 0.45	4.27 ± 1.29
Missing data	2.89						
Depressive symptomatology (PHQ-9) (%)		0.30	<.0001	<.0001	<.0001	<.0001	<.0001
No	89.00	3.16 ± 0.62	5.25 ± 1.03	3.23 ± 0.44	3.37 ± 0.67	3.36 ± 0.41	4.97 ± 1.09
Yes	8.11	2.75 ± 0.63	4.28 ± 1.36	2.83 ± 0.55	2.85 ± 0.73	3.1 ± 0.46	4.23 ± 1.31
Missing data	2.89						
Data collected during the lockdown							
Professional activity during lockdown (%)		0.0384	<.0001	<.0001	<.0001	<.0001	<.0001
No professional activity prior to lockdown		3.18 ± 0.79	4.7 ± 1.24	2.99 ± 0.56	3.18 ± 0.69	3.26 ± 0.44	4.86 ± 1.25
Working outside home	8,64	3.14 ± 0.61	5.21 ± 1.06	3.21 ± 0.44	3.36 ± 0.69	3.36 ± 0.43	4.8 ± 1.16
Partially unemployed	10,61	3.13 ± 0.67	5.03 ± 1.21	3.19 ± 0.51	3.26 ± 0.71	3.33 ± 0.43	4.93 ± 1.15
Teleworking from home (fully)	21,91	3.11 ± 0.66	5.21 ± 1.09	3.2 ± 0.49	3.29 ± 0.68	3.33 ± 0.42	5.05 ± 1.07
teleworking from home (partially)	5,46	3.13 ± 0.64	5.21 ± 1.07	3.22 ± 0.45	3.34 ± 0.66	3.33 ± 0.43	5.07 ± 1.05
student	0,33	3.19 ± 0.71	5.03 ± 1.1	3.12 ± 0.5	3.41 ± 0.6	3.32 ± 0.47	5 ± 1.14
other	0,24	3.09 ± 0.63	5.09 ± 1.14	3.17 ± 0.47	3.32 ± 0.69	3.3 ± 0.42	5.02 ± 1.07
Missing	4,99						
Children or grandchildren <18 y at home during the lockdown (%)		<.0001	0.13	<.0001	0.80	0.023	0.0001

Yes	22.13	3.15 ± 0.61	5.28 ± 1.02	3.22 ± 0.44	3.35 ± 0.68	3.35 ± 0.42	4.92 ± 1.12
No	55.33	3.14 ± 0.66	5.33 ± 1.04	3.2 ± 0.48	3.3 ± 0.68	3.3 ± 0.41	5.1 ± 1.06
Missing	22.54						

Abbreviations: BRS, Brief Resilience Scale; FFMQ, Five Facets Mindfulness Questionnaire; GAD-7, General Anxiety Disorder 7 scale; LOT-T, Life Orientation Test – Revised; PHQ-9, Patient Health Questionnaire 9 scale; PMS, Pearlin Mastery Scale; SES, Self-Esteem Scale; SWLS, Satisfaction With Life Scale.

¹ *A higher score corresponds to a higher level of positive psychological trait*

² *All P-Value based on Pearson correlation for continuous variables and Student t test, and variance analyses (ANOVA) for categorical variables.*

³ *Mean ± SD, all such value.*

Table 2. Distribution of participant who declared increasing, decreasing or not changing their snacking frequency and food group consumption during the COVID-19 lockdown. (NutriNet-Santé study, 2016-2020)

Food group (N = 33,766)	Consumption change	Frequency (%)
Snacking	Increased	19.5
	No change	71.2
	Decreased	9.4
Bread, whole-grain	Increased	9.0
	No change	59.2
	Decreased	10.4
	Do not consume	21.6
Pasta, rice, whole-grain	Increased	6.2
	No change	64.2
	Decreased	4.6
Fruit, fresh	Do not consume	25.1
	Increased	13.3
	No change	68.1
	Decreased	17.5
Vegetables, fresh	Do not consume	1.2
	Increased	14.8
	No change	67.0
	Decreased	17.8
Legumes	Do not consume	0.5
	Increased	14.7
	No change	76.8
	Decreased	2.9
Fish or shellfish, fresh	Do not consume	5.6
	Increased	4.7
	No change	49.8
	Decreased	35.4
Red meat, fresh	Do not consume	10.1
	Increased	5.6
	No change	56.2
	Decreased	22.8
Processed meat	Do not consume	15.4
	Increased	7.6
	No change	56.4
	Decreased	13.6
Sandwich, pizzas, savoury pies	Do not consume	22.4
	Increased	5.2
	No change	54.1
	Decreased	14.8
Yoghurt, cottage cheese	Do not consume	25.9
	Increased	10.0
	No change	74.4
	Decreased	6.1
Sweets, chocolate	Do not consume	9.5
	Increased	20.7
	No change	63.0
	Decreased	8.9
Biscuits, cakes	Do not consume	7.4
	Increased	19.8
	No change	58.7
	Decreased	9.8

	Do not consume	11.7
Butter	Increased	8.1
	No change	78.2
	Decreased	3.7
	Do not consume	10.0
Sugar, honey, marmalade	Increased	6.6
	No change	80.3
	Decreased	4.7
	Do not consume	8.5
Sugary drinks, sodas	Increased	2.4
	No change	20.4
	Decreased	3.3
	Do not consume	73.9
Alcoholic drinks	Increased	14.1
	No change	53.
	Decreased	10.3
	Do not consume	22.6

Abbreviations: N, number of participants; %, percentage

	Decreased	0.89 (0.83, 0.94)	0.0002	0.91 (0.85, 0.97)	0.0031	0.85 (0.82, 0.88)	<.0001	0.86 (0.83, 0.9)	<.0001	0.82 (0.75, 0.89)	<.0001	0.85 (0.78, 0.93)	0.0004
Yoghurt, cottage cheese	Increased	0.89 (0.83, 0.96)	0.0028	0.94 (0.87, 1.01)	0.079	0.84 (0.81, 0.88)	<.0001	0.87 (0.83, 0.91)	<.0001	0.85 (0.77, 0.94)	0.0014	0.92 (0.84, 1.02)	0.13
	No change	Ref		Ref		Ref		Ref		Ref		Ref	
	Decreased	0.86 (0.79, 0.94)	0.0012	0.91 (0.83, 1.00)	0.052	0.85 (0.8, 0.89)	<.0001	0.88 (0.83, 0.92)	<.0001	0.78 (0.70, 0.88)	<.0001	0.86 (0.76, 0.97)	0.015
Sweets, chocolate	Increased	0.87 (0.82, 0.92)	<.0001	0.91 (0.86, 0.96)	0.0009	0.87 (0.84, 0.90)	<.0001	0.90 (0.87, 0.93)	<.0001	0.77 (0.72, 0.83)	<.0001	0.84 (0.77, 0.90)	<.0001
	No change	Ref		Ref		Ref		Ref		Ref		Ref	
	Decreased	0.91 (0.84, 0.98)	0.014	0.94 (0.87, 1.01)	0.11	0.85 (0.82, 0.89)	<.0001	0.87 (0.83, 0.91)	<.0001	0.76 (0.69, 0.84)	<.0001	0.80 (0.72, 0.88)	<.0001
Biscuits, cakes	Increased	0.89 (0.84, 0.95)	0.0001	0.94 (0.89, 1.00)	0.037	0.88 (0.85, 0.91)	<.0001	0.91 (0.88, 0.94)	<.0001	0.80 (0.74, 0.87)	<.0001	0.88 (0.81, 0.95)	0.0010
	No change	Ref		Ref		Ref		Ref		Ref		Ref	
	Decreased	0.93 (0.86, 1.00)	0.048	0.96 (0.89, 1.03)	0.23	0.86 (0.82, 0.89)	<.0001	0.87 (0.84, 0.91)	<.0001	0.81 (0.73, 0.89)	<.0001	0.85 (0.76, 0.93)	0.0010
Butter	Increased	0.92 (0.85, 1.00)	0.062	0.97 (0.90, 1.06)	0.55	0.85 (0.81, 0.89)	<.0001	0.88 (0.83, 0.92)	<.0001	0.75 (0.67, 0.84)	<.0001	0.82 (0.74, 0.92)	0.0009
	No change	Ref		Ref		Ref		Ref		Ref		Ref	
	Decreased	0.89 (0.79, 0.99)	0.039	0.93 (0.83, 1.05)	0.23	0.87 (0.81, 0.92)	<.0001	0.89 (0.83, 0.95)	0.0005	0.76 (0.65, 0.88)	0.0002	0.81 (0.69, 0.94)	0.0062
Sugar, honey, marmalade	Increased	0.87 (0.80, 0.96)	0.0038	0.94 (0.85, 1.03)	0.15	0.81 (0.77, 0.86)	<.0001	0.85 (0.81, 0.89)	<.0001	0.74 (0.66, 0.83)	<.0001	0.83 (0.74, 0.94)	0.0029
	No change	Ref		Ref		Ref		Ref		Ref		Ref	
	Decreased	0.98 (0.89, 1.08)	0.69	1.01 (0.91, 1.12)	0.90	0.90 (0.85, 0.95)	0.0002	0.91 (0.86, 0.96)	0.0016	1.00 (0.88, 1.15)	0.94	1.06 (0.92, 1.21)	0.46
Sugary drinks, sodas	Increased	0.75 (0.63, 0.88)	0.0005	0.81 (0.68, 0.95)	0.011	0.87 (0.79, 0.95)	0.0012	0.91 (0.83, 1.00)	0.0400	0.78 (0.64, 0.96)	0.019	0.88 (0.72, 1.09)	0.25
	No change	Ref		Ref		Ref		Ref		Ref		Ref	
	Decreased	1.02 (0.89, 1.16)	0.79	1.08 (0.95, 1.24)	0.25	0.88 (0.82, 0.95)	0.0008	0.91 (0.85, 0.98)	0.015	0.86 (0.73, 1.03)	0.103	0.93 (0.78, 1.12)	0.45
Alcoholic drinks	Increased	0.90 (0.84, 0.96)	0.0026	0.95 (0.89, 1.02)	0.15	0.91 (0.87, 0.94)	<.0001	0.94 (0.90, 0.98)	0.0040	0.84 (0.77, 0.92)	0.0003	0.92 (0.84, 1.01)	0.078
	No change	Ref		Ref		Ref		Ref		Ref		Ref	
	Decreased	1.04 (0.97, 1.11)	0.31	1.06 (0.99, 1.14)	0.089	0.94 (0.90, 0.98)	0.0036	0.95 (0.91, 1.00)	0.037	0.97 (0.88, 1.08)	0.60	1.02 (0.92, 1.13)	0.73

Abbreviations: LOT-T, Life Orientation Test – Revised ; N, number of participants; SES, Self-Esteem Scale ; SWLS, Satisfaction With Life Scale.

¹ Model 1: Adjusted for age, gender, educational level, occupational status, professional activity during lockdown, monthly household income, presence of children or grandchildren <18 y during the lockdown, smoking status, physical activity, body mass index and dietary energy intake.

² Model 2: Model 1 + general anxiety disorders and depressive symptoms.

³ P value based on multinomial logistic regression with psychological characteristics as continuous independent variables.

⁴ For each food group, participants who did not consume the food group of interest were excluded from the analyses.

Table 3 (continued). Association between optimism, satisfaction with life, self-esteem, resilience, mindfulness and mastery, and changes in snacking and food group consumption related to the COVID-19 lockdown period (NutriNet-Santé study, 2016-2020)

		Resilience (BRS) (N = 25,965)				Mindfulness (FFMQ) (N = 29,179)				Mastery (PMS) (N = 17,058)			
		Model 1 ¹		Model 2 ²		Model 1 ¹		Model 2 ²		Model 1 ¹		Model 2 ²	
		OR (95% CI)	P value ³	OR (95% CI)	P value ³	OR (95% CI)	P value ³	OR (95% CI)	P value ³	OR (95% CI)	P value ³	OR (95% CI)	P value ³
Snacking	Increased	0.80 (0.76, 0.84)	<.0001	0.86 (0.82, 0.91)	<.0001	0.67 (0.62, 0.72)	<.0001	0.73 (0.68, 0.79)	<.0001	0.91 (0.88, 0.94)	<.0001	0.95 (0.91, 0.98)	0.0057
	No change	Ref		Ref		Ref		Ref		Ref		Ref	
	Decreased	0.89 (0.83, 0.95)	0.0003	0.92 (0.86, 0.98)	0.0093	0.81 (0.73, 0.89)	<.0001	0.84 (0.76, 0.93)	0.0005	0.93 (0.89, 0.98)	0.0039	0.95 (0.9, 1.0)	0.0410
Bread, whole-grain ⁴	Increased	0.87 (0.82, 0.93)	<.0001	0.89 (0.83, 0.95)	0.0009	0.83 (0.75, 0.92)	0.0003	0.85 (0.77, 0.94)	0.0022	0.94 (0.9, 0.99)	0.025	0.95 (0.91, 1.0)	0.060
	No change	Ref		Ref		Ref		Ref		Ref		Ref	
	Decreased	0.90 (0.84, 0.96)	0.0009	0.95 (0.89, 1.01)	0.11	0.96 (0.87, 1.06)	0.42	1.03 (0.94, 1.13)	0.54	0.92 (0.88, 0.97)	0.0006	0.94 (0.9, 0.99)	0.011
Pasta, rice, whole-grain	Increased	0.86 (0.80, 0.93)	0.0002	0.91 (0.84, 0.99)	0.022	0.74 (0.66, 0.84)	<.0001	0.80 (0.70, 0.90)	0.0002	0.95 (0.89, 1.00)	0.065	0.98 (0.92, 1.04)	0.43
	No change	Ref		Ref		Ref		Ref		Ref		Ref	
	Decreased	0.97 (0.88, 1.06)	0.45	1.02 (0.93, 1.12)	0.71	0.90 (0.78, 1.03)	0.11	0.95 (0.83, 1.09)	0.46	1.02 (0.96, 1.09)	0.48	1.05 (0.98, 1.13)	0.19
Fruit, fresh	Increased	0.98 (0.92, 1.03)	0.43	1.00 (0.95, 1.06)	0.93	0.98 (0.90, 1.07)	0.67	1.02 (0.93, 1.11)	0.73	1.00 (0.96, 1.04)	0.88	1.01 (0.97, 1.06)	0.63
	No change	Ref		Ref		Ref		Ref		Ref		Ref	
	Decreased	0.81 (0.77, 0.85)	<.0001	0.86 (0.82, 0.90)	<.0001	0.77 (0.72, 0.83)	<.0001	0.85 (0.79, 0.92)	<.0001	0.87 (0.84, 0.90)	<.0001	0.90 (0.86, 0.93)	<.0001
Vegetables, fresh	Increased	1.00 (0.95, 1.06)	0.92	1.01 (0.95, 1.07)	0.82	0.97 (0.89, 1.05)	0.49	0.98 (0.9, 1.07)	0.68	1.03 (0.99, 1.07)	0.17	1.03 (0.99, 1.08)	0.13
	No change	Ref		Ref		Ref		Ref		Ref		Ref	
	Decreased	0.78 (0.74, 0.82)	<.0001	0.84 (0.80, 0.88)	<.0001	0.76 (0.71, 0.82)	<.0001	0.84 (0.78, 0.91)	<.0001	0.86 (0.83, 0.90)	<.0001	0.90 (0.87, 0.93)	<.0001
Legumes	Increased	0.88 (0.83, 0.92)	<.0001	0.89 (0.84, 0.94)	<.0001	1.04 (0.96, 1.13)	0.38	1.08 (0.99, 1.17)	0.070	0.98 (0.94, 1.02)	0.22	0.99 (0.95, 1.03)	0.48
	No change	Ref		Ref		Ref		Ref		Ref		Ref	
	Decreased	0.91 (0.82, 1.02)	0.10	0.98 (0.87, 1.09)	0.68	0.91 (0.77, 1.08)	0.30	1.01 (0.85, 1.19)	0.95	0.91 (0.84, 0.99)	0.021	0.94 (0.87, 1.02)	0.13
Fish or shellfish, fresh	Increased	1.03 (0.94, 1.12)	0.58	1.05 (0.95, 1.15)	0.33	0.97 (0.84, 1.11)	0.63	1.00 (0.87, 1.14)	0.96	1.00 (0.94, 1.07)	0.90	1.02 (0.95, 1.09)	0.59
	No change	Ref		Ref		Ref		Ref		Ref		Ref	
	Decreased	0.86 (0.83, 0.90)	<.0001	0.89 (0.86, 0.93)	<.0001	0.93 (0.87, 0.99)	0.017	0.98 (0.92, 1.04)	0.47	0.95 (0.93, 0.98)	0.0031	0.98 (0.95, 1.01)	0.11

	Decreased	0.93 (0.84, 1.04)	0.23	1.00 (0.89, 1.12)	0.98	0.97 (0.82, 1.15)	0.72	1.05 (0.88, 1.25)	0.61	1.00 (0.92, 1.09)	0.91	1.03 (0.95, 1.13)	0.49
			<.000				<.000						
Alcoholic drinks	Increased	0.87 (0.82, 0.92)	1	0.91 (0.86, 0.97)	0.0035	0.79 (0.72, 0.86)	1	0.85 (0.78, 0.93)	0.0004	0.94 (0.90, 0.98)	0.0053	0.97 (0.92, 1.01)	0.16
	No change	Ref		Ref		Ref		Ref		Ref		Ref	
	Decreased	1.01 (0.95, 1.07)	0.81	1.03 (0.97, 1.10)	0.31	1.04 (0.94, 1.14)	0.47	1.08 (0.98, 1.19)	0.11	0.96 (0.92, 1.01)	0.14	0.98 (0.93, 1.03)	0.35

Abbreviations: BRS, Brief Resilience Scale; FFMQ, Five Facets Mindfulness Questionnaire; N, number of participants; PMS, Pearlin Mastery Scale

¹ Model 1: Adjusted for age, gender, educational level, occupational status, professional activity during lockdown, monthly household income, presence of children or grandchildren >18 y during the lockdown, smoking status, physical activity, body mass index and dietary energy intake.

² Model 2: Model 1 + general anxiety disorders and depressive symptoms.

³ P value based on multinomial logistic regression with psychological characteristics as continuous independent variables.

⁴ For each food group, participants who did not consume the food group of interest were excluded from the analyses.

Table 4. Distribution of changes in snacking and food group consumption during the lockdown period across the three clusters derived from the ascending hierarchical classification (AHC) (NutriNet-Santé study, 2016-2020)

	Cluster 1 "No change" (43.89%)	Cluster 2 "Healthy changes" (28.74%)	Cluster 3 "Unhealthy changes" (27.38%)	P value¹
Snacking				< 0.0001
Increase	5.15	7.07	55.41	
No change	91.90	70.02	39.21	
Decreased	2.96	22.91	5.38	
Bread, whole-grain				< 0.0001
Increased	3.12	7.84	19.60	
No change	72.71	49.72	47.35	
Decreased	2.72	18.51	13.63	
No consumption	21.45	23.93	19.42	
Pasta, rice, whole-grain				< 0.0001
Increased	1.17	6.11	14.17	
No change	74.00	58.51	54.35	
Decreased	0.58	10.35	5.06	
No consumption	24.25	25.03	26.42	
Fruit, fresh				< 0.0001
Increased	5.36	17.39	21.61	
No change	88.93	58.18	45.12	
Decreased	4.85	22.85	32.04	
No consumption	0.86	1.59	1.22	
Vegetables, fresh				< 0.0001
Increased	5.52	20.27	23.77	
No change	88.94	55.96	43.54	
Decreased	5.30	22.98	32.22	
No consumption	0.24	0.78	0.48	
Legumes				< 0.0001
Increased	4.34	18.24	27.55	
No change	91.08	69.15	62.06	
Decreased	0.28	5.71	4.14	
No consumption	4.30	6.89	6.24	
Fresh fish and shellfish				< 0.0001
Increased	1.71	5.91	8.29	
No change	68.13	36.42	34.49	
Decreased	23.72	41.98	47.03	
No consumption	6.44	15.70	10.20	
Red meat, fresh				< 0.0001
Increased	1.18	2.97	15.34	
No change	78.04	34.44	44.06	
Decreased	9.76	36.70	29.15	
No consumption	11.02	25.89	11.45	
Processed meat				< 0.0001
Increased	1.32	2.22	23.44	
No change	76.33	33.34	48.58	
Decreased	4.37	28.37	13.04	
No consumption	17.98	36.07	14.94	

Sandwich, pizzas, savoury pies				< 0.0001
Increased	0.70	1.71	15.92	
No change	68.59	35.40	50.63	
Decreased	4.88	26.23	18.84	
No consumption	25.84	36.66	14.60	
Yoghurt, cottage cheese				< 0.0001
Increased	2.13	8.55	24.04	
No change	89.50	62.45	62.74	
Decreased	0.92	13.49	6.62	
No consumption	7.45	15.50	6.60	
Sweets, chocolate				< 0.0001
Increased	5.63	6.71	59.63	
No change	88.39	51.18	34.77	
Decreased	0.58	28.01	2.12	
No consumption	5.40	14.10	3.48	
Biscuits, cakes				< 0.0001
Increased	5.37	5.99	57.52	
Decreased	0.56	31.05	2.17	
No change	84.05	43.00	34.64	
No consumption	10.02	19.96	5.67	
Butter				< 0.0001
Increased	1.09	3.38	24.43	
No change	91.89	65.72	69.40	
Decreased	0.09	11.80	0.96	
No consumption	6.92	19.10	5.21	
Sugar, honey, marmalade				< 0.0001
Increased	0.70	2.67	20.15	
No change	93.33	66.79	73.39	
Decreased	0.20	14.94	1.10	
No consumption	5.78	15.59	5.35	
Sugary drinks, sodas				< 0.0001
Increased	0.29	0.62	7.63	
No change	23.04	9.22	28.00	
Decreased	0.49	8.33	2.44	
No consumption	76.18	81.83	61.93	
Alcoholic drinks				< 0.0001
Increased	6.27	6.25	34.87	
No change	70.88	39.75	38.27	
Decreased	4.35	20.92	8.56	
No consumption	18.50	33.08	18.30	

¹ *P* value based on chi square test

Table 5. Covariance Analysis (ANCOVA) comparing mean scores of each psychological trait of participants belonging to each cluster of nutritional behaviour during the lockdown period (NutriNet-Santé study, 2016-2020)

		Clusters mean (95% CI)			Cluster 1 VS 2		Cluster 1 vs 3		Cluster 2 vs 3		
		Cluster 1 "No change" (43.89%)	Cluster 2 "Healthy changes" (28.74%)	Cluster 3 "Unhealthy changes" (27.38%)	P Value ¹	Mean difference (95% CI)	P Value ²	Mean difference (95% CI)	P Value ²	Mean difference (95% CI)	P Value ²
Optimism (LOT-R) (N = 23,400)	Model 1 ³	3.19 (3.15, 3.23)	3.19 (3.15, 3.23)	3.13 (3.09, 3.17)	<0.0001	0.01 (-0.01, 0.03)	0.46	0.07 (0.05, 0.09)	<.0001	0.06 (0.04, 0.08)	<0.0001
	Model 2 ⁴	2.98 (2.93, 3.02)	2.99 (2.94, 3.03)	2.94 (2.9, 2.98)	0.0013	-0.01 (-0.03, 0.01)	0.43	0.04 (0.02, 0.06)	0.0003	0.05 (0.02, 0.07)	0.0001
Resilience (BRS) (N = 23,455)	Model 1 ³	3.45 (3.41, 3.49)	3.42 (3.38, 3.46)	3.35 (3.31, 3.39)	<0.0001	0.04 (0.02, 0.05)	0.0005	0.11 (0.09, 0.13)	<.0001	0.07 (0.05, 0.1)	<0.0001
	Model 2 ⁴	3.2 (3.16, 3.24)	3.18 (3.14, 3.23)	3.13 (3.08, 3.17)	<0.0001	0.02 (0, 0.04)	0.10	0.07 (0.05, 0.09)	<.0001	0.06 (0.03, 0.08)	<0.0001
Self-esteem (R-SES) (N = 23,435)	Model 1 ³	3.22 (3.19, 3.25)	3.18 (3.15, 3.21)	3.15 (3.12, 3.18)	<0.0001	0.04 (0.02, 0.05)	<.0001	0.07 (0.05, 0.08)	<.0001	0.03 (0.01, 0.05)	0.0005
	Model 2 ⁴	3.04 (3.01, 3.07)	3.01 (2.98, 3.04)	3 (2.96, 3.03)	<0.0001	0.03 (0.01, 0.04)	0.0002	0.04 (0.03, 0.06)	<.0001	0.02 (0, 0.03)	0.048
Satisfaction with life (SWLS) (N = 25,965)	Model 1 ³	5.21 (5.14, 5.27)	5.03 (4.97, 5.1)	4.97 (4.9, 5.04)	<0.0001	0.17 (0.14, 0.2)	<.0001	0.24 (0.21, 0.28)	<.0001	0.07 (0.03, 0.11)	0.0004
	Model 2 ⁴	4.79 (4.72, 4.86)	4.64 (4.57, 4.72)	4.61 (4.53, 4.68)	<0.0001	0.14 (0.11, 0.17)	<.0001	0.18 (0.15, 0.22)	<.0001	0.04 (0, 0.08)	0.039
Mindfulness (FFMQ) (N = 29,179)	Model 1 ³	3.23 (3.2, 3.25)	3.24 (3.22, 3.27)	3.18 (3.15, 3.2)	<0.0001	-0.02 (-0.03, -0.01)	0.0010	0.05 (0.03, 0.06)	<.0001	0.07 (0.05, 0.08)	<0.0001
	Model 2 ⁴	3.35 (3.32, 3.37)	3.36 (3.33, 3.38)	3.28 (3.26, 3.31)	<0.0001	-0.01 (-0.02, 0)	0.084	0.07 (0.05, 0.08)	<.0001	0.08 (0.06, 0.09)	<0.0001
Mastery (PMS) (N = 17,058)	Model 1 ³	4.99 (4.91, 5.08)	4.92 (4.84, 5)	4.88 (4.79, 4.96)	<0.0001	0.07 (0.03, 0.11)	0.0003	0.12 (0.07, 0.16)	<.0001	0.04 (0, 0.09)	0.076
	Model 2 ⁴	4.63 (4.54, 4.72)	4.58 (4.49, 4.67)	4.57 (4.48, 4.66)	0.0009	0.05 (0.01, 0.09)	0.020	0.06 (0.02, 0.1)	0.0054	0.01 (-0.03, 0.06)	0.57

Abbreviations: BRS, Brief Resilience Scale; FFMQ, Five Facets Mindfulness Questionnaire; GAD-7, General Anxiety Disorder 7 scale; LOT-T, Life Orientation Test – Revised; PHQ-9, Patient Health Questionnaire 9 scale; PMS, Pearlin Mastery Scale; SES, Self-Esteem Scale; SWLS, Satisfaction With Life Scale.

¹ P value based on covariance analysis (ANCOVA)

² Adjusted P values for multiple comparisons (Holm-Bonferroni method)

³ Model 1: Adjusted for age, gender, educational level, occupational status, professional activity during lockdown monthly household income, presence of children or grandchildren >18 y during the lockdown, smoking status, physical activity, body mass index and dietary energy intake.

⁴ Model 2: Model 1 + general anxiety disorders and depressive symptoms.