

AperTO - Archivio Istituzionale Open Access dell'Università di Torino

A tasting experiment comparing food and nutritional supplement in anorexia nervosa

This is a pre print version of the following article:

Original Citation:

Availability:

This version is available <http://hdl.handle.net/2318/1758242> since 2020-10-13T10:43:00Z

Published version:

DOI:10.1016/j.appet.2020.104789

Terms of use:

Open Access

Anyone can freely access the full text of works made available as "Open Access". Works made available under a Creative Commons license can be used according to the terms and conditions of said license. Use of all other works requires consent of the right holder (author or publisher) if not exempted from copyright protection by the applicable law.

(Article begins on next page)

1
2
3 **A tasting experiment comparing food and nutritional supplement in anorexia nervosa**
4

5
6 Marzola Enrica, Cavallo Fabio, Pradella Paolo, Brustolin Annalisa, Abbate-Daga Giovanni[§]
7

8
9 Eating Disorders Center for Treatment and Research, Department of Neuroscience, University of
10

11 Turin, Via Cherasco 11, 10126, Turin, Italy
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

30 [§] Corresponding author:
31

32
33 Prof. Giovanni Abbate-Daga
34

35
36 Director of the Eating Disorders Center
37

38
39 Department of Neuroscience
40

41
42 University of Turin,
43

44
45 Via Cherasco 11, 10126, Turin, Italy
46

47
48 Tel and fax: +39 011 6335749
49

50
51 Email: giovanni.abbatedaga@unito.it
52
53
54
55
56
57
58
59

60
61
62 **Abstract**
63

64 Anorexia nervosa (AN) is a severe psychiatric disorder leading to life-threatening emaciation.

65
66 Weight restoration is crucial in treatment but few data are available on how to achieve it.
67

68
69 Nutritional supplements are needed in treatment but patients' preferences about natural versus
70
71 medical foods and their gustatory/hedonic perception are unclear. We aimed to measure disgust and
72
73 reward-based eating in AN and to assess psychological, interoceptive awareness-related, behavioral,
74
75 and hedonic aspects comparing natural versus medical food. Thirty-three inpatients with AN and 39
76
77 healthy controls (HCs) were recruited and received 50 ml of either apricot juice or nutritional liquid
78
79 supplement with apricot flavor on two consecutive days. Disgust, reward-based eating, and eating
80
81 psychopathology were evaluated. Visual Analogue Scales measuring anxiety, hunger, confusion
82
83 about internal states, need for over-exercise, restraint, and satiety were completed before and after
84
85 the experiment. Disgust and hedonic responses were measured after the experiment. Patients with
86
87 AN reported preserved disgust sensitivity and higher reward-based eating drive. When compared to
88
89 HCs, inpatients with AN reported higher scores on anxiety, hunger, confusion about internal states,
90
91 urge to over-exercise, urge to eating restraint, and satiety before and after the tasting experiment.
92
93 The supplement slightly increased patients' anxiety with HCs reporting the same trend. Still,
94
95 patients reported more food-related disgust after the supplement but their overall hedonic evaluation
96
97 was similar for both conditions. Also, anxiety, confusion about internal states, and urge to over-
98
99 exercise and restraint did not significantly increase after **consuming** either food. Therefore, if we
100
101 take into account patients' level of heightened satiety and suppressed hunger, supplements could be
102
103 helpful for patients with severe AN since greater **energy** intakes could be provided with only small
104
105 volumes of food and little changes of eating concerns.
106
107
108

109 **Keywords:** eating disorders, medical foods, weight restoration, anxiety, interoceptive awareness,
110
111 hospitalization
112
113
114
115
116
117
118

119
120
121 **1. Introduction**
122

123 Anorexia nervosa (AN) is a severe psychiatric disorder characterized by persistent
124 restriction of food intake at times alternated by breakdowns of inhibition (i.e., binges) and
125 dangerous purging behaviors, fear of being "fat" despite severe emaciation, obsessive thoughts
126 about food and weight, and disturbance in the way in which one's body weight or shape is
127 experienced. Currently, treatment outcomes are highly unsatisfactory with psychiatric comorbidity
128 and mortality being very high (Smink, Van Hoeken, & Hoek, 2012).
129

130 Although a key aspect of the treatment of AN is weight restoration (American Psychiatric
131 Association [APA], 2010; National Institute for Health and Care Excellence [NICE], 2017), food
132 aversion represents a hallmark of this disorder and one of the main obstacles to treatment (Fassino
133 & Abbate-Daga, 2013). Gustation is crucial in guiding one's own food choices, including food
134 approach, selection, preference, and avoidance (Van Dongen, Van Den Berg, Vink, Kok, & De
135 Graaf, 2012). Quantities and qualities/textures of what we eat are guided by sensory and metabolic
136 processes. Several studies deepened the tasting function in AN (Kinnaird, Stewart, & Tchanturia,
137 2018), with the overarching aim to expand knowledge on potential etiology and maintenance
138 factors, including taste perception, in turn improving the available treatment options.
139

140 The available body of evidence on taste sensitivity in AN is somehow mixed and only
141 partially connected to clinical practice. With more detail, the literature on taste in the field of eating
142 disorders focused mainly on gustatory sensitivity and hedonic response to taste stimuli. Earlier
143 papers reported a preserved gustatory sensitivity in AN (Drewnowski, 1989) while more updated
144 studies did not confirm this finding, as reported in a recent review proposing an altered taste
145 sensitivity in AN that may improve after recovery (Kinnaird, Stewart, & Tchanturia, 2018).
146 Besides, patients with AN showed decreased taste reactivity (Szalay et al., 2010) with behavioral
147 therapy potentially improving taste responsiveness (Nozoe et al., 1996). Concerning the hedonic
148 perception of taste, literature reports patients affected by bulimia nervosa having a greater
149 preference for sweet foods than those with AN, characterized by fat aversion instead (Chao, Roy,
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177

178
179
180 Franks, & Joseph, 2020). Also, an earlier study demonstrated that patients with AN tend to dislike
181
182 foods rich in fats but their perception of the sweet taste was preserved (Simon, Bellisle, Monneuse,
183
184 Samuel-Lajeunesse, & Drewnowski, 1993). Interestingly, an investigation on the hedonic aspects of
185
186 gustation in AN reported that the hedonic response to sucrose was lower if patients were asked to
187
188 swallow versus spit the sweet solution (Eiber, Berlin, De Brettes, Foulon, & Guelfi, 2002).

191 Tasting is linked to reward processes in the brain; the reward network is known to impact on
192
193 the development and maintenance of AN (Berner et al., 2019); in this regard, patients' taste
194
195 experience represents the very first step of such a crucial reward pathway. The taste is fundamental
196
197 in modulating eating behaviors: its alterations can influence directly food drive and food avoidance
198
199 alike (Ventura & Worobey, 2013). Neuroimaging studies, using taste stimuli, reported altered or
200
201 reduced activation of the insula (i.e., primary gustatory cortex), in patients with AN, compared to
202
203 HCs (Frank, Shott, Keffler, & Cornier, 2016; Wagner et al., 2008). Relatedly, women recovered
204
205 from AN reported different insula activations is **consuming** sucrose versus sucralose (i.e., sucrose-
206
207 like sweet taste but no calories) solutions (Oberndorfer et al., 2013) and very recent data highlighted
208
209 a neural insensitivity of patients with AN to the hunger stimulus (Kaye et al., 2020).

212 Notwithstanding the aforementioned literature, it turns out that only scant data are available
213
214 on taste perception as applied to “real-world” contexts. For example, in every-day practice, mostly
215
216 when working with patients with severe AN, the use of nutritional supplements is not only common
217
218 but also much needed (Marzola, Nasser, Hashim, Shih, & Kaye, 2013). The clinical rationale for
219
220 using medical foods as supplements is at least three-fold: a) they can provide vitamin and mineral
221
222 needs; b) gastric emptying of solid meals tends to be delayed in AN while liquid meals are more
223
224 tolerable; c) **energy**-dense foods are helpful to avoid abdominal bloating when patients' emaciation
225
226 requires intense daily **energy** amounts. Despite several clinical benefits, clinicians know well that
227
228 some AN sufferers are really frightened by nutritional supplements because of their **energy** density.
229
230 In contrast, other patients prefer medical foods to natural foods because the former are seen as
231
232 medications bypassing the use of real foods. Whatever the clinical presentation, studies providing
233
234

237
238
239 quantitative measures on patients' preferences regarding natural versus medical foods and their
240
241 gustatory and hedonic perception are currently lacking.
242

243 To help bridging the aforementioned gaps in literature we designed a standardized tasting
244
245 experiment asking patients with AN and healthy controls (HCs) to taste on two consecutive days 50
246
247 ml of either apricot juice (28 kcal) or nutritional liquid supplement (75 kcal) with apricot flavor and
248
249 to complete a battery of assessments before and after the tasting experiment. Keeping the volume
250
251 constant while modulating **energy** intake, we attempted to disentangle what could be related to
252
253 patients' satiety versus their eating-related cognitive aspects. Therefore, with the overarching goal
254
255 to inform treatments on the use of medical foods in the treatment of AN we aimed: a) to measure
256
257 disgust sensitivity and reward-based eating in patients with AN and HCs; b) to assess differences on
258
259 a variety of psychological (i.e., anxiety) and interoceptive awareness-related (i.e., hunger, satiety,
260
261 confusion about internal states), behavioral (i.e., urge to over-exercise, urge to eating restraint) and
262
263 hedonic (food-related hedonic evaluation and disgust) between groups (i.e., AN versus HCs) across
264
265 conditions (i.e., juice day versus supplement day) on two different time points (i.e., before and after
266
267 the tasting experiment).
268
269
270

271 Our a priori hypothesis was to find differences in disgust perception between patients with
272
273 AN and HCs with the latter group showing more reward-driven eating. Still, we expected to find
274
275 patients with AN as showing differences when compared to HCs, mostly concerning the
276
277 comparison between juice versus supplement condition.
278
279
280
281

282 **2. Methods**

283 **2.1 Participants**

284
285
286
287 Inpatients consecutively and voluntarily admitted to the Psychiatry ward of the Eating
288
289 Disorders Center of the University of Turin, at the "Città della Salute e della Scienza" hospital of
290
291 Turin, Italy, were initially asked to participate in this study between February and November 2019.
292
293
294
295

296
297
298 Inclusion criteria for patients were the following: a) diagnosis of AN as assessed with the Structured
299
300 Clinical Interview for DSM-5 (First, Williams, Karg, & Spitzer, 2016) by an experienced
301
302 psychiatrist upon admission; b) female gender; c) no substance dependence; c) no psychotic –
303
304 spectrum disorders; d) no organic comorbidities (e.g., diabetes). Out of the 45 patients interviewed,
305
306 6 did not meet the inclusion criteria, 5 refused participation and 1 failed to complete the assessment
307
308 battery. Therefore, 33 inpatients were finally enrolled.

309
310
311 Healthy controls (HCs) were recruited at the same Institution through flyers and word of
312
313 mouth and a total of 39 HCs (i.e., medical students, psychology students, residents, individuals who
314
315 were interested in giving their moral contribution to the research) were finally enrolled. Inclusion
316
317 criteria for HCs were: a) being free of psychotropic medications; b) not meeting criteria for a
318
319 current or lifetime diagnosis of EDs or other psychiatric disorders, as assessed by an experienced
320
321 psychiatrist.

322
323
324 Participants were all Caucasian and a trained nurse measured everyone's height and weight
325
326 to calculate their body mass index (BMI).

327
328
329 The Ethical Committee of the Department of Neuroscience of the University of Turin, Italy,
330
331 approved this study and all participants provided their written informed consent.

332 333 334 335 336 **2.2 Procedure**

337
338
339 To run the tasting experiment, all participants were assigned to receive 50 ml of either
340
341 apricot juice (28 kcal) or nutritional liquid supplement (75 kcal) with apricot flavor on two
342
343 consecutive days. Participants were unaware of the **energy** value of the foods. No previous data
344
345 were available to set a standardized quantity of juice/supplement; so the volume was set at 50 ml in
346
347 order to ensure research feasibility (also avoiding the bias related to patients' potential feeling of
348
349 "fullness"). Also, the volume was kept constant with a different **energy** intake (almost three times as
350
351

355
356
357 much for the medical food), to clarify what could be related to patients' satiety versus their
358
359 cognitive aspects. The apricot taste was standardized to avoid individual preferences (e.g., apricot
360
361 versus strawberry). The order of administration (i.e., juice on day 1 or day 2) was randomized in
362
363 order to avoid bias since the second administration could be influenced by the one received on the
364
365 day before. All patients were amenorrheic; HCs were not tested during the week preceding their
366
367 menses to avoid hormonal-related food craving to be a confounder. Participants were asked to
368
369 assess on a 10-cm Visual Analogue Scale anxiety, hunger, confusion about internal states, need for
370
371 physical activity, restraint, and satiety before and after the experiment on both days. Participants'
372
373 disgust and hedonic responses were also measured after the experiment on both days. Participants
374
375 were tested at 11 a.m. after a fasting period of 2.5 hours following a standardized morning breakfast
376
377 of 250 kcal at 8.30 am. Inpatients were assessed during the first week of their hospital stay. If
378
379 enteral or parenteral nutrition was required for patients, it was administered during the remaining
380
381 hours of the day (i.e., afternoon). Also, all inpatients were informed that any eventual changes in
382
383 their total daily **energy** intake (as decided with an individualized behavioral contract) would have
384
385 been adjusted for the **consumption** of either juice or liquid supplement, to make it clear that study
386
387 participation would not bring about any **energy** increases.
388
389
390
391
392
393
394

395 **2.3 Measures**

396
397 At study entry, all participants provided socio-demographical and clinical information and
398
399 were asked to complete the following assessments:
400

- 401 • Disgust scale (Haidt, Mccauley, & Rozin, 1993): is a 32 items questionnaire that
402
403 measures sensitivity and includes 2 true-false and 2 disgust-rating items for each of
404
405 seven domains of disgust elicitors (food, animals, body products, sex, body envelope
406
407
408
409
410
411
412
413

414
415
416 violations, death, and hygiene) and for a domain of magical thinking (via similarity and
417 contagion) that cuts across the seven domains of elicitors.
418

- 419
420 • Reward-based eating scale (Epel et al., 2014): some individuals report factors that drive
421 overeating, including lack of control, lack of satiation, and preoccupation with food,
422 which may stem from reward-related neural circuitry. This 9-item scale captures reward-
423 based eating drive as a single factor, with high internal consistency and invariance across
424 demographic factors.
425
- 426 • Eating disorder examination (EDE-Q; Luce & Crowther, 1999): a 41 items semi-
427 structured interview conducted by a clinician in the assessment of an eating disorder.
428 EDE-Q provides four subscales (restraint, eating concern, shape concern and weight
429 concern) and a global score.
430
- 431 • Hedonic scale (Peryam & Pilgrim, 1957): the hedonic scale indicates general levels of
432 preference of a stimuli (actual samples or food names) with 9 categories ranging from
433 "dislike extremely" to "like extremely."
434
435
436
437
438
439
440
441
442
443
444

445
446 Before and after the experiment all participants completed a battery of Visual Analogue
447 Scales (VAS) measuring, on a 10-cm line, the following: a) anxiety, b) hunger; c) confusion about
448 internal states; d) urge to over-exercise; e) urge to eating restraint; f) satiety.
449
450

451
452 After the tasting experiment, all participants completed a VAS measuring food-related
453 disgust and the hedonic scale (Peryam & Pilgrim, 1957).
454
455
456

457 458 459 460 **2.4 Statistical analysis**

461
462 The SPSS 25.0 statistical software package (IBM SPSS Statistics for Windows, Version
463 25.0. Armonk, NY: IBM Corp) was used for all analyses.
464
465
466
467
468
469
470
471
472

473
474
475 Student's t-test for independent samples was used to evaluate the differences between AN
476 and HC groups on all the baseline assessment batteries.
477
478

479
480 A mixed-model repeated-measures ANOVA was performed to investigate any differences
481 occurred over time (i.e., before and after the tasting experiment), between groups (i.e., AN versus
482 HCs), and across conditions (i.e., juice day versus supplement day). The effect size was measured
483 with the Eta Squared (η^2). According to Cohen's work (Pierce, Block, & Aguinis, 2004), the effect
484 size can be assessed as small $\eta^2=0.01-0.06$; moderate $\eta^2=0.06-0.14$; or large $\eta^2>0.14$.
485
486
487
488
489
490
491
492
493

494 **3. Results**

495 ***3.1 Sociodemographic and clinical characteristics of the sample***

496
497 A total of 33 female inpatients with AN were enrolled: 21 were diagnosed with the
498 restricting type of AN (R-AN) and 12 by the binge-purging type of AN (BP-AN). Thirty-nine
499 female HCs were recruited as well so the total sample was 72.
500
501
502
503
504
505

506 Sociodemographic characteristics are shown in Table 1. Concerning clinical variables, those
507 with AN and HCs differed with respect to BMI but had similar age (see Table 1). Patients' duration
508 of illness was 7.8 ± 8.6 years [range: 0.25 – 30 years]; four patients (12%) were receiving parenteral
509 and 11 (33%) enteral nutrition. Patients and HCs differed on all subscales of eating
510 psychopathology as measured by the EDE-Q (Table 1).
511
512
513
514
515
516

517 -----PLEASE INSERT TABLE 1 AROUND HERE-----
518

519 ***3.2 Disgust sensitivity and reward-based eating***

520
521 As shown in Table 1, patients and HCs did not differ on the disgust scale but significantly
522 differed on the reward-based eating scale (see Table 1).
523
524
525
526
527
528
529
530
531

532
533
534
535
536
537 **3.3 Correlations between disgust, reward-based eating and eating psychopathology**
538

539 No correlations were found between disgust and eating psychopathology in either group (see
540 Table 2). Concerning reward-based eating, patients with AN reported significant correlations with
541 the EDE-Q total score and all subscales but restraint (Table 2). In contrast, HCs did not show any
542 significant correlations with either scale (Table 2); therefore, only patients with AN showed higher
543 reward-based eating as correlated with more severe eating psychopathology.
544
545
546
547
548

549 -----PLEASE INSERT TABLE 2 AROUND HERE-----
550
551
552
553
554

555 **3.4 The tasting experiment**
556

557
558 **3.4.1. Group differences in the taste experiment**
559

560
561 As shown in Table 3, patients with AN and HCs displayed between-subjects significant
562 differences with large effect sizes on all measures considered (Figure 1) with the exception of the
563 hedonic scale that did not reach statistical significance between groups (Figure 2). Thus, these
564 findings indicate a **very** different subjective evaluation for all food-related aspects; in contrast,
565 hedonic evaluation was not impaired in AN.
566
567
568
569
570
571

572 **3.4.2. Time-related changes before and after the tasting experiment**
573

574
575 Significant changes before and after the tasting experiment were reported only for hunger
576 and satiety; therefore, the scores of all other considered variables (i.e., anxiety, confusion, need for
577 physical activity, and restraint) were **similar** over time.
578
579
580
581

582 **3.4.3. Condition-related differences in the tasting experiment**
583

584
585 Some significant differences comparing conditions (i.e., juice versus supplement) emerged
586 in anxiety, disgust, and hedonic response. In fact, participants were more anxious when **consuming**
587
588
589
590

591
592
593 the supplement as compared to the juice and they were less disgusted by the juice than by the
594
595 supplement. The hedonic response showed also a significant group-by-condition interaction (see
596
597 below).

600 **3.4.4. Interactions between condition and group in the tasting experiment**

602
603 The hedonic scale reported not only a significant effect of condition, but also a significant
604
605 interaction between condition (i.e., juice versus supplement) and group (i.e., AN versus HCs). That
606
607 is, being affected by AN significantly impacted on the hedonic evaluation of the food: in fact,
608
609 patients with AN deemed juice and supplement as equally pleasant while HCs reported higher
610
611 hedonic value for the juice.

614 **3.4.4. Interactions between time and group in the tasting experiment**

616
617 Significant interactions between time (i.e., differences in scores reported before and after the
618
619 tasting experiment) and group (i.e., AN versus HCs) were seen for the need for physical activity; in
620
621 fact, only patients with AN reported heightened drive to over-exercise after the experiment (in both
622
623 conditions) while HCs' need for physical activity remained the same (or even lowered) after
624
625 receiving juice or medical supplement.
626

628 -----PLEASE INSERT TABLE 3 AROUND HERE-----
629

633 **4. Discussion**

634
635
636 Our investigation of taste perception in AN in the real-world setting of the hospital stay
637
638 yielded several main findings: first, we found not only a maintained ability to perceive disgust in
639
640 AN but also more reward-based eating (directly correlated with eating psychopathology) in AN
641
642 than in HCs. Second, our study clarified that inpatients with AN and HCs report profound (i.e., with
643
644 large effect sizes) differences on all the measured taste-related aspects of eating. In particular,
645
646
647
648
649

650
651
652 patients with AN reported markedly greater anxiety, hunger, confusion about internal states, need
653
654 for physical activity, urge to eating restraint, and satiety than HCs. Thirdly, food-related hedonic
655
656 response **were** intact in AN; nevertheless, it is of note that patients reported equal hedonic values for
657
658 real versus medical foods, while HCs showed a more fine-grained reponse depending on the food
659
660 stimulus considered (that is, HCs preferred the juice). Finally, in AN, the supplement elicited more
661
662 anxiety and food-related disgust than the juice with HCs showing the same trend.
663
664

665
666 In contrast with our a priori hypothesis, patients with AN were shown to have maintained
667
668 disgust sensitivity. Research on this topic is currently growing in the field of eating disorders
669
670 (Harris et al., 2019; Menzel, Reilly, Luo, & Kaye, 2019) but, to date, the findings on disgust in AN
671
672 are overall mixed (Troop, Murphy, Bramon, & Treasure, 2000; Aharoni & Hertz, 2012; Davey,
673
674 Buckland, Tantow, & Dallos, 1998). Also, the disgust scale did not show significant correlations
675
676 with eating psychopathology for either patients or HCs. Therefore, our findings suggest that disgust
677
678 sensitivity could be not only preserved in AN but also unrelated to the core features of AN
679
680 psychopathology. Given the debate on these aspects (Harris et al., 2019; Menzel et al., 2019), future
681
682 studies are needed to clarify this discrepancy; nevertheless, differences in assessment tools could
683
684 account for this difference as well as the sample composition, namely severe hospitalized patients.
685
686

687
688 Strikingly, those with AN reported higher reward-based drive to eat than HCs. It is difficult
689
690 to compare this result with the existing literature since this scale has not been used so far in the field
691
692 of eating disorders. Nevertheless, differences between subgroups of AN could impact on this
693
694 **observation** with those **diagnosed with** the binge-purging subtype being particularly impulsive over
695
696 food (Pryor, Wiederman, & McGilley, 1996). Also, some questions (e.g., “When I start eating, I just
697
698 can’t seem to stop”; “Food is always on my mind”) could be somehow misleading since more
699
700 focused on preoccupation for food instead **of** reward. Therefore, patients with AN could have
701
702 scored higher because they are typically frightened by the possibility of losing control over food. In
703
704 keeping with this hypothesis, those between patients' reward-based eating scale and eating
705
706
707
708

709
710
711 psychopathology were the only significant correlations. Still, it could not be ruled out that
712
713 psychopathology severity could be associated with drive for food that patients could mislabel as
714
715 reward-based eating.
716
717

718 According to the a priori hypothesis, HCs and patients with AN reported significantly
719
720 different scores on all psychological (i.e., anxiety), interoceptive awareness-related (i.e., hunger,
721
722 satiety, confusion about internal states), behavioral (i.e., urge to over-exercise, urge to eating
723
724 restraint) and food-related disgust assessments, with large effect sizes. Although expected, based on
725
726 clinical experience and previous data (Kaye et al., 2020; Marzola et al., 2016), this difference has
727
728 been measured in a real-world setting entailing for participants the **consumption** of real food.
729
730 Things change for patients when they know that they will have to **consume** the food they are
731
732 presented with (Milos et al., 2013). Therefore, these findings could contribute to expand therapists'
733
734 knowledge of how difficult for patients with AN is to approach both natural and medical food.
735
736
737

738 Focusing on the differences found in the AN group between the juice and supplement
739
740 conditions with the overarching goal of potentially **informing** treatments, it is of note that the
741
742 medical food resulted to be more anxiogenic for patients when compared to the juice; however,
743
744 anxiety, confusion about internal states, and urge to both over-exercise and **restrict food intake** did
745
746 not significantly increase after **consuming** either food. Similarly, both juice and supplement
747
748 significantly increased satiety and lowered hunger, a painful stimulus for AN sufferers (Sunday &
749
750 Halmi, 1996; Westmoreland, Krantz, & Mehler, 2016). Still, patients reported more food-related
751
752 disgust after the supplement but their hedonic evaluation was the same for both conditions.
753
754 Therefore, if we take into account that patients' level of satiety/hunger were markedly different than
755
756 those of HCs, medical foods could be helpful in treatment since greater **energy** intakes could be
757
758 provided with small volumes of food. Taken together, these findings can be of clinical relevance: on
759
760 one hand, the supplement entails heightened levels of anxiety but on the other hand, it is also true
761
762 that the fruit juice generates marked anxiety anyway.
763
764
765
766
767

768
769
770 It is of note that the aforementioned results have not been biased by the issue of food portion
771
772 since the volume was kept constant so we found patients with AN as being more anxious when
773
774 evaluating the nutritional supplement, independently of the portion size. Previous lines of research
775
776 on patients' portion size assessment in AN reported that visual size determined patients' anxiety
777
778 more than the energy density of the food (Kissileff et al., 2016). Our study garners innovative data
779
780 showing that, if the portion size is kept constant, calories do not extremely impact on patients'
781
782 anxiety which does not increase after **consuming** either natural or medical foods. However, this
783
784 comparison could be hampered by the different study design: our sample was composed of severe
785
786 inpatients who knew that the presented food had to be eaten, and not only measured, during the
787
788 experiment. This could promote the activation of top-down cognitive aspects aimed at handling the
789
790 long-term consequences of eating behavior (Kaye, Fudge, & Paulus, 2009).
791
792

793
794 Patients with AN and HCs scored differently on the food-related disgust assessment and a
795
796 significant main effect of condition emerged as well. That is, patients with AN were more disgusted
797
798 after tasting the apricot-flavor supplement than the apricot juice. Therefore, this finding puts disgust
799
800 in AN in a broader perspective: in fact, on one hand disgust perception is overall maintained in AN,
801
802 but on the other hand, when focusing on food-related aspects, patients with AN perceive disgust
803
804 much more markedly than HCs.
805
806

807
808 Differently from our a priori hypothesis, patients with AN reported food-related hedonic
809
810 values comparable to those of HCs so this was the only assessment that did not differ between
811
812 groups. Assuming that the hedonic scale **includes** the assessment of the cognitive component of
813
814 taste, it is noteworthy that patients with AN, although potentially more anxious given the
815
816 supplement condition, found equally rewarding the juice and the supplement. In the light of the
817
818 current debate on reward in AN (Kaye, Wierenga, Bailer, Simmons, & Bischoff-Grethe, 2013; Kaye
819
820 et al., 2020) this is of clinical interest since these findings open up the possibility that also more
821
822 **energy-dense** food could not impact on patients' hedonic response. Once more, patients' cognitive
823
824

827
828
829 "top-down" brain circuits of control could be more activated than those of the "bottom-up" brain
830 networks, involved in the hedonic response and pleasure of a certain stimulus (Kaye et al., 2013).
831
832 However, it could be argued that, during their evaluations, patients could find other elements than
833
834 the taste itself as rewarding, like perceiving supplements as medications rather than real food.
835
836
837

838
839 In spite of some strengths like the real-world setting, the control of hunger (Tapper, 2005),
840 the measurement of hunger and satiety before the experiment, and the quantitative measurement of
841 refeeding aspects with severe patients, this study suffers from some limitations as well: inpatients in
842 a very acute phase of AN were recruited, no longitudinal data are available, and data
843
844 generalizability could be hampered by the kind (i.e., brand) of medical food used. Finally,
845
846 participants' were not asked about their overall preference between real versus medical food.
847
848
849
850

851
852 In closing, our data show that the use of medical foods (i.e., nutritional supplements) is not
853
854 contraindicated in the treatment of severe AN. In fact, patients tolerated equally well, from a
855
856 hedonic perspective, both foods although they reported the supplement as slightly more anxiogenic
857
858 and disgusting than the juice. Notwithstanding the between-group difference, HCs reported the
859
860 same trend for anxiety and disgust, albeit with a different magnitude. Also, neither juice nor the
861
862 supplement significantly increased over time patients' scores of anxiety, confusion about internal
863
864 states, and urge to restraint. Finally, when compared to HCs, patients' reported scarce hunger
865
866 coupled with heightened satiety with very large effect size. Taken together, these findings suggest
867
868 that the supplement could be a valid treatment option, useful to help patients consume an intense
869
870 energy intake without entailing great volumes of food. Furthermore, a relevant energy increase (i.e.,
871
872 three times greater than the juice) increased anxiety only a little. That said, it is of note that anxiety,
873
874 food-related disgust, heightened satiety, and tendency to physical over-exercise after meals are
875
876 hallmarks of severe AN so all trained clinicians already know that these core components of the
877
878 disorder have to be addressed anyway in treatment, independently of the refeeding strategy selected.
879
880
881
882
883
884
885

886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944

Conflict of interest

The authors have no conflicts of interest to declare.

Author contributions

GAD and EM designed the study; EM and PP conducted the assessments; EM and FC drafted the manuscript and ran the analyses; GAD supervised the analyses; AB and GAD critically revised the manuscript.

Funding sources

This is unfunded research.

Acknowledgments

None.

References

- Aharoni, R., & Hertz, M. M. (2012). Disgust sensitivity and anorexia nervosa. *European Eating Disorders Review*, *20*(2), 106–110. <https://doi.org/10.1002/erv.1124>
- American Psychiatric Association [APA]. (2010). *Practice Guideline For The Treatment of Patients With Eating Disorders Third Edition*. Retrieved from <https://www.psychiatry.org/psychiatrists/practice/clinical-practice-guidelines>
- Berner, L. A., Brown, T. A., Lavender, J. M., Lopez, E., Wierenga, C. E., & Kaye, W. H. (2019, November 1). Neuroendocrinology of reward in anorexia nervosa and bulimia nervosa:

945
946
947 Beyond leptin and ghrelin. *Molecular and Cellular Endocrinology*, Vol. 497.

948
949 <https://doi.org/10.1016/j.mce.2018.10.018>

950
951
952 Cascino, G., Castellini, G., Stanghellini, G., Ricca, V., Cassioli, E., Ruzzi, V., ... Monteleone, A.

953
954 M. (2019). The role of the embodiment disturbance in the anorexia nervosa psychopathology:

955
956 A network analysis study. *Brain Sciences*, 9(10). <https://doi.org/10.3390/brainsci9100276>

957
958
959 Chao, A. M., Roy, A., Franks, A. T., & Joseph, P. V. (2020). A Systematic Review of Taste

960
961 Differences Among People With Eating Disorders. *Biological Research for Nursing*, 22(1),

962
963 82–91. <https://doi.org/10.1177/1099800419872824>

964
965
966 Davey, G. C. L., Buckland, G., Tantow, B., & Dallos, R. (1998). Disgust and eating disorders.

967
968 *European Eating Disorders Review*, 6(3), 201–211. [https://doi.org/10.1002/\(SICI\)1099-](https://doi.org/10.1002/(SICI)1099-)

969
970 0968(199809)6:3<201::AID-ERV224>3.0.CO;2-E

971
972
973 Drewnowski, A. (1989). Taste Responsiveness in Eating Disorders. *Annals of the New York*

974
975 *Academy of Sciences*, 575(1), 399–409. <https://doi.org/10.1111/j.1749-6632.1989.tb53260.x>

976
977
978 Eiber, R., Berlin, I., De Brettes, B., Foulon, C., & Guelfi, J. D. (2002). Hedonic response to sucrose

979
980 solutions and the fear of weight gain in patients with eating disorders. *Psychiatry Research*,

981
982 113(1–2), 173–180. [https://doi.org/10.1016/S0165-1781\(02\)00232-9](https://doi.org/10.1016/S0165-1781(02)00232-9)

983
984
985 Epel, E. S., Tomiyama, A. J., Mason, A. E., Laraia, B. A., Hartman, W., Ready, K., ... Kessler, D.

986
987 (2014). The Reward-Based Eating Drive Scale: A Self-Report Index of Reward-Based Eating.

988
989 *PLoS ONE*, 9(6), e101350. <https://doi.org/10.1371/journal.pone.0101350>

990
991
992 Fassino, S., & Abbate-Daga, G. (2013, November 7). Resistance to treatment in eating disorders: A

993
994 critical challenge. *BMC Psychiatry*, Vol. 13. <https://doi.org/10.1186/1471-244X-13-282>

995
996
997 Fassino, S., Pierò, A., Gramaglia, C., & Abbate-Daga, G. (2004). Clinical, psychopathological and

998
999 personality correlates of interoceptive awareness in anorexia nervosa, bulimia nervosa and

1004
1005
1006 obesity. *Psychopathology*, 37(4), 168–174. <https://doi.org/10.1159/000079420>
1007

1008
1009 First, M., Williams, J., Karg, R., & Spitzer, R. (2016). *Structured Clinical Interview for DSM-5*
1010 *Disorders, Clinician Version (SCID-5-CV)*. Arlington, VA: American Psychiatric Association.
1011

1012
1013
1014 Frank, G. K. W., Shott, M. E., Keffler, C., & Cornier, M. A. (2016). Extremes of eating are
1015 associated with reduced neural taste discrimination. *International Journal of Eating Disorders*,
1016 49(6), 603–612. <https://doi.org/10.1002/eat.22538>
1017
1018

1019
1020
1021 Haidt, J., McCauley, C., & Rozin, P. (1993). *Individual Differences in Sensitivity to Disgust: A scale*
1022 *sampling seven domains of disgust elicitors*.
1023

1024
1025
1026 Harris, A. A., Romer, A. L., Hanna, E. K., Keeling, L. A., LaBar, K. S., Sinnott-Armstrong, W., ...
1027
1028 Zucker, N. L. (2019). The central role of disgust in disorders of food avoidance. *International*
1029 *Journal of Eating Disorders*, 52(5), 543–553. <https://doi.org/10.1002/eat.23047>
1030
1031

1032
1033 Karlsson, G. P., Clinton, D., & Nevoenon, L. (2013). Prediction of weight increase in anorexia
1034 nervosa. *Nordic Journal of Psychiatry*, 67(6), 424–432.
1035
1036 <https://doi.org/10.3109/08039488.2012.754051>
1037

1038
1039
1040 Kaye, W. H., Fudge, J. L., & Paulus, M. (2009, August). New insights into symptoms and
1041 neurocircuit function of anorexia nervosa. *Nature Reviews Neuroscience*, Vol. 10, pp. 573–
1042 584. <https://doi.org/10.1038/nrn2682>
1043
1044

1045
1046
1047 Kaye, W. H., Wierenga, C. E., Bailer, U. F., Simmons, A. N., & Bischoff-Grethe, A. (2013).
1048 Nothing tastes as good as skinny feels: the neurobiology of anorexia nervosa. *Trends in*
1049 *Neurosciences*, 36(2), 110–120. <https://doi.org/10.1016/j.tins.2013.01.003>
1050
1051

1052
1053
1054 Kaye, W. H., Wierenga, C. E., Bischoff-Grethe, A., Berner, L. A., Ely, A. V., Bailer, U. F., ...
1055
1056 Fudge, J. L. (2020). Neural Insensitivity to the Effects of Hunger in Women Remitted From
1057 Anorexia Nervosa. *American Journal of Psychiatry*, appi.ajp.2019.1.
1058
1059

1063
1064
1065 <https://doi.org/10.1176/appi.ajp.2019.19030261>
1066

1067
1068 Kinnaird, E., Stewart, C., & Tchanturia, K. (2018, August 1). Taste sensitivity in anorexia nervosa:
1069 A systematic review. *International Journal of Eating Disorders*, Vol. 51, pp. 771–784.
1070

1071
1072 <https://doi.org/10.1002/eat.22886>
1073

1074
1075 Kissileff, H. R., Brunstrom, J. M., Tesser, R., Bellace, D., Berthod, S., Thornton, J. C., & Halmi, K.
1076 (2016). Computerized measurement of anticipated anxiety from eating increasing portions of
1077 food in adolescents with and without anorexia nervosa: Pilot studies. *Appetite*, 97, 160–168.
1078

1079
1080 <https://doi.org/10.1016/j.appet.2015.11.026>
1081

1082
1083
1084 Luce, K. H., & Crowther, J. H. (1999). The reliability of the eating disorder examination—
1085 Self-report questionnaire version (EDE-Q). *International Journal of Eating Disorders*, 25(3),
1086 349–351. [https://doi.org/10.1002/\(SICI\)1098-108X\(199904\)25:3<349::AID-](https://doi.org/10.1002/(SICI)1098-108X(199904)25:3<349::AID-)
1087

1088
1089 [EAT15>3.0.CO;2-M](https://doi.org/10.1002/(SICI)1098-108X(199904)25:3<349::AID-)
1090

1091
1092
1093 Marzola, E., Nasser, J. A., Hashim, S. A., Shih, P. an B., & Kaye, W. H. (2013, November 7).
1094 Nutritional rehabilitation in anorexia nervosa: Review of the literature and implications for
1095 treatment. *BMC Psychiatry*, Vol. 13. <https://doi.org/10.1186/1471-244X-13-290>
1096

1097
1098
1099 Marzola, E., Panepinto, C., Delsedime, N., Amianto, F., Fassino, S., & Abbate-Daga, G. (2016). A
1100 factor analysis of the meanings of anorexia nervosa: Intrapsychic, relational, and avoidant
1101 dimensions and their clinical correlates. *BMC Psychiatry*, 16(1).
1102

1103
1104 <https://doi.org/10.1186/s12888-016-0894-6>
1105

1106
1107
1108
1109 Menzel, J. E., Reilly, E. E., Luo, T. J., & Kaye, W. H. (2019). Conceptualizing the role of disgust in
1110 avoidant/restrictive food intake disorder: Implications for the etiology and treatment of
1111 selective eating. *International Journal of Eating Disorders*, 52(4), 462–465.
1112

1113
1114 <https://doi.org/10.1002/eat.23006>
1115

1116
1117
1118 Milos, G., Kuenzli, C., Soelch, C. M., Schumacher, S., Moergeli, H., & Mueller-Pfeiffer, C. (2013).
1119

1122 How much should I eat? Estimation of meal portions in anorexia nervosa. *Appetite*, 63, 42–47.

1123
1124
1125
1126 <https://doi.org/10.1016/j.appet.2012.12.016>

1127
1128
1129 National Institute for Health and Care Excellence [NICE]. (2017). Eating disorders: recognition and
1130 treatment. *NICE Guideline [NG69]*. Retrieved from <https://www.nice.org.uk/guidance/ng69>

1131
1132
1133
1134 Nozoe, S. I., Masuda, A., Naruo, T., Soejima, Y., Nagai, N., & Tanaka, H. (1996). Changes in taste
1135 responsiveness in patients with anorexia nervosa during behavior therapy. *Physiology and*
1136 *Behavior*, 59(3), 549–553. [https://doi.org/10.1016/0031-9384\(95\)02105-1](https://doi.org/10.1016/0031-9384(95)02105-1)

1137
1138
1139
1140
1141 Oberndorfer, T. A., Frank, G. K. W., Simmons, A. N., Wagner, A., McCurdy, D., Fudge, J. L., ...
1142
1143 Kaye, W. H. (2013). Altered insula response to sweet taste processing after recovery from
1144 anorexia and bulimia nervosa. *American Journal of Psychiatry*, 170(10), 1143–1151.
1145
1146
1147 <https://doi.org/10.1176/appi.ajp.2013.11111745>

1148
1149
1150 Peryam, D. R., & Pilgrim, F. J. (1957). Hedonic scale method of measuring food preferences. *Food*
1151 *Technology*, 11(Suppl.), 9–14.

1152
1153
1154
1155 Pierce, C. A., Block, R. A., & Aguinis, H. (2004). Cautionary Note on Reporting Eta-Squared
1156 Values from Multifactor ANOVA Designs. *Educational and Psychological Measurement*,
1157 64(6), 916–924. <https://doi.org/10.1177/0013164404264848>

1158
1159
1160
1161
1162 Pryor, T., Wiederman, M. W., & McGilley, B. (1996). Clinical correlates of anorexia nervosa
1163 subtypes. *The International Journal of Eating Disorders*, 19(4), 371–379. Retrieved from
1164 <http://www.ncbi.nlm.nih.gov/pubmed/9156690>

1165
1166
1167
1168
1169 Simon, Y., Bellisle, F., Monneuse, M. O., Samuel-Lajeunesse, B., & Drewnowski, A. (1993). Taste
1170 responsiveness in anorexia nervosa. *British Journal of Psychiatry*, 162(FEB.), 244–246.
1171
1172
1173 <https://doi.org/10.1192/bjp.162.2.244>

1174
1175
1176 Smink, F. R. E., Van Hoeken, D., & Hoek, H. W. (2012). Epidemiology of eating disorders:

1181
1182
1183 Incidence, prevalence and mortality rates. *Current Psychiatry Reports*, 14(4), 406–414.

1184
1185 <https://doi.org/10.1007/s11920-012-0282-y>

1187
1188 Sunday, S. R., & Halmi, K. A. (1996). Micro- and macroanalyses of patterns within a meal in
1189
1190 anorexia and bulimia nervosa. *Appetite*, 26(1), 21–36. <https://doi.org/10.1006/appe.1996.0002>

1191
1192
1193 Szalay, C., Ábrahám, I., Papp, S., Takács, G., Lukáts, B., Gáti, Á., & Karádi, Z. (2010). Taste
1194
1195 reactivity deficit in anorexia nervosa. *Psychiatry and Clinical Neurosciences*, 64(4), 403–407.

1196
1197 <https://doi.org/10.1111/j.1440-1819.2010.02106.x>

1198
1199
1200 Tapper, K. (2005, October). Motivating operations in appetite research. *Appetite*, Vol. 45, pp. 95–
1201
1202 107. <https://doi.org/10.1016/j.appet.2005.05.002>

1203
1204
1205 Troop, N. A., Murphy, F., Bramon, E., & Treasure, J. L. (2000). Disgust sensitivity in eating
1206
1207 disorders: A preliminary investigation. *International Journal of Eating Disorders*, 27(4), 446–
1208
1209 451. [https://doi.org/10.1002/\(SICI\)1098-108X\(200005\)27:4<446::AID-EAT9>3.0.CO;2-W](https://doi.org/10.1002/(SICI)1098-108X(200005)27:4<446::AID-EAT9>3.0.CO;2-W)

1210
1211
1212 Van Dongen, M. V., Van Den Berg, M. C., Vink, N., Kok, F. J., & De Graaf, C. (2012). Taste-
1213
1214 nutrient relationships in commonly consumed foods. *British Journal of Nutrition*, 108(1), 140–
1215
1216 147. <https://doi.org/10.1017/S0007114511005277>

1217
1218
1219 Ventura, A. K., & Worobey, J. (2013, May 6). Early influences on the development of food
1220
1221 preferences. *Current Biology*, Vol. 23. <https://doi.org/10.1016/j.cub.2013.02.037>

1222
1223
1224 Wagner, A., Aizenstein, H., Mazurkewicz, L., Fudge, J., Frank, G. K., Putnam, K., ... Kaye, W. H.
1225
1226 (2008). Altered insula response to taste stimuli in individuals recovered from restricting-type
1227
1228 anorexia nervosa. *Neuropsychopharmacology*, 33(3), 513–523.

1229
1230 <https://doi.org/10.1038/sj.npp.1301443>

1231
1232
1233 Westmoreland, P., Krantz, M. J., & Mehler, P. S. (2016, January 1). Medical Complications of
1234
1235 Anorexia Nervosa and Bulimia. *American Journal of Medicine*, Vol. 129, pp. 30–37.

<https://doi.org/10.1016/j.amjmed.2015.06.031>

1240
1241
1242
1243
1244
1245
1246
1247
1248
1249
1250
1251
1252
1253
1254
1255
1256
1257
1258
1259
1260
1261
1262
1263
1264
1265
1266
1267
1268
1269
1270
1271
1272
1273
1274
1275
1276
1277
1278
1279
1280
1281
1282
1283
1284
1285
1286
1287
1288
1289
1290
1291
1292
1293
1294
1295
1296
1297
1298

Figure 1. Pre- and post-experiment differences between patients with anorexia nervosa and healthy controls in anxiety, hunger, confusion about internal states, restraint, need for physical activity, and satiety.

Figure 1a. Anxiety was significantly different between groups and a significant effect of condition (i.e., juice versus supplement) emerged. Range of mean scores: 4.3 – 29.5.

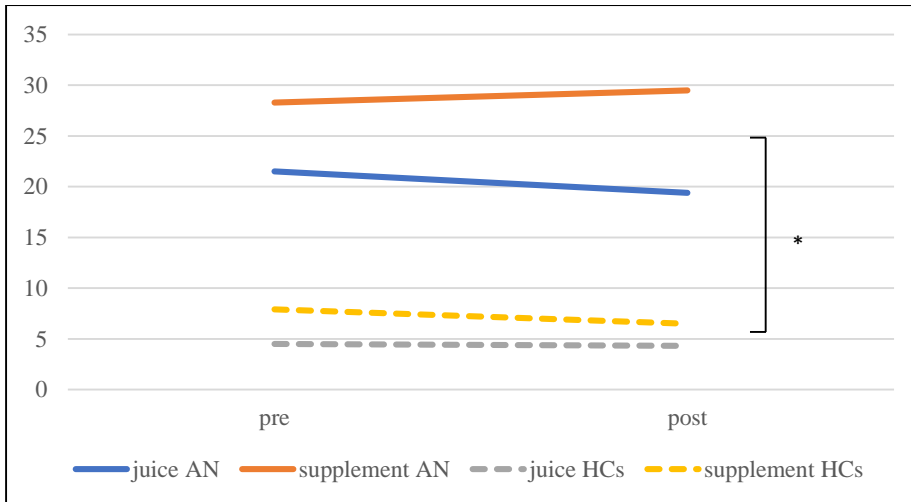


Figure 1b. Hunger was significantly different between groups and a significant effect of time (i.e., before and after the experiment) emerged. Range of mean scores: 9.5 – 31.9.

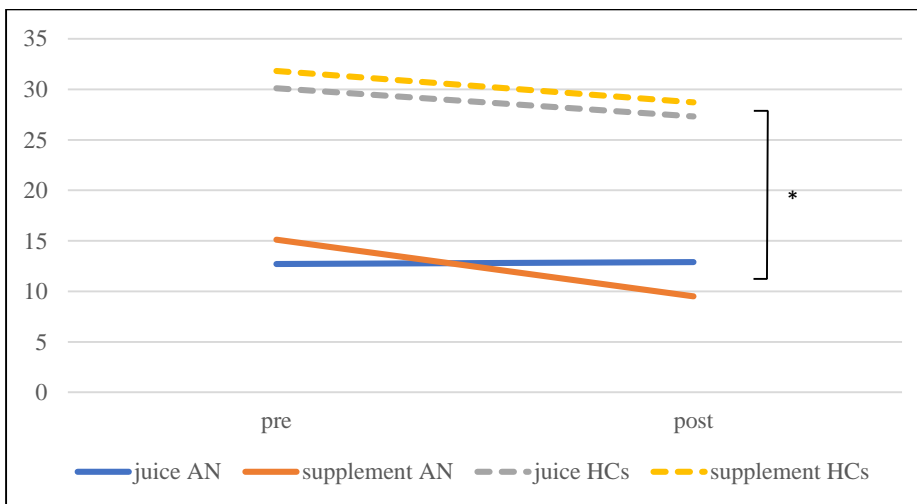


Figure 1c. Confusion about internal states was significantly different between groups. Range of mean scores: 1.8 – 22.4.

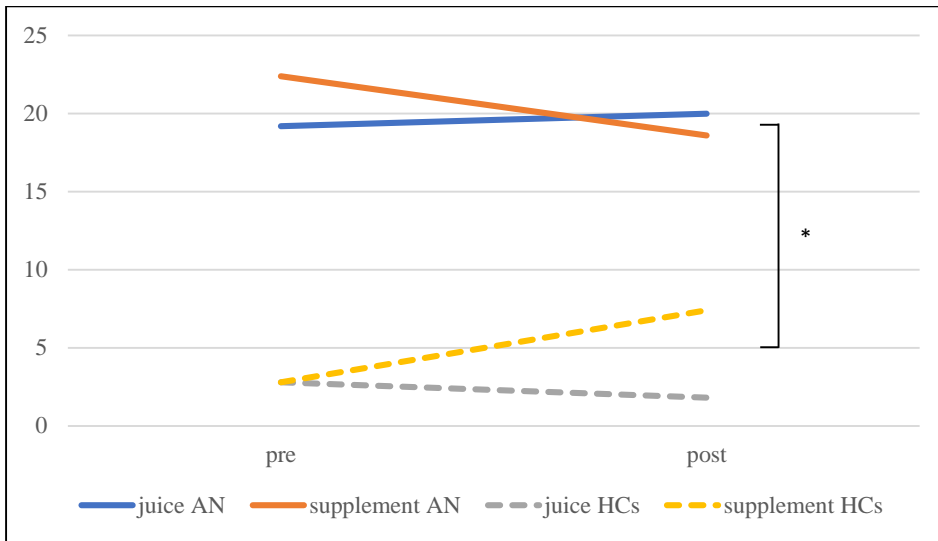


Figure 1d. Need for physical activity was significantly different between groups and a significant interaction time*group emerged. Range of mean scores: 11.4 – 43.8.

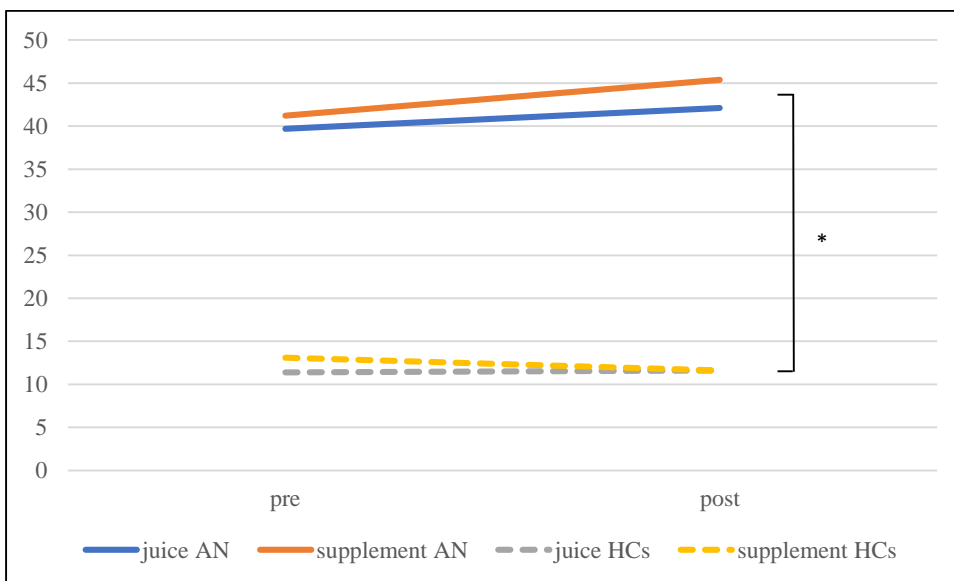


Figure 1e. Restraint was significantly different between groups. Range of mean scores: 3.4 – 38.6.

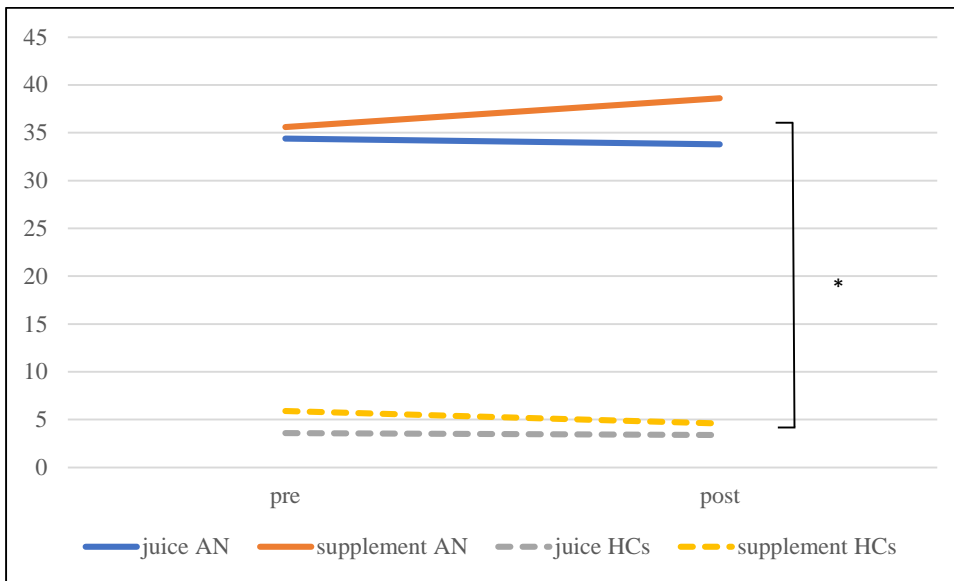


Figure 1f. Satiety was significantly different between groups and a significant effect of time (i.e., before and after the experiment) emerged. Range of mean scores: - 19 – 34.7.

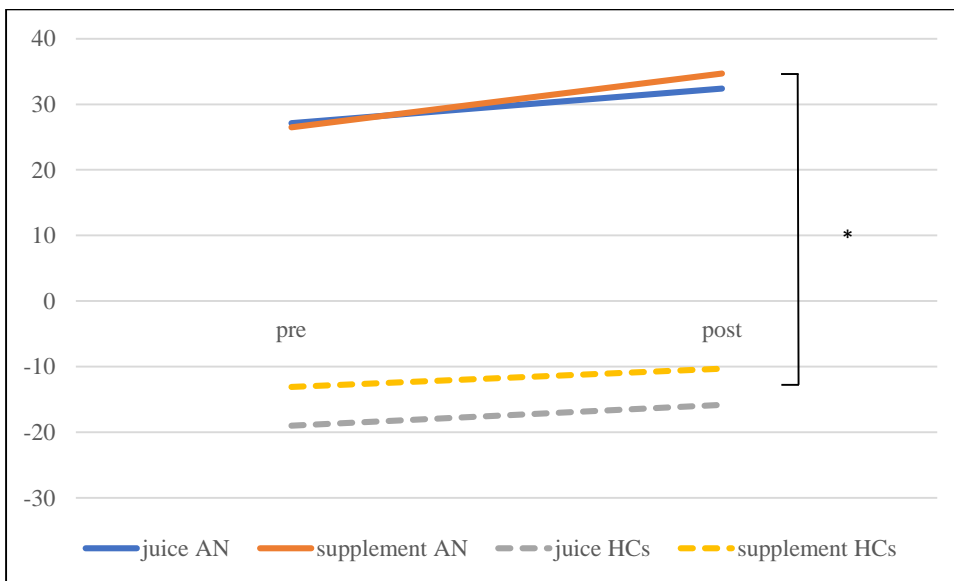


Figure 2. Assessments of patients with anorexia nervosa (AN) and healthy controls (HCs) after the tasting experiment.

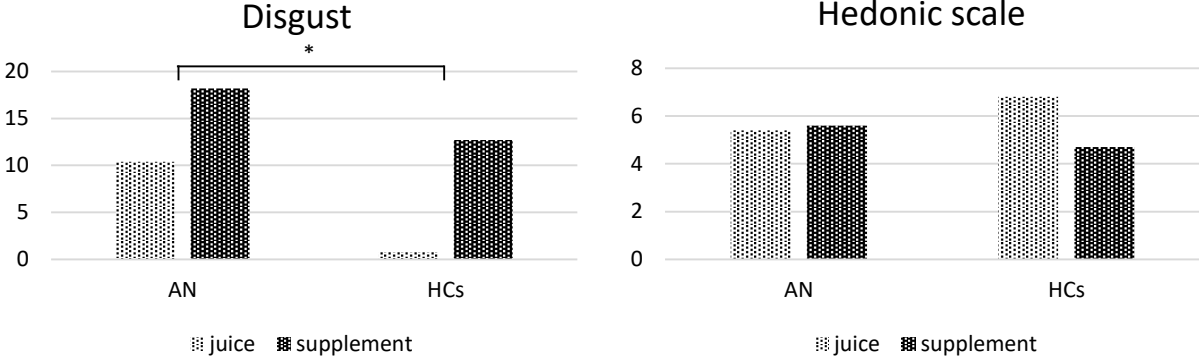


Table 1. Comparison of disgust and reward-based eating between patients with anorexia nervosa (AN) and healthy controls (HCs).

	Patients with AN		HCs		Test statistics	
	n=33		n=39		t	p
	Mean(SD)	N(%)	Mean(SD)	N(%)		
Age	26.2(10.3)		23.9(2.7)		1.36	0.18
BMI	13.9(1.6)		20.6(2.2)		14.44	<0.001
Duration of illness, years	7.8(8.6)		-		-	-
Education level						<0.001*
≤ 8 years		12(36.4)		0(0)		
≤ 13 years		9(27.3)		7(17.9)		
> 14 years		12(36.4)		32(82.1)		
Employment						0.235*
Student		20(60.6)		29(74.4)		
Employed		7(21.2)		9(20.5)		
Unemployed		6(18.2)		2(5.1)		

EDE-Q

Total score	3(1.9)	0.9(0.9)	6	<0.001
Restraint	2.6(2)	0.9(1.1)	4.4	<0.001
Preoccupation with food	2.6(1.9)	0.5(0.8)	6.3	<0.001
Preoccupation with shape	3.8(2.1)	1.3(1.2)	6.2	<0.001
Preoccupation with weight	3(1.9)	0.9(1.1)	5.8	<0.001

Disgust scale

Core	29.5(8.6)	31.2(7.2)	0.96	0.338
Animal-reminder	17.6(8)	19.7(5.9)	1.31	0.194
Contamination	10.5(4.6)	8.9(3.5)	1.68	0.096
Total	57.2(17.9)	59.8(14)	0.71	0.478
Reward-based eating	15.2(8.3)	9.2(6.6)	3.48	0.001

scale

* Fisher's exact test

Table 2. Correlations between disgust scale, reward-based eating scale, and eating psychopathology

	EDE-Q Total	EDE-Q Restraint	EDE-Q Preoccupation with food	EDE-Q Preoccupation with shape	EDE-Q Preoccupation with weight
Disgust scale					
Patients with AN	-0.046	-0.063	.087	-0.079	-0.064
HCs	.21	.1	.253	.22	.21
Reward-based Eating Scale					
Patients with AN	.51**	.27	.633**	.484**	.468*
HCs	.05	.18	-0.09	.019	.017

****<0.01**

Table 3. Differences between AN and HCs over time and across conditions.

	Patients with AN		HCs		Effect of time			Effect of condition			Condition*group			Time*group			Effect of group		
	n=33		n=39		F	p	η^2	F	p	η^2	F	p	η^2	F	p	η^2	F	p	η^2
	pre	post	pre	post															
	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)															
Anxiety					.47	.49	.007	15.07	<.001	.18	3.78	.056	.05	.03	.86	.001	19.78	<.001	.22
juice	21.5(25.2)	19.4(27)	4.5(6.3)	4.3(6.5)															
supplement	28.3(27.3)	29.5(31.4)	7.9(10.2)	6.5(8.7)															
Hunger					5.7	.019	.08	.09	.77	.001	.3	.58	.01	.009	.92	.001	15.97	<.001	.19
juice	12.7(19.6)	12.9(20.8)	30.1(20.3)	27.3(21.7)															
supplement	15.1(20.4)	9.5(17.2)	31.8(21.3)	28.7(21)															
Confusion					.009	.92	<.001	1.57	.21	.02	.41	.52	.006	1.31	.26	.018	16.6	<.001	.19
juice	19.2(26.4)	20(25.2)	2.8(8.5)	1.8(4.9)															
supplement	22.4(29.8)	18.6(27.5)	2.8(6.8)	7.4(17.7)															
Physical activity					2.34	.13	.03	1.2	.28	.02	.24	.62	.003	5	.03	.07	19.4	<.001	.22
juice	38.5(35)	40.3(36.5)	11.4(21.6)	11.6(21.7)															
supplement	39.4(31.8)	43.8(35.8)	13.1(22)	11.6(21.1)															
Restraint					.1	.75	.002	1.88	.17	.03	.14	.71	.002	1.52	.22	.02	34.8	<.001	.33

juice	34.4(31.3)	33.8(33.8)	3.6(11.3)	3.4(11.3)															
supplement	35.6(33.5)	38.6(32.6)	5.9(15)	4.6(11.4)															
Satiety					11.4	.001	.14	1.97	.16	.03	1.1	.3	.01	1.66	.2	.02	50.5	<.001	.42
juice	27.1(33.7)	32.4(38.7)	-19(19)	-15.8(22.7)															
supplement	26.5(31.5)	34.7(35.4)	-13.1(26.9)	-10.3(26)															
Disgust						N/A		19.2	<.001	.21	0.9	.35	.01		N/A		4.4	.04	.06
juice	---	10.4(18)	---	0.77(3.3)															
supplement	---	18.2(24.6)	---	12.7(19.8)															
Hedonic scale						N/A		17.9	<.001	.2	23.6	<.001	.25		N/A		.41	.52	.006
juice	---	5.4(2.3)	---	6.8(1.4)															
supplement	---	5.6(2.2)	---	4.7(1.9)															

Legend: Confusion: confusion about internal states; physical activity: urge to over-exercise.

Ethical statement

The Ethical Committee of the Department of Neuroscience of the University of Turin, Italy, approved this study and all participants provided their written informed consent.