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Taste Alterations Do Not Affect Change in Food Habits and Body Weight in Breast Cancer Patients

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Abstract. *Background/Aim: Chemotherapy-induced taste alterations (TAs) affect approximately 53-84% of breast cancer patients with significant consequences on flavor perception, possibly leading to food aversion and changes in daily dietary habits. The aim of this study was to investigate the relationship between TAs and changes in food habits and body weight among early breast cancer (EBC) patients undergoing adjuvant chemotherapy. Patients and Methods: TAs were prospectively evaluated in 182 EBC patients from April 2014 to June 2018. TAs, dietary habits, and body weight were collected by a trained dietician. TAs were classified into different subtypes according to the following basic taste perception: metallic, sweet, bitter, salty, sour, and umami taste. Results: During adjuvant chemotherapy, a significant reduction in the consumption of bread, breadsticks, red meat, fat salami, snacks, added sugar, milk, and alcoholic beverages was observed, regardless of TAs onset. No correlation between these dietary changes and different TAs subtypes was found. Body weight remained stable in most EBC patients (71.4%) and was not influenced by TAs onset and by different TAs subtypes. Conclusion: EBC patients change their dietary habits during adjuvant chemotherapy, mostly following the World Cancer Research Fund recommendations, irrespective of TAs onset and without affecting body weight.*

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Dysgeusia is variably defined as an abnormal or impaired sense of taste, an unpleasant alteration of taste sensation, or a distortion or perversion of the sense of taste (1). Taste sensation is primarily based on the following basic qualities, namely sweet, bitter salty, sour; recently savory or umami (the taste of glutamate) was added as a new basic taste quality (2). Dysgeusia affects approximately 53-84% of breast cancer patients treated with chemotherapy (3, 4) and taxanes are the cytotoxic drugs more frequently associated with the onset of this symptom (5). It has been shown that the main mechanism for taxane-related taste alteration is a neurological damage (6) involving both cranial nerves (VII, IX, and X) and taste receptors (7-9). Chemotherapy-induced taste alterations (TAs) may have significant consequence on flavor perception leading to food aversion, which in turn may lead to changes in daily dietary intake of certain foods (10), and consequently in body weight variation. It has been suggested that TAs are linked to a change in food-related behaviors in order to self-manage this unpleasant side-effect and some examples are eating strongly flavored food, eating candy before meals, drinking sweetened drinks (3). The high caloric intake correlated to this eating-behavior could justify weight gain reported frequently in early breast cancer (EBC) patients during adjuvant chemotherapy (11-15).

The aim of the study was to investigate the relationship between TAs and changes in dietary habits and in body weight among a consecutive series of EBC patients undergoing adjuvant chemotherapy and followed up to 12 months after the end of the treatment.

Patients and Methods

Trial oversight. A prospective, single-center trial was conducted at the Medical Oncology and Breast Unit of the ASST Spedali Civili of Brescia, registered in "*ClinicalTrials.gov* database" (NCT identification number: NCT03210441) and approved by the local Ethic Committee of Brescia.

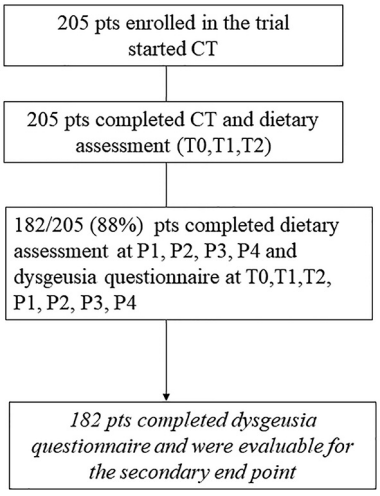

Figure 1. *Consort diagram. pts: Patients; CT: chemotherapy; T0: baseline evaluation; T1: first follow-up visit during chemotherapy; T2: second follow-up one week after chemotherapy end; P1: follow-up 3 months after chemotherapy; P2: follow-up 6 months after chemotherapy; P3: follow-up 9 months after chemotherapy; P4: follow-up 12 months after chemotherapy.*

Table I. *Characteristics of the patients.*

	Number of patients (%) (n=182)
Median age (range)	64 (25-80)
Menopausal status	
Premenopausal	76 (41.8)
Postmenopausal	106 (58.2)
pT	
1	110 (60.5)
≥2	72 (39.5)
pN	
0	102 (56)
≥1	80 (44)
Histological type	
No special type (NST)	166 (91.2)
Others	16 (8.8)
Estrogen receptor	
Positive	54 (29.7)
Negative	128 (70.3)
Grading	
G1 or G2	21 (11.5)
G3	160 (88)
Unknown	1 (0.5)
Ki-67 labeling index	
<20%	32 (17.6)
≥20%	150 (82.4)
HER2	
Positive	107 (58.8)
Negative	75 (41.2)
Chemotherapy	
Adjuvant	139 (76.4)
Neoadjuvant	43 (23.6)
Type of chemotherapy	
Anthracycline	30 (16.5)
Taxane alone	25 (13.7)
Anthracycline and taxane	118 (64.8)
Others	9 (4.9)

pT: Pathological tumor stage; pN: pathological nodal stage; G1: well differentiated tumor; G2 moderately differentiated tumor; G3: undifferentiated tumor; HER2: human epidermal growth factor receptor 2.

The primary aim of the study was to evaluate eating habit changes during adjuvant chemotherapy and up to 12 months after its completion (16). The secondary aims were to assess TAs and weight changes during adjuvant chemotherapy and follow-up after the completion of adjuvant treatment.

This trial enrolled 205 EBC patients from April 2014 to June 2018 and the eligibility criteria, reported in detail elsewhere (16), were in briefly the following: histologically confirmed EBC; eligibility for adjuvant or neoadjuvant chemotherapy regardless of tumor biology and menopausal status; willingness to adhere to the study protocol. In the present paper we would like to report the results of the secondary aims of the study, that were to investigate the correlation between TAs, changes in dietary habits and in body weight. TAs assessment was performed by a trained dietician through two different questionnaires: 1) the National Cancer Institute Common Terminology Criteria for Adverse Event v4.0 (NCI-CTCAE) (17); 2) the Italian version of Chemotherapy-induced Taste Alteration Scale (CiTAS) (18, 19). According to these questionnaires' TAs were classified into six different taste impairment defined as: metallic taste, dysgeusia for sweet, dysgeusia for bitter, dysgeusia for salty, dysgeusia for sour and dysgeusia for umami.

Data collection. The questionnaires were administered at the following time point: T0) at baseline (before starting chemotherapy); T1) during chemotherapy; T2) after the last cycle of chemotherapy. Subsequently, they were administered every 3 months during the follow-up visits (P1 at 3 months, P2 at 6 months, P3 at 9 months and P4 at 12 months). Dietary habits, body-mass index (BMI) calculation and information about employment, physical activity and alcohol consumption were collected according to the methodology reported elsewhere (16).

Questionnaires and visits were completed at baseline (T0), during chemotherapy (T1 and T2) or during subsequent follow-up (P1, P2, P3, P4) by 182 patients out of 205 (88%). Therefore, we considered 182 patients evaluable for the analysis of this secondary end point. The consort diagram is shown in Figure 1.

Statistical analysis. Categorical variables were expressed as frequencies and percentages; continuous variables were expressed as median and 95% confidence interval (95% CI). TAs were graduated according to NCI-CTCAE criteria (v4.0) and classified on the basis of toxicity grading as severe (grade 3-4), mild-to-moderate (grade 1-2), and none: for the aim of this study, since no severe toxicities were reported, TAs were classified as "present or absent". Correlations between TAs (present *vs*. absent) with change in dietary habits and in body weight were explored at T1 considering the wider proportion of TAs in our population during chemotherapy; to assess differences between the 2 groups the Mann-Whitney *U*-test was used. As reported in a previous paper (16), we assessed the dietary intake of

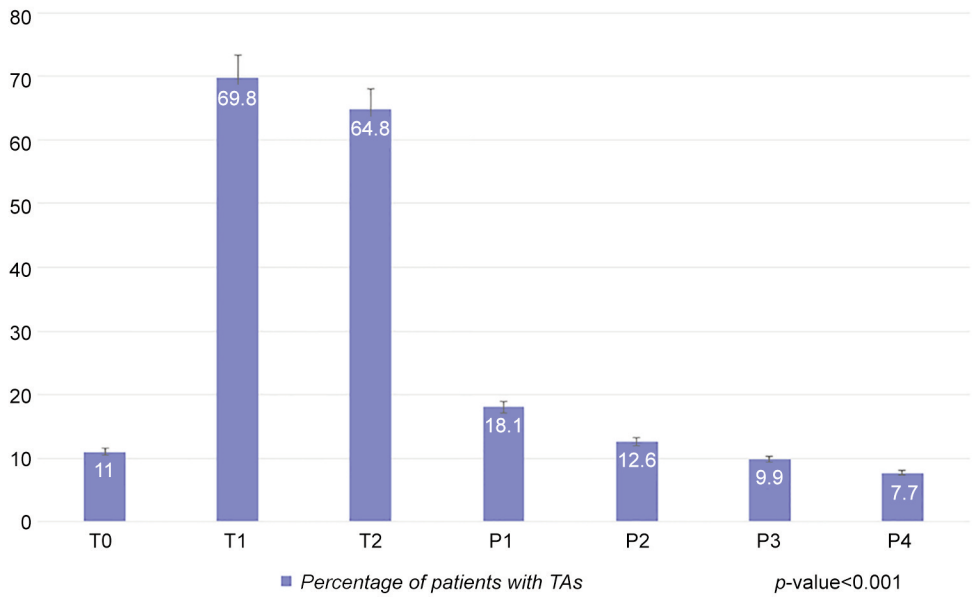

Figure 2. *Taste alterations (TAs) evaluation at baseline, during chemotherapy, and subsequent follow-up. T0: Baseline evaluation; T1: first follow-up visit during chemotherapy; T2: second follow-up one week after chemotherapy end; P1: follow-up 3 months after chemotherapy; P2: follow-up 6 months after chemotherapy; P3: follow-up 9 months after chemotherapy; P4: follow-up 12 months after chemotherapy.*

the following foods and beverages: fruit, vegetables, pasta, bread, breadsticks, potatoes, white meat, red meat, fish, fat salami, lean salami, eggs, fresh cheese, aged cheese, legumes, milk, yogurt, ice creams, snacks, added sugar (to coffee, tea, or other hot or cold beverages), soft drinks, wine, beer, schnapps, butter, and oil. The differences between eating habits from baseline to second follow-up T2 in each group of patients with and without TAs were assessed by Wilcoxon signed-rank test.

As reported previously (16) a weight gain or loss ≥5% following adjuvant chemotherapy was considered to be clinically meaningful (20, 21): patients were classified as "increased weight", "decreased weight" or "stable weight" if weight gained from baseline of at least 5%, decreased from baseline of at least 5% or did not change from baseline over threshold value of ±5%, respectively. TAs were assessed in the three weight categories by chi square test.

Results

Patient characteristics. The characteristics of all patients enrolled in the prospective trial were previously reported (16). The main clinical features of the 182 patients included in the current analysis are listed in Table I. Median age was 64 years (range=25-80); most patients were postmenopausal (58.2%). The most common chemotherapeutic drugs administered in 118 patients (64.8%) were the combination of anthracyclines and taxanes. The rate of TAs in patients included in the study showed a consistent increase from baseline (11%) to the first time point T1 (69.8%), remained substantially stable at T2 (64.8%), and consistently improved in the time points following the discontinuation of chemotherapy to reach baseline values at P4 (7.7%) (Figure 2).

Correlation between TAs and dietary intakes. As reported in Table II, the patients reported a significant reduction in their intake of bread, breadsticks, red meat, fat salami, snacks, milk, beer, and wine regardless of having TAs or not. Similar data were obtained analyzing TAs according to subtypes (Table III and Table IV), except for snacks, that were consumed in greater quantity at T0 among patients developing bitter TA. The intake of other food and drink such as fruit, vegetables, pasta, potatoes, white meat, fish, lean salami, eggs, fresh cheese, aged cheese, legumes, yogurt, ice creams, added sugar, soft drinks, schnapps, butter, and oil did not change significantly in our series of patients (data not shown).

Correlation between TAs and body weight. As described in Table V, median weight and BMI did not change significantly during adjuvant chemotherapy irrespective of TAs onset. As reported previously (16), most patients (71.4%) maintained stable weight during treatment, 29 patients increased weight (15.9%) and 52 patients (12.6%) decreased weight. We did not find any correlation between TAs and the weight change categories (Table VI).

Discussion

Despite TAs onset being a highly prevalent side-effect of chemotherapy (4, 5, 22), it remains a neglected side-effect compared to other toxicities of chemotherapy and literature is limited as well as clinician awareness and management

support. TAs have also been reported even before starting chemotherapy in some cases (23).

The rate of TAs in EBC patients included in the study showed a consistent increase from baseline (11%) to the first time point T1 (69.8%), remained substantially constant at T2 (64.8%), and consistently improved in the time points following the discontinuation of chemotherapy, to reach baseline values at 12 months (7.7%). It is well known that TAs may cause food aversion and it has been reported that reduce energy intake, leading to malnutrition, weight loss, and a poorer prognosis in patients with advanced cancer on active treatment (24). On the other hand, compensation of TAs with tasting but high caloric foods may lead to weight gain (20). To the best of our knowledge, no papers have addressed this topic in EBC patients on adjuvant chemotherapy.

The aim of this study was to assess if TAs onset as general disorder and in all its single subtypes, such as metallic taste and sweet, bitter, sour, salty, and umami dysgeusia was associated with change in eating habits and in body weight during adjuvant chemotherapy.

As reported in a previously published paper (16), EBC patients nowadays are highly motivated and inclined to change eating habits towards a healthier direction early during adjuvant treatment, in order to prevent weight increase and potentially improve treatment efficacy. Most commonly, patients modified their diet through a reduction in consumption of animal fat, read meat, processed meat, added sugar, milk and other dairy products, bread, cereals and through a rise in fruit consumption (16, 25). Among our patients, who underwent a TAs and dietary assessment by a trained dietician, we observed a significantly reduction of the consumption of bread, breadsticks, red meat, fat salami, milk, and alcoholic beverages during adjuvant chemotherapy, regardless of TAs onset.

The reduction in bread, breadsticks and snacks intake is in line with recommendation number 3 of the second report of the World Cancer Research Fund (WCRF) (26), advising to limit high energy foods. Moreover, it is in line with the fourth recommendation of the WCRF third report (2018) (27), advising to limit consumption of snacks and bakery foods. The decreased intake in red meat and fat salami is in line with recommendation number 5 of both reports (WCRF 2007 and 2018) (26, 27), advising to limit the consumption of red and processed meat. Our patients significantly decreased the intake of two alcoholic beverages (wine and beer), in line with recommendations number 6 and 7, in WCRF 2007 and 2018, respectively, that advice to limit alcohol intake. For these reasons, most of the change in dietary habits are in line with WCRF recommendations for the primary prevention of cancer and also directed to cancer survivors (26, 27).

As previously reported (16), cancer treatment did not significantly affect body weight and BMI; in this paper among patients with TAs, as well as in those who perceived metallic taste and who reported an impairment of sweet, bitter, sour, salty and umami taste, weight and BMI did not change significantly, compared with patients without any TAs.

To the best of our knowledge, this is the first report exploring the correlation between TAs and change in eating habits or in body weight among a large series of EBC

Table II. *Correlation between taste alterations (TAs) and eating habits.*

Food (gram pro week or milliliters pro week)	No taste alterations at T1	Taste alteration at T1	*p*-Value
Bread, T0	418.18	430.85	0.972
95% CI	(344.85-491.51)	(372.73-488.97)	
Bread, T1	326.82	290.52	0.332
95% CI	(266.75-396.89)	(249.62-331.43)	
p-Value	0.026	<0.001	
Breadsticks, T0	79.29	116.68	0.171
95% CI	(53.26- 105.32)	(89.82-143.54)	
Breadsticks, T1	70.9	74.27	0.996
95% CI	(44.43-97.39)	(53.65-94.88)	
p-Value	0.255	<0.001	
Red meat, T0	120.09	139.96	0.407
95% CI	(93.94-146.24)	(117.74-162.18)	
Red meat, T1	108.18	101.22	0.912
95% CI	(77.37-138.99)	(85.23-117.21)	
p-Value	0.160	<0.001	
Fat salami, T0	29.38	28.61	0.316
95% CI	(19.40- 39.35)	(19.87- 37.34)	
Fat salami, T1	21.45	21.30	0.686
95% CI	(11.84-31.07)	(13.5-29.10)	
p-Value	0.070	0.023	
Snacks, T0	148.93	186.89	0.189
95% CI	(96.88-227.97)	(143.56-230.21)	
Snacks, T1	109.64	139.02	0.687
95% CI	(70.77-148.51)	(97.96-180.09)	
p-Value	0.605	0.016	
Milk, T0	395.45	484.48	0.701
95% CI	(242.14-548.77)	(367.28-601.67)	
Milk, T1	325.45	389.31	0.320
95% CI	(170.45-480.46)	(282.36-496.27)	
p-Value	0.039	0.133	
Wine, T0	271.59	301.16	0.260
95% CI	(182.48-360.70)	(206.05-396.27)	
Wine, T1	172.73	168.85	0.108
95% CI	(91.41-254.05)	(90.60-247.11)	
p-Value	0.036	<0.001	
Beer, T0	95.76	127.81	0.937
95% CI	(41.02- 150.49)	(71.44-184.17)	
Beer, T1	76.50	42.26	0.601
95% CI	(20.40-132.60)	(22.54-61.97)	
p-Value	0.371	0.001	

T0: Baseline; T1: first follow-up during chemotherapy. Food and beverage consumptions are expressed as mean of grams per week or milliliters per week with corresponding 95% confidence interval in brackets (95% CI).

Table III. *Correlation between type of taste alterations (TAs) (metallic taste, sweet TA, bitter TA) and food or beverage's habits.*

Food or drink	Metallic taste			Sweet taste alteration			Bitter taste alteration		
	Absence	Presence	*p*-Value	Absence	Presence	*p*-Value	Absence	Presence	*p*-Value
Bread, T0	418.03 (360.30-475.76)	427.40 (351.69-503.10)	0.878	423.32 (368.40-478.24)	418.97 (334.66-503.27)	0.943	418.91 (365.74-472.07)	428.02 (338.98-617.06)	0.974
Bread, T1	317.55 (271.46-363.63)	272.95 (223.78-322.11)	0.254	306.09 (265.29-346.90)	284.91 (223.73-346.10)	0.615	311.55 (272.27-350.84)	273.71 (208.70-338.72)	0.131
p-Value	<0.001	<0.001		<0.001	<0.001		<0.001	0.006	
Breadsticks, T0	109.90 (83.56-136.25)	98.01 (65.55-130.47)	0.289	105.50 (82.57-128.44)	103.97 (62.66-145.27)	0.410	84.71 (66.44-102.97)	146.64 (98.06-195.22)	0.186
Breadsticks, T1	80.19 (68.07-102.32)	62.88 (38.30-87.45)	0.495	75.38 (54.37-96.39)	68.28 (42.17-94.38)	0.980	69.20 (50.36-88.04)	80.95 (48.49 -113.40)	0.205
p-Value	0.008	0.005		<0.001	0.056		0.002	0.040	
Red meat, T0	127.16 (107.03-147.30)	144.86 (113.95-175.77)	0.546	139.29 (117.11-161.46)	124.57 (97.33-151.81)	0.773	113.82 (111.95-155.70)	135.78 (107.32-164.23)	0.978
Red meat, T1	104.81 (83.67-125.94)	97.95 (80.51-115.38)	0.959	102.94 (85.41-120.47)	100 (74.89-125.11)	0.992	96.64 (79.58-113.70)	112.93 (86.69-139.17)	0.296
p-Value	0.0013	0.003		0.002	0.040		0.003	0.026	
Fat salami, T0	33.99 (25.15-44.37)	21.92 (14.52-30.34)	0.014	26.60 (20-33.2)	33.97 (18.21-49.72)	0.954	28.15 (19.67-36.63)	30.78 (19.49-42.06)	0.395
Fat salami, T1	25.43 (17.07-34.32)	15.82 (9.04-24.52)	0.047	17.39 (11.68-23.11)	29.83 (15.14-44.51)	0.406	20.25 (13.54-26.97)	23.97 (11-36.93)	0.650
p-Value	0.009	0.163		0.004	0.003		0.448	0.651	
Milk, T0	417.31 (307.33-527.29)	526.37 (358.52-694.21)	0.571	459.03 (349.31-568.76)	468.97 (286.01-651.97)	0.379	496.01 (378.66-613.36)	393.10 (233.55-552.66)	0.498
Milk, T1	339.66 (223.27-456.05)	422.60 (285.19-560.02)	0.183	363.45 (253.69-473.20)	395.26 (243.49-547.03)	0.669	398.95 (285.92-511.98)	322.41 (182.31-462.52)	0.746
p-Value	0.038	0.260		0.018	0.445		0.299	0.467	
Sugar, T0	80.87 (62.64-99.09)	68.39 (46.87-89.91)	0.224	75.36 (58.65-92.07)	76.47 (51.26-101.67)	0.785	69.87 (55.58-84.17)	87.72 (56.97-118.46)	0.555
Sugar, T1	57.33 (41.04-73.62)	53.94 (36.55-71.33)	0.326	57.31 (41.49-73.13)	53.10 (36.55-69.66)	0.981	51.13 (39.73-62.54)	65.78 (37.72-93.83)	0.562
p-Value	0.001	0.075		0.003	0.026		0.004	0.007	
Snacks, T0	183.17 (128.48-237.87)	165.62 (112.55-218.68)	0.545	182.52 (131.46-233.58)	162.41 (106.99-217.84)	0.909	154.29 (105.74-202.83)	220.34 (157.30-283.34)	0.007
Snacks, T1	138.75 (96.19-181.31)	114.25 (69,78-158.71)	0.586	125.55 (91.23-159.86)	135 (71.22-198.78)	0.725	122.02 (84.77-159.26)	142.24 (86.20-198.28)	0.344
p-Value	0.043	0.184		0.040	0.212		0.278	0.013	
Wine, T0	327.82 (222.89-432.76)	236.73 (148.22-325.24)	0.499	268.64 (188.04-349.25)	334.59 (189.86-479.32)	0.431	240.02 (171.16-308.88)	393.32 (226.99-559.65)	0.330
Wine, T1	185.40 (97.87-272.93)	152.83 (76.25-229.40)	0.477	170.14 (96.60-243.74)	175.65 (69.53-281.77)	0.325	144.17 (89.71-198.73)	228.99 (82.20-375.77)	0.690
p-Value	<0.001	0.010		<0.001	0.002		<0.001	0.001	
Beer, T0	103.92 (55.04-152.80)	139.01 (62.56-215.46)	0.220	90.82 (56.97-124.67)	174.96 (65.32-284.60)	0.318	104.68 (65.95-143.42)	146.51 (42.91-250.11)	0.904
Beer, T1	57.91 (25.37-90.45)	46.34 (19.31-73.37)	0.779	51.30 (23.18-79.42)	56.90 (21.66-92.13)	0.628	58.24 (28.39-88.08)	42.67 (14.45-70.89)	0.967
p-Value	0.029	0.010		0.010	0.030		0.029	0.004	

T0: Baseline; T1: first follow-up during chemotherapy. Food and beverage consumptions are expressed as mean of grams per week or milliliters per week with corresponding 95% confidence interval in brackets (95% CI).

patients, who underwent adjuvant chemotherapy and were prospectively followed. The strengths of the study include its prospective design and the standardized assessment of TAs carried out by a trained dietitian through a validated questionnaire, the Italian version of CiTAS, which was given at several timepoints. The large amount of data collected about different foods and beverages represents a further added value. However, the main limitations are related to the high level of dropouts (12%) for the secondary endpoint evaluation and to the lack of objective tool for TAs

Table IV. *Correlation between type of taste alterations (TAs) (salty TA, sour TA, and umami TA) and food or beverage's habits.*

Food or drink	Salty taste alteration			Sour taste alteration			Umami taste alteration		
	Absence	Presence	*p*-Value	Absence	Presence	*p*-Value	Absence	Presence	*p*-Value
Bread, T0	407.11 (350.71-463.72)	439.69) (364.28-515.09	0.744	423.35 (371.95-474.74)	417.07 (314.06-520.09)	0.719	424.50 (361.08-487.93)	418.42 (351.99-484.85)	0.957
Bread, T1	310.31 (266.78-353.83)	285.63 (232.15-339.10)	0.310	300 (262.11-337.89)	296.34 (220.19-372.49)	0.832	301.24 (257.04-345.44)	296.38 (243.27-349.50)	0.660
p-Value	0.001	<0.001		<0.001	0.006		<0.001	0.002	
Breadsticks, T0	87.06 (64.14-109.98)	126.75 (91.52-161.98)	0.091	92.43 (73.86-110.99)	146.71 (83.97-209.44)	0.587	86.58 (62.77-110.40)	129.47 (94.51-164.43)	0.122
Breadsticks, T1	67.11 (47.63-86.60)	80.25 (52.37-108.13)	0.649	67.83 (51.13-84.54)	90.37 (45.21-135.42)	0.426	74.41 (50.43-98.38)	71.25 (49.66-92.84)	0.375
p-Value	0.021	0.003		0.002	0.040		0.017	0.001	
Red meat, T0	132.99 (107.83-158.15)	136.25 (112.70-159.80)	0.568	128.31 (109.78-146.83)	154.88 (111.72-198.03)	0.447	140.35 (115.14-165.55)	126.64 (103.90-149.39)	0.245
Red meat, T1	97.68 (78.53-116.83)	107.19 (85.50-128.87)	0.625	99.83 (84.03-115.60)	109.15 (75.73-142.57)	0.651	102.97 (83.10-122.84)	100.66 (80.09-121,22)	0.342
p-Value	0.005	0.012		0.003	0.026		<0.001	0.181	
Fat salami, T0	26.91 (19.88-33.93)	31.56 (19.17-43.96)	0.695	28.05 (20.59-35.51)	32.20 (16.33-48.06)	0.671	26.39 (19.14-33.63)	32.50 (19.95-45.05)	0.942
Fat salami, T1	17.68 (11.65-23.71)	26.06 (14.55-37.58)	0.800	19.19 (13.22-25.16)	29.02 (11.03-47.02)	0.551	20.54 (13.15-27.94)	22.70 (12.14-33.25)	0.523
p-Value	0.016	0.159		0.003	0.651		0.020	0.141	
Milk, T0	402.06 (300.70-503.42)	535.31 (366.14-704.48)	0.967	430.51 (331.74-529.29)	567.68 (321.58-813.78)	0.401	460.40 (340.84-579.95)	464.80 (310.97-618.74)	0.889
Milk, T1	350.52 (235.48-465.55)	402.19 (263.30-541.07)	0.407	358.64 (256.37-460.91)	424.39 (244.96-603.82)	0.268	362.38 (254.02-470.73)	389.14 (239.87-538.42)	0.841
p-Value	0.101	0.144		0.054	0.202		0.022	0.602	
Sugar, T0	69.56 (52.08-87.94)	83.19 (60.89-105.49)	0.477	73.53 (57.98-89.08)	82.99 (52.01-113.97)	0.390	77.82 (58.30-97.35)	72.93 (53.46-92.40)	0.835
Sugar, T1	51.21 (38.31-64.11)	61.66 (40.34-82.97)	0.906	57.67 (43.17-72.16)	50.18 (31.84-68.53)	0.952	48.66 (36.31-61.01)	65.59 (43.21-87.97)	0.958
p-Value	0.003	0.020		0.004	0.007		<0.001	0.288	
Snacks, T0	160.82 (106.52-215.13)	194.25 (139.02-249.48)	0.175	169.41 (123.96-214.86)	197.56 (124.15-270.97)	0.129	164.55 (122.27-206.84)	191.05 (119.93-262.18)	0.118
Snacks, T1	134.23 (89.40-179.05)	121.88 (79.85-163.90)	0.729	135 (96.61-173.39)	107.56 (67.95-147.17)	0.968	108.42 (75.49-141.34)	155.53 (98.35-212.70)	0.500
p-Value	0.419	0.013		0.078	0.086		0.021	0.226	
Wine, T0	297.36 (197.87-396.85)	281.64 (177.50-385.79)	0.205	256.89 (181.60-332.19)	400.91 (217.97-583.86)	0.993	276.92 (178.90-374.94)	307.98 (202.40-413.55)	0.626
Wine, T1	187.18 (94.03-280.32)	153.52 (82.21-224.83)	0.569	171.19 (101.58-240.80)	174.54 (53.12-295.95)	0.634	155.94 (71.53-240.35)	193.26 (108.49-278.03)	0.640
p-Value	<0.001	0.002		<0.001	0.001		<0.001	0.041	
Beer, T0	113.12 (58.43-167.81)	124.78 (57.53-192.03)	0.634	106.16 (59.87-152.45)	158.96 (57.37-260.55)	0.148	128.24 (62.31-194.18)	105.30 (58.75-151.84)	0.067
Beer, T1	69.74 (33.32-106.17)	33 (12.64-53.36)	0.467	56.42 (29.83-83)	42.26 (5.84-78.68)	0.850	49.83 (18.41-81.25)	57.53 (27.21-87.86)	0.566
p-Value	0.151	0.001		0.029	0.004		0.005	0.064	

T0: Baseline; T1: first follow-up during chemotherapy. Food and beverage consumptions are expressed as mean of grams per week or milliliters per week with corresponding 95% confidence interval in brackets (95% CI).

evaluation, which could have been complementary to the questionnaires employed.

In conclusion, our prospective study failed to confirm a correlation between TAs onset and food habits as well as with weight change during adjuvant chemotherapy. EBC women during adjuvant treatment tend to adopt some dietary habit changes as reported in a previous paper (16), irrespective to TAs onset, in agreement with WCRF recommendations (26, 27), and without significantly affecting body weight.

Table V. *Correlation between taste alterations (TAs) at first follow-up during chemotherapy (T1) with weight and body-mass index (BMI) at baseline (T0), during chemotherapy (T1), and at the end of chemotherapy (T2).*

	No TAs at T1	TAs at T1	*p*-Value
Weight (Kg)			
T0	63.35 (59.94-66.76)	64.74 (62.65-66.83)	0.254
T1	63.16 (59.79-66.52)	64.65 (62.46-66.83)	0.309
p-Value	0.470	0.233	
BMI (Kg/m^2)			
T0	24.41 (23.96-25.57)	24.67 (23.96-25.57)	0.266
T1	24.45 (23.87-25.48)	24.87 (23.87-25.48)	0.531
p-Value	0.784	0.282	
Weight (Kg)			
T0	63.36 (60.01-66.60)	64.84 (62.85-66.96)	0.254
T2	63.53 (60.52-66.69)	65.00 (62.99-67.22)	0.326
p-Value	0.610	0.788	
BMI (Kg/m^2)			
T0	24.34 (22.99-25.63)	24.83 (24.06-25.65)	0.266
T2	24.37 (23.14-25.60)	24.87 (24.08-25.69)	0.315
p-Value	0.504	0.804	

Data are expressed with corresponding 95% confidence interval in brackets (95% CI).

Table VI. *Taste alterations (TAs) and weight categories change.*

	Decreased weight N (%)	Stable weight N (%)	Increased weight N (%)	*p*-Value
TAs onset (overall)				
Absent	3 (13)	44 (33.8)	8 (27.6)	0.127
Present	20 (87)	86 (74.4)	21 (72.4)	
Metallic taste				
Absent	10 (43.5)	78 (60)	20 (69)	0.171
Present	13 (56.5)	52 (40)	9 (31)	
Sweet taste alteration				
Absent	15 (65.2)	83 (63,8)	23 (79.3)	0.278
Present	8 (34.8)	47 (6.2)	6 (20.7)	
Bitter taste alteration				
Absent	13 (56.5)	91 (70)	19 (65.5)	0.430
Present	10 (43.5)	39 (30)	10 (34.5)	
Salty taste alteration				
Absent	9 (39.1)	76 (58.5)	14 (48.3)	0.177
Present	14 (60.9)	54 (41.5)	15 (51.7)	
Sour taste alteration				
Absent	15(65.2)	100 (76.9)	24 (82.8)	0.322
Present	8 (34.8)	30 (23.1)	5 (17.2)	
Umami taste alteration				
Absent	10(43.5)	80 (61.5)	14 (48.3)	0.156
Present	13 (56.5)	50 (38.5)	15 (51.7)	

Conflicts of Interest

The Authors declare no conflicts of interest.

Authors' Contributions

RP, AB and BZ contributed to study conceptualization and design. RP, PdM, SB, AT, AZ, LL, GS contributed to data acquisition. MZ, LV, and DC contributed to data analysis. RP, PdM, and SM drafted the manuscript. AB, SG, VA, and ELS critically revised the manuscript. All Authors gave final approval.

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References

1 Ponticelli E, Clari M, Frigerio S, De Clemente A, Bergese I, Scavino E, Bernardini A and Sacerdote C: Dysgeusia and health-related quality of life of cancer patients receiving chemotherapy: A cross-sectional study. Eur J Cancer Care (Engl) *26(2)*, 2017. PMID: 28101929. DOI: 10.1111/ecc.12633

2 Brand JG: Within reach of an end to unnecessary bitterness? Lancet *356(9239)*: 1371-1372, 2000. PMID: 11052575. DOI: 10.1016/S0140-6736(00)02836-1

3 Speck RM, DeMichele A, Farrar JT, Hennessy S, Mao JJ, Stineman MG and Barg FK: Taste alteration in breast cancer patients treated with taxane chemotherapy: experience, effect, and coping strategies. Support Care Cancer *21(2)*: 549-555, 2013. PMID: 22864536. DOI: 10.1007/s00520-012-1551-3

4 Denda Y, Niikura N, Satoh-Kuriwada S, Yokoyama K, Terao M, Morioka T, Tsuda B, Okamura T, Ota Y, Tokuda Y, Sasano T and Shoji N: Taste alterations in patients with breast cancer following chemotherapy: a cohort study. Breast Cancer *27(5)*: 954-962, 2020. PMID: 32301097. DOI: 10.1007/s12282-020-01089-w

5 Steinbach S, Hummel T, Böhner C, Berktold S, Hundt W, Kriner M, Heinrich P, Sommer H, Hanusch C, Prechtl A, Schmidt B, Bauerfeind I, Seck K, Jacobs VR, Schmalfeldt B and Harbeck N: Qualitative and quantitative assessment of taste and smell changes in patients undergoing chemotherapy for breast cancer or gynecologic malignancies. J Clin Oncol *27(11)*: 1899-1905, 2009. PMID: 19289621. DOI: 10.1200/JCO.2008.19.2690

6 Heckmann JG, Heckmann SM, Lang CJ and Hummel T: Neurological aspects of taste disorders. Arch Neurol *60(5)*: 667-671, 2003. PMID: 12756129. DOI: 10.1001/archneur.60.5.667

7 Henkin RI: Drug-induced taste and smell disorders. Incidence, mechanisms and management related primarily to treatment of sensory receptor dysfunction. Drug Saf *11(5)*: 318-377, 1994. PMID: 7873092. DOI: 10.2165/00002018-199411050-00004

8 Hovan AJ, Williams PM, Stevenson-Moore P, Wahlin YB, Ohrn KE, Elting LS, Spijkervet FK, Brennan MT and Dysgeusia Section, Oral Care Study Group, Multinational Association of Supportive Care in Cancer (MASCC)/ International Society of Oral Oncology (ISOO): A systematic review of dysgeusia induced by cancer therapies. Support Care Cancer *18(8)*: 1081-1087, 2010. PMID: 20495984. DOI: 10.1007/s00520-010-0902-1

9 Epstein JB, Smutzer G and Doty RL: Understanding the impact of taste changes in oncology care. Support Care Cancer *24(4)*: 1917-1931, 2016. PMID: 26820877. DOI: 10.1007/s00520-016-3083-8

10 Drareni K, Dougkas A, Giboreau A, Laville M, Souquet PJ and Bensafi M: Relationship between food behavior and taste and smell alterations in cancer patients undergoing chemotherapy: A structured review. Semin Oncol *46(2)*: 160-172, 2019. PMID: 31204004. DOI: 10.1053/j.seminoncol.2019.05.002

11 Rock CL, Flatt SW, Newman V, Caan BJ, Haan MN, Stefanick ML, Faerber S and Pierce JP: Factors associated with weight gain in women after diagnosis of breast cancer. Women's Healthy Eating and Living Study Group. J Am Diet Assoc *99(10)*: 1212-1221, 1999. PMID: 10524383. DOI: 10.1016/s0002-8223(99)00298-9

12 van den Berg MM, Winkels RM, de Kruif JT, van Laarhoven HW, Visser M, de Vries JH, de Vries YC and Kampman E: Weight change during chemotherapy in breast cancer patients: a meta-analysis. BMC Cancer *17(1)*: 259, 2017. PMID: 28403873. DOI: 10.1186/s12885-017-3242-4

13 Makari-Judson G, Judson CH and Mertens WC: Longitudinal patterns of weight gain after breast cancer diagnosis: observations beyond the first year. Breast J *13(3)*: 258-265, 2007. PMID: 17461900. DOI: 10.1111/j.1524-4741.2007.00419.x

14 Makari-Judson G, Braun B, Jerry DJ and Mertens WC: Weight gain following breast cancer diagnosis: Implication and proposed mechanisms. World J Clin Oncol *5(3)*: 272-282, 2014. PMID: 25114844. DOI: 10.5306/wjco.v5.i3.272

15 Demark-Wahnefried W, Winer EP and Rimer BK: Why women gain weight with adjuvant chemotherapy for breast cancer. J Clin Oncol *11(7)*: 1418-1429, 1993. PMID: 8315439. DOI: 10.1200/JCO.1993.11.7.1418

16 Pedersini R, di Mauro P, Bosio S, Zanini B, Zanini A, Amoroso V, Turla A, Vassalli L, Ardine M, Monteverdi S, Zamparini M, Gurizzan C, Cosentini D, Ricci C, Simoncini EL and Berruti A: Changes in eating habits and food preferences in breast cancer patients undergoing adjuvant chemotherapy. Sci Rep *11(1)*: 12975, 2021. PMID: 34155246. DOI: 10.1038/s41598-021-92138-7

17 Basch E, Reeve BB, Mitchell SA, Clauser SB, Minasian LM, Dueck AC, Mendoza TR, Hay J, Atkinson TM, Abernethy AP, Bruner DW, Cleeland CS, Sloan JA, Chilukuri R, Baumgartner P, Denicoff A, St Germain D, O'Mara AM, Chen A, Kelaghan J, Bennett AV, Sit L, Rogak L, Barz A, Paul DB and Schrag D: Development of the National Cancer Institute's patient-reported outcomes version of the common terminology criteria for adverse events (PRO-CTCAE). J Natl Cancer Inst *106(9)*: dju244, 2014. PMID: 25265940. DOI: 10.1093/jnci/dju244

18 Campagna S, Gonella S, Stuardi M, Sperlinga R, Cerponi M, Olivero M, Giuliano PL, Marchese R, Carnovali E, Pedersini R, Berchialla P and Dimonte V: [Italian validation of the Chemotherapy Induced Taste Alteration Scale]. Assist Inferm Ric *35(1)*: 22-28, 2016. PMID: 27183423. DOI: 10.1702/2228.24016

19 Campagna S, Gonella S, Sperlinga R, Giuliano PL, Marchese R, Pedersini R, Berchialla P and Dimonte V: Prevalence, severity, and self-reported characteristics of taste alterations in patients receiving chemotherapy. Oncol Nurs Forum *45(3)*: 342-353, 2018. PMID: 29683116. DOI: 10.1188/18.ONF.342-353

20 Ee C, Cave AE, Naidoo D, Bilinski K and Boyages J: Weight before and after a diagnosis of breast cancer or ductal carcinoma in situ: a national Australian survey. BMC Cancer *20(1)*: 113, 2020. PMID: 32075592. DOI: 10.1186/s12885-020-6566-4

21 Klein S, Burke LE, Bray GA, Blair S, Allison DB, Pi-Sunyer X, Hong Y, Eckel RH and American Heart Association Council on Nutrition, Physical Activity, and Metabolism: Clinical implications of obesity with specific focus on cardiovascular disease: a statement for professionals from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism: endorsed by the American College of Cardiology Foundation. Circulation *110(18)*: 2952-2967, 2004. PMID: 15509809. DOI: 10.1161/01.CIR.0000145546.97738.1E

22 Zabernigg A, Gamper EM, Giesinger JM, Rumpold G, Kemmler G, Gattringer K, Sperner-Unterweger B and Holzner B: Taste alterations in cancer patients receiving chemotherapy: a neglected side effect? Oncologist *15(8)*: 913-920, 2010. PMID: 20667968. DOI: 10.1634/theoncologist.2009-0333

23 Mattes RD, Arnold C and Boraas M: Learned food aversions among cancer chemotherapy patients. Incidence, nature, and clinical implications. Cancer *60(10)*: 2576-2580, 1987. PMID: 3478121. DOI: 10.1002/1097-0142(19871115)60:10<2576::aid-cncr2820601038>3.0.co;2-5

24 Holmes S: Food avoidance in patients undergoing cancer chemotherapy. Support Care Cancer *1(6)*: 326-330, 1993. PMID: 8156251. DOI: 10.1007/BF00364971

25 Salminen E, Bishop M, Poussa T, Drummond R and Salminen S: Dietary attitudes and changes as well as use of supplements and complementary therapies by Australian and Finnish women following the diagnosis of breast cancer. Eur J Clin Nutr *58(1)*: 137-144, 2004. PMID: 14679379. DOI: 10.1038/sj.ejcn.1601760

26 Michael M, Tola A, Tim B and Junshi C: World Cancer Research Fund/American Institute for Cancer Research. Food, Nutrition, Physical Activity, and the Prevention of Cancer: A Global Perspective. Washington DC, AICR, 2007. Available at: https://discovery.ucl.ac.uk/id/eprint/4841/1/4841.pdf [Last accessed on May 6, 2022]

27 World Cancer Research Fund/American Institute for Cancer Research: Diet, Nutrition, Physical Activity and Cancer: A Global Perspective. Continuous Update Project Expert Report, 2018. Available at: https://www.wcrf.org/dietandcancer [Last accessed on January 23, 2022]

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