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REVIEW ARTICLE

Sensory preferences of supplemented food products among cancer patients: a systematic review

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Abstract

Purpose Oral nutritional supplements and fortified foods, here considered supplemented food products (SFP), are recommended as part of nutrition therapy guidelines to treat malnutrition among cancer patients. However, their successful use is limited by patients' failure to meet recommended intakes. This systematic review aimed to identify sensory preferences for SFP among cancer patients and evaluate the methodologies employed in sensory preference assessment.

Methods A systematic search was conducted in several relevant databases yielding 1056 papers of which 19 met the inclusion criteria. Two authors independently selected papers and extracted findings. The included papers were categorized according to the focus of the preference assessment.

Results Studies comparing sensory preferences for SFP of cancer patients with those of a control group suggested that the liking for SFP by cancer patients differs from healthy participants. Patient heterogeneity in site and stage of tumor, variation in study methodologies, and type of treatment complicated a conclusion regarding the effects of cancer treatment and taste changes on taste preferences. However, some general results were observed among the studies, such as the preference for fresh milk-based supplements when compared with other supplement types.

Conclusion This review highlighted the need for consistent reporting and control of variables that influence the sensory characteristics of SFP when sensory preferences are assessed in the clinical setting. Attention to these methodological details will enhance the reliability and accuracy of sensory preference assessment among cancer patients for realistic evaluation of SFP targeted to their nutritional needs.

Keywords Acceptability · Cancer · Compliance · Fortified foods · Oral nutritional supplements · Taste change

Introduction

The prevalence of cancer-related malnutrition is frequent, ranging from 9 to 55% depending on the type of cancer and how malnutrition is assessed [1]. Cancer-related malnutrition is associated with poor response to treatment, increased treatment toxicity, reduced quality of life [2], increased mortality, morbidity, and length of hospitalization [3]. Therefore, detection and treatment of malnutrition or inadequate nutrition in cancer patients must occur as early as possible.

Currently, there is no consensus on the best way to treat malnutrition among cancer patients. However, the European Society for Clinical Nutrition and Metabolism (ESPEN) guidelines recommend nutrition counseling as 1st-line nutrition therapy to maintain or increase nutrient intake in cancer patients [4]. Similarly, the Academy of Nutrition and Dietetics recommends nutritional therapy for patients undergoing chemotherapy or radiotherapy [5]. In addition to nutrition counseling, fortified foods (foods containing added nutrients) and/or oral nutritional supplements (ONS; commercially available homogeneous and usually nutritionally complete nutrient mixtures for oral consumption) are recommended to achieve the required amount of nutrients and calories [4]. In this review, the term "supplemented food products" (SFP) will be used to refer collectively to both fortified foods and ONS.

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Clinical outcomes expected from SFP consumption are limited by patients' failure to achieve the recommended ONS intake [6]. Successful increase in patient nutrient and caloric intake through SFP depends on long-term compliance and acceptability of the product [7]. Although commonly recommended for cancer patients at risk for malnutrition, ONS are not habitually consumed by advanced cancer patients [8, 9]. Many symptoms known to impact oral intake are prevalent among oncology patients (e.g., nausea and vomiting, mucositis) [2], including taste and smell alterations (TSA) which are common among patients receiving cancer treatment [10, 11] and may affect sensory preferences and general acceptability of the product. Lack of acceptability can present a barrier to long-term compliance and effective use of ONS [7, 12–14]. The extent to which TSA and sensory preferences influence ONS compliance of patients with cancer remains relatively unknown. Greatest wastage of ONS was observed among a group of elderly patients who disliked the product's taste [15]. Moreover, when ONS are consumed regularly over long periods, "taste fatigue" occurs [12]. Supplements offering a variety of flavors are more likely to prevent taste fatigue [7].

Understanding the sensory preferences of SFP of cancer patients is necessary to improve their consumption. Sensory evaluation can be used to assess sensory preferences. The use of sensory evaluation, a scientific discipline "used to evoke, measure, analyze and interpret those responses to products as perceived through the senses of sight, smell, touch, taste, and hearing" [16] is commonly applied to optimize chemosensory characteristics in the food and beverage industry. This discipline can be applied in the development, improvement, and assessment of preferences for SFP by cancer patients.

Although sensory characteristics such as taste, flavor, aroma, color, and consistency will impact the acceptance of short- and long-term consumption, literature assessing the sensory preference of SFP is limited. Furthermore, the methods used to assess sensory characteristics and preferences are rarely based on established sensory evaluation methods. The aim of this systematic review is to identify sensory preferences for SFP among cancer patients as well as to evaluate and compare the methodologies employed in the assessment of those sensory preferences.

Methods

Search strategy

A systematic review was conducted. Searches were conducted in several databases (OVID MEDLINE, OVID EMBASE, OVID PsycInfo, WOS CABI, EBSCO CINAHL, EBSCO AGRICOLA, SCOPUS, Proquest Dissertations and Theses GLOBAL, PROSPERO, and OVID All EBM Reviews: Cochrane DSR, ACP Journal Club, DARE, CCTR, CMR, HTA, and NHSEED) by an expert searcher (SC) July and August 2016 and updated in September 2017. Searches employed both controlled vocabularies (e.g., MeSH, EMTREE, etc.) and keywords representing concepts such as (cancer or neoplasms) AND (palatability or compliance) AND (food supplements). Search strategies were adapted for each database. No limits were applied. References were exported to RefWorks citation manager. Search strategies are presented in Appendix 1.

Articles were considered for evaluation if they were published in peer-reviewed journals and were retrievable through the University of Alberta Library Services including interlibrary loan. Studies were included if they assessed taste preference, liking, or ranking evaluations of oral nutritional supplements/fortified foods among cancer patients irrespective of patient age, tumor type, or tumor stage. Studies were excluded if the main focus was on developed food intake patterns (aversions or preferences), the supplements/foods were not assessed for taste quality (food records only), or only compliance and/or nutritional outcomes after the consumption of SFP were assessed. Publications in form of reviews, communications, editorials, letters, abstracts, or expert opinions were also excluded. Additionally, a hand search through reference lists of relevant articles was performed.

Data extraction

Duplicate papers retrieved within the searches were deleted. The first and second authors evaluated the retrieved articles for inclusion, obtaining full text of those identified as meeting inclusion criteria. The third and fourth authors confirmed that the chosen publications met the inclusion criteria. Any disagreement about a publication was discussed and resolved by consensus. On occasion, authors of publications were contacted to request details of the methods employed.

The first and second authors independently extracted data from the selected studies. The following details were extracted from each study: authors; year, country, and journal of publication; patient population characteristics (diagnosis, demographic information (age mean and range, number of males/females), treatment); details of the evaluations (sensory method, assessments, and when applicable, details of the control group used for comparisons); supplements or fortified foods assessed (number, characteristics); and results.

The systematic review of the literature presented in this paper is the result of a thorough search of databases and references in peer-reviewed journals to be captured. We believe that our search strategy captured all sensory evaluations of SFP among cancer patients. However, as is the case with any review, these searches may fail to cover all relevant published papers. Moreover, some companies and researchers might assess sensory preferences for SFP among cancer patients without publication in international journals because they do not consider the studies relevant or prefer to keep them as part of the company expertise.

Results

Literature search findings

The search criteria were met by 1056 articles. After exclusion of 138 duplicates, the titles and abstracts of 918 publications were reviewed; 884 of the potentially relevant studies did not meet the inclusion criteria, and the remaining 34 articles were extracted for full review (Fig. 1). Studies in a different language extracted for full review were translated to English by bilingual volunteers. A further 16 papers were eliminated for a variety of reasons (Fig. 1). After the search, one additional article was retrieved and included. Nineteen studies were included in the final review [12–14, 17–32].

Description of patients and SFP included in the review

A high variability in cancer type, treatment received and SPF products evaluated was found among the different studies; no two studies evaluated the same patient group. Most studies included a mixed population of two or more tumor types ($n = 14$), some focusing on a specific area (pelvic ($n = 1$), thoracic ($n = 1$)), stage (metastatic ($n = 1$), advanced ($n = 1$)), or age group (pediatric ($n = 1$)). The remaining studies included only one cancer type (hematological ($n = 2$), testicular ($n = 1$), head and neck ($n = 1$), or gastrointestinal ($n = 1$)).

The majority of SFP evaluated in the studies were ready-made ONS and liquids. Supplements evaluated were diverse; 14 studies evaluated different formats (e.g., milk-based, juice-based, powdered, hospital prepared) and/or brands of commercially available supplements either with the same flavor ($n = 4$) or a variety of flavors ($n = 10$), 3 studies assessed the effect of powdered supplement addition into food recipes, 1 study assessed homemade supplements and 1 paper evaluated a fortified soft ice cream.

Description of comparisons used in the review

The final 19 articles were categorized into 3 formats of sensory preference assessment; studies comparing the sensory preferences for SFP of cancer patients with those of a control

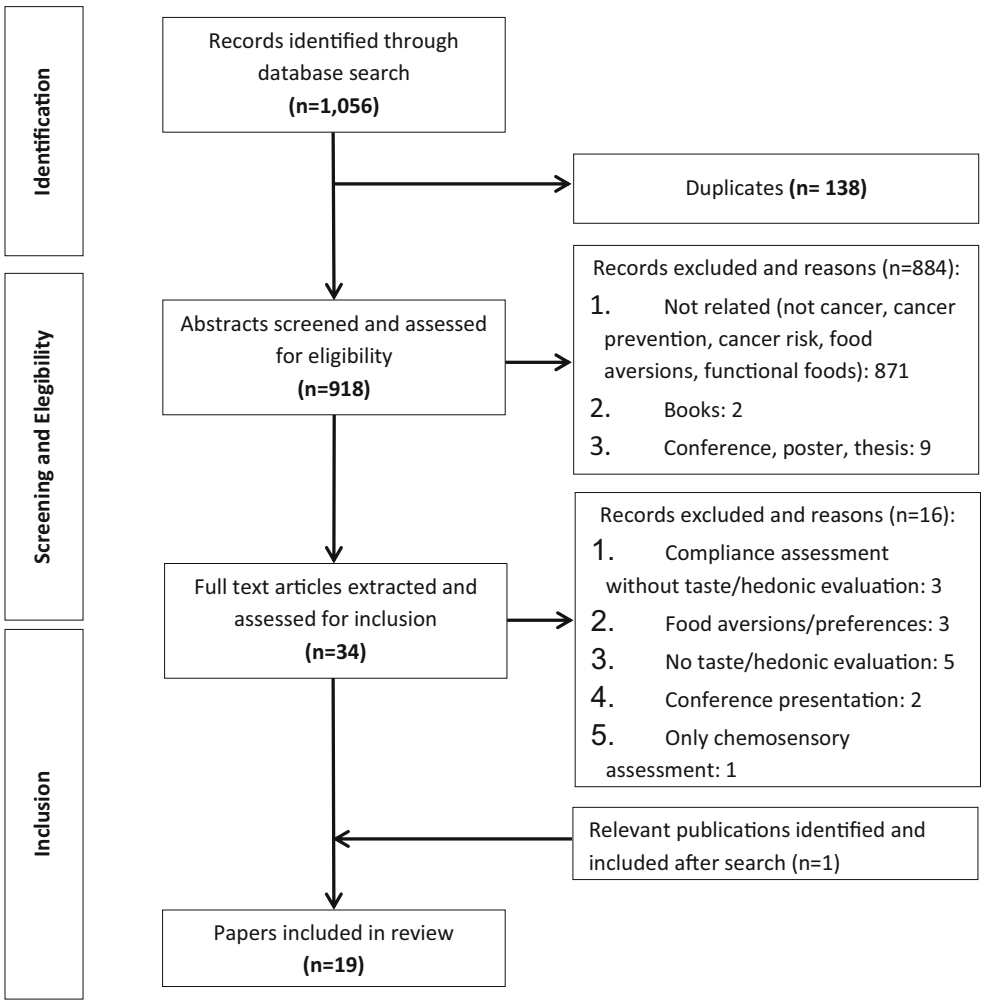

Fig. 1 PRISMA diagram

group ($n = 9$) [12, 13, 17–19, 21, 22, 26, 27], studies assessing the sensory preferences of cancer patients over time ($n = 6$) [12, 14, 24, 25, 27, 32] and studies assessing the presence of TSA in cancer patients and its influence on sensory preferences ($n = 5$) [17, 18, 21, 22, 25].

Diversity in choice of sensory methodologies and validity of their application to assess sensory preferences and/or acceptance was documented among the studies. Standard sensory evaluation methodologies and practices were not commonly employed. Moreover, the control of study variables known to influence the evaluation of a product's sensory characteristics (e.g., testing location, product, and presentation format), and thus the sensory preferences of the products, was not consistently reported. Therefore, following the presentation of the data, we present a comparison and analysis of sensory evaluation methods used in the reviewed studies and discuss the control of study variables that influence sensory evaluation outcomes.

Sensory science is a scientific discipline incorporating reliable and validated methods. A brief overview of affective sensory tests is presented to clarify the terms used in this review. Affective testing is a class of sensory tests used to determine the degree of liking/disliking, acceptance, preference, or emotions for a product [33]. Preference and acceptance tests are the two principle categories that exist within affective testing, defined by the task performed and research question of the test (Table 1).

Sensory preferences and/or acceptance of SFP comparing cancer patients and a control group

Nine studies compared the preference or acceptance of supplements by cancer patients with healthy participants (control groups; Table 2). Five studies combined a preference ranking test (ranking in order of liking) with an acceptance rating (rating degree of liking), while the remaining studies focused only on the acceptance of taste and/or other attributes. Although acceptance and preference sensory tests ask participants to assess different affective aspects, in this review, acceptance and preference ranking results were similar when both were used within a study; those supplements that were rated significantly higher were also ranked as preferred.

The presence of TSA among cancer patients, such as alterations in taste intensity and/or the perception of metallic taste without an external stimulus, is well documented [10, 11]. TSA impact sensory perception and preferences, and contribute to differences in preferences between cancer patients and healthy individuals. Age-related decrements in smell and taste perception are also well documented [36, 37]. As the mean age in all studies with adult patients was over 57 years, the use of an age-matched control group provided the appropriate comparison to accommodate age-related changes in taste and smell. However, only three of nine studies used age- and sex-matched individuals and one study used an age-matched control group. In all studies where the control group was not matched, no significant differences were found between the two groups for the supplement's ratings. In contrast, all studies using a sex- and -age or age-matched control group, observed differences in the acceptance and/or preference for at least one of the supplements. Collectively, these studies suggest that the liking for SFP by cancer patients may differ from those of healthy participants and highlights the importance of selecting a control group matched for key characteristics known to influence sensory preferences.

Sensory preferences of cancer patients over time

Impaired taste perception and altered food preferences have been observed during and post-treatment. Four studies assessed changes in taste preferences after cancer treatment (Table 3). Three studies with diverse patients with different cancer treatments (CT, RT or combined) showed no effect of cancer treatment on SFP preferences. Conversely, one study showed increased preference for powdered supplements after treatment except two flavors (vegetable and chocolate). However, other studies using qualitative methods revealed that taste preferences of cancer patients change over the course of treatment and tastes that are well tolerated before treatment may no longer be tolerable [38].

Table 1 Characteristics and aims of affective sensory test categories (adapted from Meilgaard et al. [34])

Test category	Task	Example questions	Characteristics and results obtained
Preference tests	Choice	Which sample do you prefer/like better?	• Forces a choice of 1 product over other(s). • Indicates whether a product is preferred over another(s). • Does not indicate whether the products are liked/disliked. • The obtained results are ordinal and can be analyzed using non-parametric statistics to detect a significant difference in preference [35].
Acceptance tests	Rating	How much do you like this product? How acceptable is this product?	• Indicates the magnitude of the level of liking/disliking of each product. • Parametric statistical analysis can then be used to determine if significant differences exist between products [35].

Table 2 Comparison of sensory preferences and/or acceptance for SFP between cancer patients and control group

Reference (country)	Patients characteristics[a]	Control group characteristics	Sensory evaluation procedure	SFP evaluated	Comparison of sensory preference and/or acceptance between patients and control group
De Wys et al. [21] (USA)	Metastatic neoplasia, $n = 25$; NR; age = 57 (25–81)	NR ($n = 25$)	Taste rating using 7-point rating scale ("very bad taste" (− 3) to "very good taste" (3))	5 commercial ONS (4 milk-based and 1 semisynthetic product, all vanilla flavored)	1 product was rated significantly lower by controls compared with patients. Range of average scores for each product is broader for controls.
Gallagher and Tweedle [22] (England)	Variety of sites ($n = 50$); NR; age = NR; before treatment, metastatic ($n = 15$)	Age and sex matched ($n = 50$)	Taste rating using 7-point scale (very bad taste to very good taste)	8 commercial supplements, each unflavored and in 2 alternative flavors	Cancer patients and controls differed in their ratings for the supplements. 3 supplements received significantly higher ratings from patients compared with controls.
Brown et al. [17] (USA)	Breast and lung $n = 39$; 19 M; age = 56; CT ($n = 28$), RT ($n = 3$), metastatic ($n = 16$), ≥ 1 week since last CT	Age and sex matched ($n = 37$)	Rating using modified wine-tasting scale assessing appearance, body, flavor, aroma, sweetness, and aftertaste. Higher scores reflect more pleasing elements	11 nutritional supplements: polymeric and elemental ($n = $ NR), flavored and unflavored ($n = $ NR)	1 ONS was rated significantly higher by female patients compared with female controls. There was no significant difference in rating for the remaining ONS or between male patients and controls.
Rahemtulla et al. [12] (UK)	GI, initial $n = 60$, after treatment $n = 47$; 35 M; age = 64(23–84); before and 6 weeks after initial CT	Friends/relatives of patients or hospital staff. Initial $n = 63$ (22 M); after treatment $n = 47$. Significantly more females and older.	a) Liking rating using 10 cm visual analog scale from "definitely dislike" (0) to "definitely like" (10) b) Preference ranking	3 commercial ONS: 1 strawberry-flavored UHT milk based, 1 forest fruit-flavored juice based, and 1 strawberry-flavored fresh milk based	No significant differences in ONS ratings between control and patient groups, before or after CT. Fresh milk product was preferred by both groups.
McGough et al. [27] (UK)	Pelvic, initial $n = 50$ (5 M) after treatment $n = 38$; age = 61 (34–89); Before and after 5 weeks of external beam pelvic RT	Friends/relatives of patients. Initial $n = 50$ (19 M); after treatment $n = 46$. Significantly older and smaller proportion of males.	a) Liking using 7-point Likert scale ("definitely dislike" (1) to "definitely like" (7)) b) Preference ranking	5 supplements (3 elemental, 1 polymeric, and 1 peptide formula) in similar flavors (4 lemon/lime and 1 orange/pineapple)	No significant differences in mean ONS-liking ratings between patients and controls before and after RT, all rating the peptide formula significantly lower. The peptide supplement was the least-preferred supplement by patients and controls.
Martin et al. [26] (Canada)	Any type, $n = 86$, NR; age = NR	Patients' family/friends and hospital staff. Smoothie $n = 88$ (NR); oatmeal $n = 57$ (NR); tomato pasta sauce $n = 64$ (NR)	Rating of aroma, taste/flavor, and liking of the products using 7-point hedonic scale ("dislike extremely" (1) to "like extremely" (7)).	A n-3 PUFA supplement added into 3 different foods: instant oatmeal, mixed berry smoothie, and tomato pasta sauce	No significant differences between patient and non-patient ratings for each of the foods.
Cohen et al. [19] (Australia)	Any pediatric cancer, $n = 21$; 14 M; age = 12.9 (± 3.9); receiving CT	Pediatric orthopedic patients or healthy. $n = 38$ (16 M). Slightly younger	a) Liking rating on 10 cm CAS from "I don't like the taste at all" to "I like the taste a lot" b) Preference ranking. Both assessments done in two conditions (blinded and branded)	5 chocolate-flavored ONS. 3 commercial drinks (2 UHT and 1 fresh milk based) and 2 hospital based (1 UHT and 1 fresh milk based)	No significant difference in the ONS ratings between control group and patients, although patients gave lower ratings to all supplements compared with controls. In both groups, ratings were significantly higher for commercially available supplements over hospital-prepared. A higher number of children from both groups preferred the commercial fresh milk product. The UHT hospital supplement was ranked as least preferred by both groups, especially controls.
Brown et al. [13] (UK)	Thoracic cancer, $n = 31$; 18 M; age = 69 (± 9); variety of palliative treatments	Age-matched healthy volunteers ($n = 32$). Smaller proportion of males	a) Rating evaluation using 7-point Likert scale ("definitely like" (1) to "definitely dislike" (7)) b) Preference ranking	4 supplement types: juice, milk, yogurt, and skimmed milk powder based, in different flavors. Participants selected flavor of each supplement type before tasting.	Cancer patients rated the skim milk powder product significantly higher. Controls rated the yogurt product significantly higher. For ranking, most patients preferred the skim milk powder product and most controls preferred the yogurt style product (least preferred among patients).
Baik et al. [18] (Korea)	Variety of solid tumors, $n = 30$; 11 M; age = 59 (± 15;19–89); current treatment or ≤ 6 months	Age and sex matched ($n = 30$). Smaller number of controls smoking and drinking alcohol	a) Rating of color, flavor, viscosity, and taste on 5-point Likert scale ("very bad" (1) to "very good" (5)) b) Preference ranking	3 powdered cereal-based trial supplements mixed with milk, all compared with commercial liquid-isolated soy protein supplement.	Taste of cereal product and viscosity of fruit product received significantly lower ratings by cancer group compared with controls. No significant difference in overall preference rating for the

Table 2 (continued)

Reference (country)	Patients characteristics[a]	Control group characteristics	Sensory evaluation procedure	SFP evaluated	Comparison of sensory preference and/or acceptance between patients and control group
					supplements by both groups. Patients showed significant preference for the fruit and commercial supplements while there was no significant difference in preference for the supplements by control group.

NR, not reported; *M*, males; *CT*, chemotherapy; *RT*, radiotherapy; *GI*, gastrointestinal; *SCLC*, small cell lung cancer; *CAS*, colored analog scale; *PUFA*, poly unsaturated fatty acids

[a] Diagnosis, size (number of males (*n*)), age (includes mean or median age (year) + range), and treatment status

Most studies used one-sip assessments in a "taste and rate" format, a common and practical approach as participants provide a single liking score. However, this approach does not reflect changes in liking during consumption of a complete serving of product. As confirmed by Methven et al. [39] and Thomas et al. [40], working with healthy participants in multi-sip assessments of SFP, dynamic changes in the perception of negative mouthfeel, and taste attributes (e.g. dry, mouthdrying, metallic) build up over consecutive sips, decrease the liking of SFP, and thus lead to reduced consumption. In both studies, the most liked products were consumed in higher volumes, showing the influence of acceptance on overall consumption.

SFP will successfully improve patient nutritional status only if products are consumed over a period of weeks. Hence, longitudinal assessment of both the volume of product consumed and its acceptance are required to reflect potential intake and subsequent improvement of nutrient intake. Of the studies reviewed, only two evaluated the relation between taste preferences and compliance of ONS over time. Bolton et al. [32] allowed patients to taste and preference rank six ONS to determine each patient's most preferred product for a home use test. The researchers then assessed the compliance of the preferred supplement over the 3-week study and observed that the majority of patients consumed their preferred supplement over the 21 days. The average acceptance rating over the 21 days was above 7.3 cm (on a 10-cm visual analog scale) except for two cases (5 and 0 cm). Although 16.7% of patients stopped drinking their preferred product due to a decrease in palatability or disliking of the product, most patients consumed their preferred flavor chosen at the beginning of the trial over the 21 days. In another study by Bolton et al. [14], patients were randomized to one of three supplement groups and patient compliance was assessed over time. The median time patients were on supplement was 60 days. Initial taste dislike and flavor fatigue caused shorter supplement consumption compared with other reasons (e.g., side effects, back to normal eating, disease progression) and was the stated cause of discontinued supplement intake by 54% of patients. "Flavor fatigue" was greater among patients who found the supplements unpalatable from the onset. The three supplements were not offered in identical flavors and the authors suggested product acceptance may have been negatively influenced by the novel flavors of one product (orange and banana versus chocolate and strawberry of other products). These two studies highlight the influence of sensory preferences on SFP compliance. The opportunity to taste SFP and choose the preferred product can increase compliance in a longitudinal evaluation and may have direct application in the clinical setting. In these compliance studies, the volume of SFP consumed by the patients is not presented. In addition to recording the amount of time patients are able to consume SFP, the ability of patients to consume prescribed quantities should be assessed, as this may also be affected by taste fatigue and palatability.

Table 3 Studies evaluating changes in sensory preferences over time

Reference	Country	Patients characteristics[a]	SFP	Comparison	Results
Bolton et al. [32]	UK	$n = 30$ (18 M); age = NR; variety of sites (mostly SCLC); active treatment for all or part of the study	6 ONS: 3 containing protein and energy and 3 supplying energy only	Short- vs. long-term palatability (after 21 days)	Over the 3-week study, the majority of patients consumed the ONS preferred at the first visit
Bolton et al. [14]	UK	$n = 60$ (NR); age = 59; variety of advanced cancer patients; variety of treatment	3 ONS: 1 milk-based product and 2 "synthetic"	Length of time the ONS can be consumed	Flavor-related issues were the main reason for discontinuation of ONS. The median time for supplement intake was 60 days
Rahemtulla et al. [12]	UK	Initial $n = 60$ (35 M). After treatment $n = 47$; 64 (23–84); GI cancer; 6 weeks CT	3 ONS: UHT milk based, fruit juice based, and fresh milk-based	Change in taste preferences following a 6-week of chemotherapy	There were no changes in taste preferences after 6-week CT
McGough et al. [27]	UK	Initial $n = 50$ (5 M). After treatment $n = 38$; age = 61(34–89); pelvic cancer; 5 weeks of pelvic RT	5 ONS (3 elemental, 1 polymeric, and 1 peptide formula): similar flavors of each ONS	Change in preferences after radical pelvic RT	There were no changes in ONS preferences after RT
Gómez-Candela et al. [24]	Spain	Powdered supplement ($n = 31$; age = 61.3 (± 12); liquid ONS $n = 30$, age = 63.6 (± 11.3); variety of cancer; variety of treatments	2 ONS: hypercaloric powder with 1.5 g of EPA and hypercaloric liquid supplement	Sensory preferences of ONS enriched by EPA over a month	Preference for ONS was higher at the end of treatment except for 2 flavors (powdered product with vegetables and with chocolate flavor)
Ijpma et al. [25]	Netherlands	$n = 21$ (21 M); age = 32 (27–36); disseminated testicular cancer; CT	6 ONS: 2 high-protein milk based, 2 juice based, and 2 yogurt based	Palatability of 6 ONS at multiple time point during treatment	There were no changes in palatability in 5 out of 6 ONS after CT

NR, not reported; *M*, males; *CT*, chemotherapy; *RT*, radiotherapy; *SCLC*, small cell lung cancer

[a] Sample size (number of males (*n*)), age (includes mean or median age (year) + range), cancer type, and treatment status

As presented previously in this review, product acceptance by healthy participants is not consistent with that of cancer patients. Therefore, the study of temporal changes in liking and perception of SFP among cancer patients could help elucidate the reasons for a lower than anticipated compliance in this setting. However, these types of assessments are difficult to conduct because they require longer tasting sessions and could represent an extra burden for patients.

The influence of TSA on sensory preferences of cancer patients

TSA are commonly reported among cancer patients and may lead to changes in sensory preferences over the course of cancer treatment. Five of nineteen studies assessed TSA and their association with SFP acceptability (Table 4). In three studies, TSA were measured objectively by threshold assessments (Henkin technique, concentration range of test solutions, and commercially available taste strips and "Sniffin' Sticks" for taste and smell thresholds assessment) while in two studies TSA were measured subjectively (patient reported alterations in taste since onset of cancer). Thresholds are commonly used in research and clinical settings mainly because they provide numeric values suitable for comparisons; however, their assessment can be time consuming and prone to errors if factors such as subject adaptation and subject fatigue are not considered [41]. Self-reported TSA rather than clinical measures have been suggested as a more appropriate predictor of food intake behavior since sensory perception encompasses more complex concepts such as flavor and food enjoyment that clinically assessed thresholds fail to capture [42, 43].

In a mixed population of cancer patients with different treatment regimens, 40% of patients reported experiencing TSA after cancer onset, which may explain the significant differences in taste preferences of supplements between cancer patients and healthy controls in the study [18]. Only one study [25] assessed TSA and palatability of products before and after treatment; TSA were reported after treatment without changes in palatability of the tested products. However, in two studies [21, 25], basic taste thresholds were correlated with the preference score of SFP, indicating that taste and smell function of patients influences palatability of SFP. One study observed higher sensitivity to bitter taste and lower sensitivity to sweet taste among cancer patients compared with healthy controls, resulting in significant differences in taste preferences between them [22].

Table 4 Assessment of taste and smell alteration (TSA) influencing sensory perception among cancer patients

Reference	Country	Patients characteristics[a]	TSA assessment method	Results
De Wys et al. [21]	USA	$n = 25$ (NR); 57 (25–81); variety of metastatic cancers	Taste-recognition threshold using Henkin technique (urea and sucrose recognition threshold)	SFP preference scores statistically correlated with urea and not sucrose-recognition thresholds. Negative SFP preference scores were more common among patients with a low-urea-recognition threshold than among those with a normal threshold.
Gallagher and Tweedle [22]	UK	$n = 50$ (NR); age = NR; variety of cancer sites; before treatment	Single-drop taste-recognition thresholds (urea for bitter, sucrose for sweet, sodium chloride for salt, and hydrochloric acid for sour)	Cancer patients showed lower sensitivity to sweet and higher sensitivity to bitter tastes compared with age- and sex-matched healthy subjects.
Brown et al. [17]	USA	$n = 39$ (19 M); male with lung cancer: age = 57.3 (± 7.4; 42–72), female with breast cancer: age = 56.4 (± 8.5;41–70); CT ($n = 28$), RT ($n = 3$); ≥ 1 week since last CT	Subjective taste/food aversions since onset of cancer	11 M and 16 F reported the development of changes in the sense of taste since illness onset, including hypogeusia ($n = 6$ M/6 F), meat aversion ($n = 4$ M/6F), and excessive sweet taste of food ($n = 1$ M/4F).
Baik et al. [18]	Korea	$n = 30$ (11 M); 59 (± 15;19–89); variety of cancers; receiving treatment or ended treatment ≤ 6 months	Self-assessment of taste change since the diagnosis of cancer.	40% of patients reported taste changes after diagnosis of cancer.
Ijpma et al. [25]	Netherlands	$n = 21$ (21 M); age = 32 (27–36); disseminated testicular cancer; CT	Taste-recognition and taste-detection thresholds for sweet, sour, salty, and bitter using taste strips; composite smell function (thresholds, discrimination, and identification) using "Sniffin' Sticks." Self-assessment of taste change and "foods taste differently" since start of treatment; presence and identification of continuous bad taste in the mouth.	Compared with baseline, the salt taste threshold increased after treatment. Some taste and smell thresholds were statistically correlated with liking or disliking of specific supplement flavors. Metallic taste of supplement was associated with lower liking of the supplements. The metallic taste of the juice-based apple ONS increased over treatment.

NR, not reported; *M*, males; *F*, females; *CT*, chemotherapy; *RT*, radiotherapy

[a] Sample size (*n*; (number of males), age (includes mean or median age (year) + range), cancer type, and treatment status

TSA were reported separately for males and females in one study. Gender could affect TSA and sensory preferences as females may be more prone than males to increased taste sensitivity during cancer treatment [44, 45]. As studies are heterogeneous in cancer sites, treatment, and method used to assess TSA, it is difficult to compare results. In addition, only one of these studies report confounding factors for TSA such as smoking and patient use of dentures [18], while no studies reported other symptoms known to impact oral intake.

Comparison and analysis of sensory evaluation methodologies

The discipline of sensory science comprises a set of methodologies and standards to reduce potential bias from the sample itself or the surroundings that may influence consumer perception [35]. By following these standards, the sensory properties of a product can be isolated to provide informative, valid, and reliable results [34].

This review highlights the need for thorough reporting and control of study variables in product sensory testing; standards should be incorporated and reported such as product serving size and temperature, presentation order and product identity details (ingredients, manufacturer, flavor), as well as external factors such as tasting area conditions and location (e.g., cafeteria, home, clinic, quiet room), time of day, number of products evaluated in one session, and use of palate cleansing before and between sample evaluations to avoid taste carry-over effect. The results of this review revealed that food industry sensory evaluation standards are not consistently translated into the clinical setting, reducing the reliability of study results. For future studies of SFP evaluation, standards organizations such as the American Society for Testing and Materials (ASTM) [33] and the International Organization for Standardization (ISO) [46] as well as sensory evaluation textbooks [34, 35, 47] can be consulted to guide product evaluation and study design.

In the 19 papers reviewed, rating scales to assess acceptance or liking ($n = 15$), either alone ($n = 8$) or combined with

Table 5 Comparison and analysis of sensory evaluation methodologies

Authors (year)	Stated aim	Number of patients (*n*); age (mean ± standard deviation)	Number of products evaluated	Sensory evaluation methodology						
				Type of sensory evaluation[a]	Scale	Sample serving size and temperature (*T*)	Samples blinded	Samples randomized among participants	Palate cleansing	Control of other external factors
Studies assessing the supplement's acceptance rating for 1 or more attributes										
De Wys et al. [21]	Evaluate patient preferences for several supplements	*n* = 25; age = 57 (25–81)	5	Taste acceptance rating	7 points (−3 = "very bad taste," 3 = "very good taste")	5 mL; *T* = NR	✓	✓	✓	
Gallagher and Tweedle [22]	Evaluate taste thresholds and palatability of ONS among cancer patients and control group	*n* = 50; age = NR	24 (8 in 3 flavors)	Taste acceptance rating	7 points (−3 = "very bad taste," 3 = "very good taste")	20 mL bottles; *T* = NR		✓	✓	✓
Brown et al. [17]	Compare quantitative evaluations of ONS by cancer patients and matched controls.	Male lung cancer: *n* = 19; age = 57.3 (± 7.4; 42–72); female breast cancer: *n* = 20; age = 56.4 (± 8.5;41–70)	11	Acceptance rating of appearance, body, flavor, aroma, sweetness, and aftertaste	Modified wine scale	15 mL; *T* = cold	✓	Same order for all patients	✓	✓
De Luis et al. [20]	Evaluate acceptability of 3 commercial ONS by hematological cancer patients	*n* = 32; age = 47.6 (± 16.8)	3	Rating of color, smell, taste, texture, and temperature	VAS (1 = "very good," 5 "very bad")	NR		✓		
Martin et al. [26]	Determine overall acceptability of 3 food products fortified with n-3 polyunsaturated fatty acid (PUFA)	Smoothie *n* = 38; oatmeal *n* = 22; tomato pasta sauce *n* = 26; age = NR	1 of 3 (1 supplement into 3 recipes)	Rating of aroma, taste/flavor, and liking	7-point hedonic scale (1 = "dislike extremely," 7 = "like extremely")	Sample = 30 mL; *T* = NR				Test at time of day when typically eaten
Trinidade et al. [31]	Investigate if introduction of fortified soft ice-cream increases compliance with oral-feeding regimes in post-operative HNC patients.	*n* = 30; age = NR	1	Acceptance rating of taste, temperature, consistency, and ease of eating	10-point scales with end anchors (1 = "not at all enjoyable" and 10 = "extremely enjoyable" or 1 = "very difficult to swallow" and 10 = "extremely difficult to swallow" for ease of eating)	200 g	Only 1 product was evaluated			
Gómez-Candela et al. [24]	Evaluate and compare efficacy and acceptance of an oral powdered supplement enriched	Powdered supplement (*n* = 31; age = 61.3	1 out of 2	Liking rating of taste, smell, consistency, and	Percentage scale (0–100%)	Product evaluated in patient homes				

Table 5 (continued)

Authors (year)	Stated aim	Number of patients (*n*); age (mean ± standard deviation)	Number of products evaluated	Sensory evaluation methodology						
				Type of sensory evaluation[a]	Scale	Sample serving size and temperature (*T*)	Samples blinded	Samples randomized among participants	Palate cleansing	Control of other external factors
	with EPA, compared with standard liquid ONS	(± 12); liquid ONS *n* = 30, age = 63.6 (± 11.3)		consumption willingness.						
Ijpma et al. [25]	Investigate palatability of 6 ONS in testicular cancer patients before, during, and after chemotherapy	*n* = 21; age = 32 (27–36)	6	Liking rating of appearance, smell, taste, sweetness, thickness, texture, aftertaste, and mouthfeel	7-point hedonic scale; 16 attributes assessed on 7-point Likert-type scale (1 = "dislike very much," 7 = "like very much")	Sample = 30 mL; *T* = cold	✓	✓	✓	✓
Studies assessing preference ranking										
Parkinson et al. [29]	Develop standard recipes using natural protein and energy supplements and determine the most acceptable	*n* = 60; age = NR	40 (10 recipes, in 4 levels each)	Preference ranking		NR	✓	✓		
Morris et al. [28]	Compare palatability and ability to increase energy of 2 supplements when added to common recipes	*n* = 10 in each panel; age = NR	30 (10 recipes in 3 supplement levels)	Preference ranking		NR	✓	✓		
Studies using both acceptance rating and preference ranking										
Bolton et al. [32]	Evaluate extent of loss of palatability among cancer patients using 6 commercial ONS	*n* = 30; age = NR	6	Preference ranking		NR	✓	✓		
			ONS chosen in preference ranking	Acceptance rating	10 cm VAS for "how acceptable is this product?" (end points not reported)	Product evaluated at home				
Rahemtulla et al. [12]	a) Examine short-term preferences of GI cancer patients and controls for milk- and non-milk-based supplements	Initial *n* = 60. After treatment *n* = 47; age = 64 (23–84)	4	Liking rating	10 cm visual analog scale (0 = "definitely dislike," 10 = "definitely liked")	30 mL; *T* = room *T*	✓	✓	✓	
				Preference ranking						

Table 5 (continued)

Authors (year)	Stated aim	Number of patients (*n*); age (mean ± standard deviation)	Number of products evaluated	Sensory evaluation methodology						
				Type of sensory evaluation[a]	Scale	Sample serving size and temperature (*T*)	Samples blinded	Samples randomized among participants	Palate cleansing	Control of other external factors
	b) Assess reliability of VAS to assess preferences for ONS.									
McGough et al. [27]	Identify if elemental peptide and polymeric ONS are acceptable to patients and compare preferences with healthy controls	Initial *n* = 50. After treatment *n* = 38; age = 61 (34–89)	6	Liking rating Preference ranking	7-point Likert type (1 = "definitely dislike," 7 = "definitely like")	30 mL; *T* = cold	✓	✓	✓	✓
Cohen et al. [19]	Examine taste preferences for ONS in children undergoing cancer treatment. Determine if preference is influenced by source of the product (commercial vs. hospital)	*n* = 21; age = 12.9 (± 3.9)	10 in 2 blocks of 5	Liking rating Preference ranking	10 cm colored analog scale (CAS) (0 = "I don't like the taste at all," 10 = "I like the taste a lot")	Sample = 10 mL; *T* = NR	✓	✓	✓	
Brown et al. [13]	Assess initial liking and preferences of patients with thoracic cancer for ONS and compare those preferences with age-matched healthy volunteers	*n* = 31; age = 69 (± 9)	5	Liking rating Preference ranking	7-point Likert agree-disagree scale (1 = "definitely like," 7 = "definitely dislike")	Sample = 30 mL (drink as much as desired); *T* = cold	✓	✓	✓	✓
Baik et al. [18]	Compare sensory assessments of trial ONS and a top seller. Examine possible differences between patient and control groups.	*n* = 30; age = 59 (± 15; 19–89)	4 (3 trials and control)	Rating of color, flavor, viscosity, and taste Preference ranking	5-point Likert scale (1"very bad" (1), 5 = "very good")	Sample = 30 mL; *T* = NR	✓	✓	✓	✓
Petersen and Andersen [30]	Examine taste perception of ONS in patients with malignant hematological disease and assess reproducibility of VAS.	*n* = 41; age = 53 (34–70)	4 (1 repeated)	Intensity rating for sweet, sour, salt, bitter, thickness, gritty, metal, and ability to drink 150 mL ("palatability"). Preference ranking	10 cm VAS	Sample = 4 mL; *T* = room	✓	✓		
Studies using other sensory evaluation methods										

Table 5 (continued)

Authors (year)	Stated aim	Number of patients (*n*); age (mean ± standard deviation)	Number of products evaluated	Sensory evaluation methodology						
				Type of sensory evaluation[a]	Scale	Sample serving size and temperature (*T*)	Samples blinded	Samples randomized among participants	Palate cleansing	Control of other external factors
Bolton et al. [14]	Randomized trial to evaluate long-term palatability of 3 ONS over indefinite time-frame	*n* = 60 (20 on each group); age = 59 (30–79), 58.5 (22–75), and 58 (31–80)	1 randomly assigned	Comments regarding the supplement and reasons to quit were documented		Product evaluated at home				
Garofolo et al. [23]	Describe the development of 8 formulations of hypocaloric homemade supplements to increase supply of energy, protein, and micronutrients	*n* = 312; age = NR	8	Questionnaire with closed question about the flavor (good/regular/-bad) and open-ended questions for opinion						

T, temperature; *NR*, not reported; *VAS*, visual analog scale; *EPA*, eicosapentaenoic acid

[a] For papers with several assessments, only those involving sensory acceptance/preference are presented

preference ranking ($n = 7$) were most commonly used (Table 5). Among the studies, scales used were highly variable and inconsistent with the reliable and validated scales commonly used in sensory science to rate acceptance [48].

In most studies, samples were presented in a randomized presentation order (14 out of 19) and sample identity was blinded (12 out of 19). As confirmed by Cohen et al. [19], the acceptance and preference of the supplements can be influenced by the brand, appearance, or any previous information about the products. The use of blinded samples, identified by three digit codes, is a common practice in sensory science to reduce bias. Moreover, sample presentation order will influence results and a balanced or randomized presentation design is essential to reduce presentation order bias [35].

Sample serving size should be sufficient for participants to evaluate all product attributes and re-taste if necessary. For products similar to ONS (e.g., flavored milk), consumption of a normal serving size of the product is recommended because factors such as sweetness or satiety can be liked or accepted at low volumes, while overall acceptability is reduced by an increased volume. Eleven of nineteen studies reported the product serving size used. However, 5 of those 11 studies used serving sizes smaller than 30 mL, which is concerning especially when more than one attribute is assessed. For example, Petersen and Andersen [30] provided only 4 mL of product to assess eight attributes in two different tests, while Brown et al. [17] provided 15 mL samples and asked participants to rate six different attributes.

Only six studies reported product serving temperature. The sensory science recommendation is to serve products at the temperature at which they are normally consumed [49]. Additionally, the number of products evaluated in one session differed among the studies, ranging from 1 to 24. The number of samples evaluated depends on the sensory and mental fatigue of the participants [34], and especially in the cancer setting, the presence of other symptoms such as pain or fatigue can represent a barrier to the number of samples that can be assessed.

In some studies included in this review, the terms preference and acceptance (liking) are used interchangeably. However, as mentioned previously, both tests assess different outcomes. While in preference measurement the participant chooses one product over one or more other products, acceptance assessments do not require direct comparison with another product and the participant rates their liking or acceptance on a scale [35]. Thus, in acceptance ratings, the participant may like or dislike two products equally, while in preference ranking, the participant must compare and choose one product over another.

Commonalities in patient sensory preferences for SFP

A synthesis of the results of the papers in this review reveal low patient acceptance for ONS in six [12, 14, 20–22, 27] out of nine papers reporting "average ratings" (e.g., below mildly good taste, 2.5/5 points, etc.). In contrast, studies of food products ($n = 3$) [12, 23, 26] showed good product acceptance. Despite the variability in sensory methodologies and patient populations among the studies, a preference for fresh milk-based supplements when compared with other supplement types and a general low acceptance of ONS were reported. Comparing sensory preferences of ONS and supplemented foods with similar flavors is worthy of investigation in future studies.

Six of nineteen studies compared acceptance and/or preference of fresh milk-based products with fruit juice-based, ultra-high-temperature (UHT) milk and powdered milk-based products. These studies revealed that patients with cancer prefer fresh milk-based supplements [12, 14, 19, 21, 25, 32]. A previous published systematic review [50] including 46 studies (mostly cancer patients) found greater compliance with liquid ONS than solids when patients have poor appetite as liquid ONS are less satiating. Liquid fresh milk-based supplements could be a good choice as a base matrix to create new supplements for cancer patients. Chilled and frozen products such as ice cream can also enhance palatability and acceptability of SFP among cancer patients [31].

Conclusion

The effectiveness of SFP for nutrition support depends on its consumption, which is directly influenced by its sensory acceptance. This review highlighted the need for the use of existing reliable and validated scales and methodologies for the assessment of sensory preferences and product acceptance and consistent reporting and control of variables that influence the sensory characteristics of the SFP when product sensory preferences are assessed in the clinical setting. Future research in this field would benefit from the application of sensory evaluation standards and facilitate analysis and comparisons among different studies. Sensory evaluation testing of SFP should be performed with the product's target audience, as not all patients have the same nutritional needs.

In general, patients expressed a preference for fresh milk-based supplements when compared with other supplement types. The acceptance and preference for SFP by cancer patients differs from healthy age-matched controls. For future studies it will be beneficial to report other symptoms known to impact oral intake as well as smoking and patient use of dentures.

Compliance is often an issue with SFP due to taste fatigue, the lack of flavor varieties, and taste alterations. Since sensory preferences are variable among patients, providing SFP that meet patients' sensory preference needs and expectations can improve SFP compliance and patient

nutritional status. The opportunity to taste SFP and select the preferred product can increase compliance in a longitudinal evaluation. Additionally, the use of validated methods of patient TSA assessment, either self-reported or objective measures, can provide insight regarding patient preference for product attributes such as flavor or sweetness intensity and potentially guide future product reformulation.

Three studies in this review showed no effects of cancer treatment on taste preferences, which is inconsistent with the findings of many other studies. Patient heterogeneity of site and stage of tumor, variation in study methodologies and type of treatment have made it difficult to draw conclusions regarding the effects of cancer treatment and TSA on taste preferences of cancer patients. Moreover, considering major advances in cancer treatment such as targeted therapy and immunotherapy, future studies to evaluate the effects of these therapeutic alternatives on TSA are worthy of further evaluation.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Appendix. Search strategies

Database: Epub ahead of print, in-process and other non-indexed citations, Ovid MEDLINE(R) Daily, and Ovid MEDLINE(R) (1946 to present; searched: 26 July 2016); search strategies:

1. (cancer* or neoplasm* or tumor* or tumour* or oncolog* or radiation* or radiotherap* or chemotherap* or metast*).mp. [mp = title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] (3670728)
2. exp. Neoplasms/ (2874307)
3. 1 or 2 (3980067)
4. ((food* or diet* or nutrition*) adj3 (therap* or enrich* or supplement*)).ti,ab. [mp = title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] (61084)
5. *functional food/ or fortifi*.ti,ab. or (oral adj3 (nutrit* or supplement* or enrich*)).ti,ab. (19254)
6. Dietary supplements/ (40598)
7. *Food additives/ (3990)
8. Food, fortified/ (8254)
9. *Foods, specialized/ (126)
10. *Vitamins/ (19001)
11. *Trace elements/ (10322)
12. (vitamin* or trace element* or ONS).ti,ab. (189352)
13. 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 (290193)
14. (exp. *Taste/ or exp. *Odors/) and (prefer*or percept* or perceiv* or blandness or comply* or accept* or complian* or likeability or liking).mp. (1909)
15. ((food or gustat* or taste or tasting or tastes or tasted or flavour* or flavor* or sensor perception* or diet) adj3 (prefer*or percept* or perceiv* or blandness or comply* or accept* or complian* or likeability or liking)).mp. [mp = title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] (3329)
16. 14 or 15 (4792)
17. exp. Food preferences/ (11381)
18. Taste perception/ (1035)
19. (palatab* or eating problem* or eating difficult* or swallowing problem* or swallowing difficult*).mp. [mp = title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] (7825)
20. 16 or 17 or 18 or 19 (23059)
21. 3 and 13 and 20 (106)

Database: Embase (1974 to 2016 July 26); search strategies:

1. (cancer* or neoplasm* or tumor* or tumour* or oncolog* or radiation* or radiotherap* or chemotherap* or metast*).mp. [mp = title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword] (4643768)
2. exp. neoplasm/ (3724477)
3. 1 or 2 (5181925)
4. 4 ((food* or diet* or nutrition*) adj3 (therap* or enrich* or supplement*)).ti,ab. [mp = title, abstract, heading

word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword] (75281)
5. *functional food/ or fortifi*.ti,ab. or (oral adj3 (nutrit* or supplement* or enrich*)).ti,ab. (24444)
6. diet supplementation/ or supplementation/ or exp. mineral supplementation/ (100653)
7. *diet therapy/ (8837)
8. food additive/ (9144)
9. nutritional support/ (15440)
10. exp. *vitamin supplementation/ (5594)
11. exp. *trace element/ (17740)
12. (vitamin* or trace element* or ONS).ti,ab. (241805)
13. 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 (410926)
14. (taste/ or "smelling and taste"/ or exp. odor/) and (prefer*or percept* or perceiv* or blandness or comply* or accept* or complian* or likeability or liking).mp. (4689)
15. ((food or gustat* or taste or tasting or tastes or tasted or flavour* or flavor* or sensor perception* or diet) adj3 (prefer*or percept* or perceiv* or blandness or comply* or accept* or complian* or likeability or liking)). mp. [mp = title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword] (4391)
16. 14 or 15 (8237)
17. food preference/ (11227)
18. organoleptic property/ or nutritional tolerance/ (1418)
19. (palatab* or eating problem* or eating difficult* or swallowing problem* or swallowing difficult*).mp. [mp = title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword
20. 16 or 17 or 18 or 19 (29732)
21. 3 and 13 and 20 (292)

Database: EBM reviews: Cochrane Database of Systematic Reviews (2005 to 27 July 2016), EBM reviews: ACP Journal Club (1991 to June 2016), EBM reviews: Database of Abstracts of Reviews of Effects (1st quarter 2016), EBM reviews: Cochrane Central Register of Controlled Trials (June 2016), EBM reviews: Cochrane Methodology Register (3rd quarter 2012), EBM reviews: Health Technology Assessment (2nd quarter 2016), EBM reviews: NHS Economic Evaluation Database (1st quarter 2016); search strategies:

1. (cancer* or neoplasm* or tumor* or tumour* or oncolog* or radiation* or radiotherap* or chemotherap* or metast*).ti,ab. (mp = ti, ab, tx, kw, ct, ot, sh, hw] (103931)
2. ((food* or diet* or nutrition*) adj3 (therap* or enrich* or supplement*)).ti,ab. [mp = ti, ab, tx, kw, ct, ot, sh, hw] (7916)
3. *functional food/ or fortifi*.ti,ab. or (oral adj3 (nutrit* or supplement* or enrich*)).ti,ab. (3870)
4. (vitamin* or trace element* or ONS).ti,ab. (14432)
5. 2 or 3 or 4 (23726)
6. ((food or gustat* or taste or tasting or tastes or tasted or flavour* or flavor* or sensor perception* or diet) adj3 (prefer*or percept* or perceiv* or blandness or comply* or accept* or complian* or likeability or liking or dislik* or aversion)).mp. [mp = ti, ab, tx, kw, ct, ot, sh, hw] (943)
7. (palatab* or eating problem* or eating difficult* or swallowing problem* or swallowing difficult*).mp. [mp = ti, ab, tx, kw, ct, ot, sh, hw] (773)
8. 6 or 7 (1650)
9. 1 and 5 and 8 (27)

Note: OVID EBM ALL—no longer accessible in September 2017—search was updated in Wiley Cochrane Library.

Database: PsycINFO (1987 to July week 3 2016); search strategies:

1. (cancer* or neoplasm* or tumor* or tumour* or oncolog* or radiation* or radiotherap* or chemotherap* or metast*).ti,ab. [mp = title, abstract, heading word, table of contents, key concepts, original title, tests, and measures] (59619)
2. exp. neoplasms/ (39844)
3. 1 or 2 (62214)
4. ((food* or diet* or nutrition*) adj3 (therap* or enrich* or supplement*)).ti,ab. [mp = title, abstract, heading word, table of contents, key concepts, original title, tests, and measures] (3185)
5. (fortifi* or (oral adj3 (nutrit* or supplement* or enrich*))).ti,ab. (672)
6. dietary supplements/ (1469)
7. *food additives/ (110)
8. *vitamins/ (1719)
9. (vitamin* or trace element* or ONS).ti,ab. (5280)
10. 4 or 5 or 6 or 7 or 8 or 9 (9503)
11. (food or gustat* or taste or tasting or tastes or tasted or flavour* or flavor* or sensor perception* or diet).mp. and exp. AVERSION/ [mp = title, abstract, heading word, table of contents, key concepts, original title, tests, and measures] (254)
12. ((food or gustat* or taste or tasting or tastes or tasted or flavour* or flavor* or sensor perception* or diet) adj3 (prefer*or percept* or perceiv* or blandness or comply* or accept* or complian* or likeability or liking or dislik* or aversion)).mp. [mp = title, abstract, heading word, table of contents, key concepts, original title, tests, and measures] (3278)
13. 11 or 12 (3396)

14. exp. Food preferences/ or exp. food intake/ (12023)
15. Taste perception/ or exp. olfactory perception/ or exp. odor discrimination/ (10139)
16. palatab*.mp. [mp = title, abstract, heading word, table of contents, key concepts, original title, tests, and measures] (2139)
17. 13 or 14 or 15 or 16 (24557)
18. 3 and 10 and 17 (21)

Proquest Dissertations and Theses(searched: 2 August 2016):

ti ((food OR gustat* OR taste OR tasting OR tastes OR tasted OR flavor* OR flavor* OR sensor perception* OR diet) AND (prefer* OR percept* OR perceiv* OR blandness OR comply* OR accept* OR complian* OR likeability OR liking OR dislik* OR aversion) OR palatab*) AND all (((food* OR diet* OR nutrition* or oral) AND (therap* OR enrich* OR supplement) OR vitamin* or trace element* or ONS or fortifi*)) AND all (cancer* OR neoplasm* OR tumor* OR tumour* OR oncolog* OR radiation* OR radiotherap* OR chemotherap* OR metast*) = 3

ab ((food OR gustat* OR taste OR tasting OR tastes OR tasted OR flavour* OR flavor* OR sensor perception* OR diet) AND (prefer* OR percept* OR perceiv* OR blandness OR comply* OR accept* OR complian* OR likeability OR liking OR dislik* OR aversion) OR palatab*) AND all (((food* OR diet* OR nutrition* or oral) AND (therap* OR enrich* OR supplement) OR vitamin* or trace element* or ONS or fortifi*)) AND all (cancer* OR neoplasm* OR tumor* OR tumour* OR oncolog* OR radiation* OR radiotherap* OR chemotherap* OR metast*) = 40

SCOPUS (searched: 2 August 2016):

(TITLE (((food* OR diet* OR nutrition*) W/3 (therap* OR enrich* OR supplement*))) OR TITLE ("functional food" OR onl OR "food additive" OR "trace element" OR vitamin*) AND TITLE-ABS-KEY (((food OR gustat* OR taste OR tasting OR tastes OR tasted OR flavour* OR flavor* OR sensory) W/3 (prefer* OR percept* OR perceiv* OR blandness OR comply* OR accept* OR complian* OR liability OR liking))) AND TITLE-ABS-KEY (cancer* OR neoplasm* OR chemotherap* OR tumor* OR tumour* OR radiotherap* OR metasti*)

CINAHL (searched: 2 August 2016)

AGRICOLA (searched: 2 August 2016)

ABI (searched 2 August 2016)

PROSPERO (searched: 2 August 2016)

No hits for line: (taste perception or taste preference or gustat*) and (food supplement* or nutritional supplement* or onl or enrich* food*) and (cancer* or neoplasm* or chemotherap* or radiotherp* or metast* or tumor* or tumor*)

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