ABSTRACT

Taste and smell changes, otherwise known as chemosensory changes, are frequently reported symptoms in cancer. Research to date has mainly focused on patients undergoing treatment i.e. chemotherapy (CT) or head and neck radiotherapy (RT). However, it has been suggested that taste and smell changes may also occur pre-treatment with diverse primary cancer sites. There is a paucity of research on this issue and mechanisms for these findings are poorly understood.

Both subjective and objective methods can be used to measure taste and smell changes. Increased and decreased taste and/or smell sensitivity has been observed pre- and post-treatment. Bitter is reported to be most disturbed by cancer and its treatment. Distorted smell perception is frequently described as rancid. Given that taste and smell function is positively correlated with dietary intake, alterations may affect nutritional status. Adequate dietary intake is imperative with cancer, since 20% of patients die from malnutrition, rather than malignancy.

Previous research and clinical experience suggest that many cancer symptoms e.g. anorexia, dry mouth, taste changes and weight loss occur together in groups or clusters. Correct categorisation of symptom clusters is likely to be therapeutically important because treatment of one symptom may influence another in the same cluster.

This review aims to summarize the prevalence, pathophysiology and clinical sequelae of taste and smell changes in cancer, with an emphasis on the treatment-naive population. A greater understanding of these abnormalities may help to identify and promote earlier interventions, prevent weight loss complications and enhance quality of life.

**Keywords:** taste and smell changes; chemosensory changes; cancer; oncology; clinical review
1. INTRODUCTION

The chemical senses of taste and smell are essential to life. They alert us to danger (e.g. gas, fire), prevent us ingesting toxic substances and support oral nutrition\(^1\). Together, taste and smell drive flavour perception, i.e. the sensory impression of food\(^2\) and support digestion. They increase salivary flow, trigger the release of gastrointestinal enzymes and hormones, and stimulate gut motility\(^3\). Brain reward pathways (which involve the hedonic aspects of eating) are also affected\(^4\). Disturbance of these senses is termed chemosensory dysfunction\(^5\). Food preferences may change and food aversions can develop\(^6, 7\). These can significantly impair food intake, reduce enjoyment of meals and lead to poor nutritional status and weight loss\(^1, 8\). Adequate dietary intake is imperative at all stages of cancer, since 20% of cancer patients die from malnutrition, rather than the malignancy\(^9\).

1.1 Normal Physiology of Taste and Smell

Taste

Taste perception is mediated by receptor cells in taste buds on the dorsal and posterio-lateral tongue surfaces and the epithelial surface of the oropharynx and larynx. These cells detect chemical signals which produce taste and stimulate neurotransmitter release onto first-order afferent nerve fibres, which then convey signals to the brainstem\(^10\). Second-order neurons travel through the thalamus and project to the insular cortex, operculum, and other areas such as the caudal orbital cortex. The latter is responsible for conscious perception of taste\(^10\).

Smell

Odour perception is also stimulated by chemical signalling. Odour molecules bind to neuroepithelium receptors in the cilia of olfactory receptor neurons\(^11\). This depolarizes the receptor cell and propagates an olfactory nerve action potential, which terminates in the nasal olfactory bulb. Convergence of olfactory bulb action potentials generates signals to the primary olfactory cortex. Olfactory information then passes to adjacent areas such as the caudal orbital cortex, where the combination of odour and taste creates the perception of flavour\(^11\) (Figure 1).

Olfaction can be further classified as orthonasal or retronasal\(^12\). The former refers to odours which pass through the external nares or nostrils when one sniffs, the latter to odours which
pass through the mouth and the internal nares during eating and drinking. Retronasal stimulation improves gustation. Of taste perception, 80-90% may in fact be smell.\(^\text{13}\)

![Image: Normal Physiology of Taste and Smell. Source: Kibiuk and Stuart\(^\text{14}\).

1.2 Prevalence and Pathophysiology of Taste and Smell Changes in Cancer

Research into taste and smell changes in cancer has primarily focused on patients undergoing chemotherapy (CT) or head and neck radiotherapy (RT). Alterations of taste and smell function can be classified into three major types:\(^\text{15}\):

1. **Transport losses**: Failure of stimuli to reach taste or smell receptors, e.g. blocked taste buds or nasal passages, dry mouth.
2. **Sensory losses**: Damage to sensory organs by, e.g. age-related decline, anti-cancer treatments, medication, tumour obstruction.
3. **Neural losses**: Damage to peripheral or central nervous system, e.g. head trauma, tumour invasion, neurological diseases, surgery, toxins.

**Chemotherapy**

Taste changes have been reported in 48-80%\(^\text{16-18}\) and smell changes in 14-46%\(^\text{16, 19}\). The lower smell changes prevalence may be due to less CT damage to olfactory receptors, since they have a slower turnover (mean 30 days) than gustatory receptors (mean 10 days)\(^\text{20}\). The olfactory epithelium is also more robust\(^\text{21}\). Most studies have included heterogeneous populations of varying disease severity, and multiple treatment regimens of varied duration\(^\text{16}\). There is no consensus on the relative prevalence of chemosensory changes post CT in one cancer type versus another\(^\text{16, 22}\) or for different drugs. Taxane-based CT\(^\text{22}\) and irinotecan\(^\text{23}\) may have the greatest effect on taste changes, but changes have also been
noted with cyclophosphamide, folinic acid antagonists, methotrexate and platinum agents\textsuperscript{16}. Recent studies suggest that the nucleoside analogue, gemcitabine, has the least effect on taste\textsuperscript{16, 23}. There is no difference between CT agents’ effect on olfaction\textsuperscript{22, 24}.

CT causes taste and smell changes via cytotoxic damage to rapidly dividing gustatory and olfactory receptors\textsuperscript{8}. Cytotoxic drugs themselves can also have an independent effect on gustatory function. They can cause a bitter taste by entering the mouth through gingival sulcus fluid (a serous transudate or exudate) or diffusing from capillaries to receptor cells\textsuperscript{25}. Saliva and mucous production can also be disrupted causing oral mucositis, dry mouth and dental caries, which in turn affect taste\textsuperscript{26}.

Radiotherapy
Most research about RT-induced chemosensory changes has focused on head and neck cancer. To date, there is very limited research on taste and smell changes post RT in other cancers. Of those given RT to the head and neck, taste changes occur in 92-100\%\textsuperscript{27, 28} and smell changes in 50\%\textsuperscript{29}.

RT can damage sensory receptors, dependant on the field of administration\textsuperscript{21}. Salivary glands can also be affected. This can cause hyposalivation and dry mouth, which may reduce taste due to limited delivery of chemical stimulants to receptors\textsuperscript{30}. The minimum radiation dose capable of reducing taste ranges from 15 to 30Gy depending on treatment conditions and disease state\textsuperscript{31}. Olfactory loss can also occur secondary to the direct toxic effects of RT\textsuperscript{26}.

Treatment-Naive
Of people not in active treatment, the prevalence of chemosensory changes range from 10-86\%. Most literature is relatively old and contradictory (Table 1). Yavuzsen et al.\textsuperscript{32} found no relationship between taste changes and anti-cancer therapy and propose that the cancer itself may be responsible. Sandow et al.\textsuperscript{33}, on the other hand, did not corroborate this. They found no differences in taste and smell acuity between oropharyngeal cancer pre-treatment and controls. Mechanisms for altered sensory perception in the treatment-naive are poorly understood\textsuperscript{5, 34} and understudied\textsuperscript{35, 36}. Several explanations have been proposed (Table 2). However, most studies did not characterise chemosensory changes pre-treatment\textsuperscript{1}. 
Table 2: Possible Mechanisms that may affect Chemosensory Function in Cancer Patients Naive to CT/RT.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Possible Mechanisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical</td>
<td>• Tumour obstruction to chemoreceptor sites(^\text{26}).</td>
</tr>
<tr>
<td></td>
<td>• Surgical resection of the oral or nasal cavity(^\text{57}).</td>
</tr>
<tr>
<td>Neurological</td>
<td>• Tumour interference with neural transmission and sensory processing(^\text{26}).</td>
</tr>
<tr>
<td></td>
<td>• Tumour damage to cranial nerves I, VII, IX or X(^\text{8}).</td>
</tr>
<tr>
<td></td>
<td>• Increased salivary sodium concentration due to neural stimulation of salivary acinar cells (elevating salt taste threshold)(^\text{38}).</td>
</tr>
<tr>
<td></td>
<td>• Centrally mediated phantom tastes/smells(^\text{26}).</td>
</tr>
<tr>
<td></td>
<td>• Conditioned aversion to food secondary to post-prandial pain/vomiting(^\text{8}).</td>
</tr>
<tr>
<td>Metabolic</td>
<td>• Tumour secretion of amino-acid-like substances(^\text{39}).</td>
</tr>
<tr>
<td></td>
<td>• Increased salivary urea concentration due to tissue catabolism (bitter taste)(^\text{40}).</td>
</tr>
<tr>
<td></td>
<td>• Immune-cell derived by-products such as TNF-(\alpha), IL-1(\beta), IL-6, which stimulate the gustatory nerve system(^\text{41}).</td>
</tr>
<tr>
<td></td>
<td>• Lipid peroxidation of oral epithelial cells due to tumour-related oxidative stress, leading to the production of carbonyls (causing a metallic taste)(^\text{42}).</td>
</tr>
<tr>
<td>Non-tumour related</td>
<td><strong>Smoking Status</strong></td>
</tr>
<tr>
<td></td>
<td>• Significant relationship with olfactory impairment only(^\text{43}).</td>
</tr>
<tr>
<td></td>
<td>• Can occur due to structural and functional changes in the olfactory neuroepithelium(^\text{44}).</td>
</tr>
<tr>
<td></td>
<td>• No relationship with former smoking status(^\text{7, 43}).</td>
</tr>
<tr>
<td>Age</td>
<td>• Age-related decline due to delayed cell renewal(^\text{45}).</td>
</tr>
<tr>
<td></td>
<td>• Mediated by reduced levels of oestrogen and testosterone or alterations in neurotransmitter levels(^\text{45, 46}).</td>
</tr>
<tr>
<td>Medication</td>
<td>• Side-effects e.g. antibiotics and analgesics(^\text{47}).</td>
</tr>
<tr>
<td></td>
<td>• Can induce their own taste change or affect the CNS and/or PNS(^\text{46}).</td>
</tr>
<tr>
<td>Micronutrient Deficiencies</td>
<td>• Zinc and/or vitamin B(_{12})^(^\text{45}) due to increased catabolism, malnutrition and cachexia(^\text{8}).</td>
</tr>
<tr>
<td>Oral complications of cancer</td>
<td>• Infections, ulcers, dry mouth(^\text{48}).</td>
</tr>
</tbody>
</table>

CNS, Central Nervous System; IL-1\(\beta\), Interleukin-1 Beta; IL-6, Interleukin-6; PNS, Peripheral Nervous System; TNF-\(\alpha\), Tumour Necrosis Factor-Alpha.

Despite study discrepancies, there is a consensus that the prevalence of chemosensory changes in cancer is underestimated\(^\text{49}\). A study in 1998 found that taste changes were under-recognised by medical oncologists in 36% of cases\(^\text{50}\) and the situation is unchanged\(^\text{23}\).
Patients may be unaware of chemosensory changes$^{51}$, deem them to be trivial or cannot articulate their sensations$^{52}$, and they may go unnoticed. Staff and patients may communicate less about symptoms they believe untreatable$^{52}$, as few, if any, effective interventions are available$^{8}$.

2. IDENTIFYING TASTE AND SMELL CHANGES
Taste and smell changes can be measured by both subjective and objective means$^{34, 53}$ (Table 3). Objective measures of altered clinical thresholds are not the sole determinant of sensory perception and food intake. This involves more complex concepts, e.g. flavour as described above. Patients may be burdened by chemosensory changes not identified in objective testing$^{54}$. Consequently, sensory evaluation is more accurately represented by self-report measures that avoid these limitations$^{5, 16, 34, 35}$. This is reflected in the US Food and Drug Administration’s 2006 approval of patient-reported outcomes as a criterion in admissions to all trials$^{55}$. Self-report measures are, therefore, applicable for investigating a wide range of problems. Moreover, food and mealtimes have important symbolic, cultural and religious values beyond nutrition and thus chemosensory changes may also be expected to cause psychosocial issues$^{5}$. Patient-reported data rather than clinical measures have, consequently, been suggested to be a more suitable predictor of dietary behaviour$^{16}$.

3. CHARACTERISATION OF TASTE AND SMELL CHANGES
Taste and smell changes can be broadly classified into three categories: loss of sensitivity, distorted perception, and hallucination (Table 4). Dysfunction of both taste and smell commonly co-occur$^{1, 5, 35}$. Increased and decreased objective clinical thresholds for basic tastes (sweet, sour, salty, bitter and umami (the savouriness of protein-rich foods)) have been reported pre- and post-treatment$^{5, 22, 56}$. It is uncertain whether this lack of consensus about clinical thresholds is due to varied measurement techniques or other reasons like tumour type or treatment regimens$^{57}$. Bitterness is the basic taste reported to be most distorted by cancer and its treatment, in terms of both frequency and magnitude$^{58}$. Metallic or ‘nauseating’ tastes are common$^{59}$, the former being present in 32% with breast, colorectal, head and neck, lung, stomach, and other cancers$^{50}$ and in 16% with lung cancer$^{60}$. Elevated salt thresholds have also been documented, both objectively and subjectively$^{2, 61}$. Phantogeusia (Table 4) has not been reported in cancer patients$^{53}$. 
There is little literature on smell changes, as noted above, but higher odour thresholds (reduced sensation)\(^6^3\) and stronger olfactory sensations\(^1\) have been observed, both subjectively and objectively. Distorted smell perception is often described as rancid\(^6^4\). In cancer, regardless of tumour site, qualitative changes in smell perception like altered discrimination predominate\(^8\). Hallucinations may also occur during strong emotional experiences, such as receiving CT; someone may experience a chemical odour due to treatment anxiety\(^6^5\). Odour signals are processed in the limbic system, which also handles memories and emotions\(^6^6\).

There are discrepancies between experimental data on the characterisation of chemosensory changes and patient reports\(^2^6\). This may reflect the link between retronasal olfaction and improved taste\(^1^3\). In particular, Henkin \textit{et al.}\(^6^7\) recently demonstrated that hyposmia was associated with increased salt intake.

### 4. CHEMOSENSORY DYSFUNCTION AND SYMPTOM CLUSTERS

Clinical experience and research suggest that many cancer symptoms e.g. anorexia, dry mouth, taste changes and weight loss are interrelated and occur together in groups or clusters\(^6^8, 6^9\). Various descriptions of a symptom cluster exist, yet a consensus definition has not been established\(^7^0\). In addition, there is no agreement as to what constitutes a symptom cluster\(^7^1\), whether they share a common pathophysiology\(^6^9\), or whether one symptom

<table>
<thead>
<tr>
<th>Disorder</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Taste-related abnormality</strong></td>
<td></td>
</tr>
<tr>
<td>Ageusia</td>
<td>Absence.</td>
</tr>
<tr>
<td>Hypogeusia</td>
<td>Decreased sensitivity.</td>
</tr>
<tr>
<td>Dysgeusia</td>
<td>Distortion.</td>
</tr>
<tr>
<td>Phantogeusia</td>
<td>Perception without an external stimulus.</td>
</tr>
<tr>
<td>Heterogeusia</td>
<td>Inability to differentiate between tastes.</td>
</tr>
<tr>
<td><strong>Odour-related abnormality</strong></td>
<td></td>
</tr>
<tr>
<td>Anosmia</td>
<td>Absence.</td>
</tr>
<tr>
<td>Hyposmia</td>
<td>Decreased sensitivity.</td>
</tr>
<tr>
<td>Dysosmia</td>
<td>Distorted ability to identify odours.</td>
</tr>
<tr>
<td>-Parosmia</td>
<td>Inability to identify an odour’s ‘natural’ smell.</td>
</tr>
<tr>
<td>-Agnosia</td>
<td>Inability to discriminate perceived odours.</td>
</tr>
<tr>
<td>Phantosmia</td>
<td>Odour perception without any odour.</td>
</tr>
</tbody>
</table>
cluster can potentiate another. In particular, Honea et al.\textsuperscript{72} found that when CT stimulates chemoreceptor trigger zones, it causes nausea and vomiting, which is associated with reduced appetite, altered taste and fatigue.

Nevertheless, one research group has recently described a symptom cluster as “a stable group of two or more symptoms that predictably co-occur and are independent of other clusters”\textsuperscript{73}. Seven clusters have been identified\textsuperscript{69}, with taste change featuring as part of the fatigue/anorexia-cachexia cluster (Table 5). The relationship between these changes, particularly in the absence of therapy, requires greater scrutiny\textsuperscript{5}, since symptom clusters may not correlate with tumour burden\textsuperscript{71}. Correct categorisation of clusters is likely to be therapeutically important because management of one symptom may be influenced by another in the cluster\textsuperscript{74}, e.g. taste changes and anorexia.

Table 5: Characterisation of Cancer Symptom Clusters\textsuperscript{69}.

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Aerodigestive</td>
<td>Cough, dysphagia, dyspnoea, hoarseness.</td>
</tr>
<tr>
<td>2. Debility</td>
<td>Confusion, oedema.</td>
</tr>
<tr>
<td>3. Fatigue/anorexia-cachexia</td>
<td>Anorexia, dry mouth, early satiety, easy fatigue, taste change, weakness, weight loss (&gt;10 %).</td>
</tr>
<tr>
<td>5. Neuropsychological</td>
<td>Anxiety, depression, sleep problems.</td>
</tr>
<tr>
<td>7. Upper gastrointestinal</td>
<td>Belching, bloating, dizzy spells, dyspepsia.</td>
</tr>
</tbody>
</table>

4.1 Fatigue/Anorexia-Cachexia Symptom Cluster and Nutritional Status

Symptom clusters can interfere with appetite and ability to eat\textsuperscript{5, 75}, and may be one determinant of the cancer anorexia-cachexia syndrome\textsuperscript{32}. This significantly affects nutritional status\textsuperscript{76}. Malnutrition has been identified in 40% of hospitalized cancer patients, regardless of disease stage\textsuperscript{77}, and up to 90% of those with advanced cancer\textsuperscript{78, 79}. Interestingly, Khalid et al.\textsuperscript{80} noted that people who do not have a mechanical cause for malnutrition e.g. in colorectal cancer, experience symptoms which could negatively affect nutritional status. This highlights the importance of identifying and managing these symptoms, such as taste and smell changes.
Altered chemosensation can interfere with the hedonic value and normal physiological responses to food and cause food aversion\textsuperscript{8}. This may occur pre-treatment, inhibiting food intake\textsuperscript{81}. A substantial decrease in calorie intake (430-1100 kcal/day) associated with severe taste and smell changes has been reported in advanced cancer\textsuperscript{1, 5, 7}. Average energy intake in this population subgroup (19 kcal/kg BW/day)\textsuperscript{5} was significantly below typical basal metabolic rates (22-24 kcal/kg/day)\textsuperscript{82}.

Not only is energy intake reduced, but a decreased diversity of foods is consumed. In another study, up to 55% experienced an unpleasant bitter taste and odour of high-protein foods, especially red meat, and so avoided them\textsuperscript{81}. People with advanced cancer with altered taste had a significantly lower mean percentage energy contribution from protein compared with those without taste changes\textsuperscript{83}. Protein metabolism is also dysregulated in cancer and correlated with muscle wasting\textsuperscript{84}. However, Ovesen et al.\textsuperscript{85} showed that in breast, lung and ovarian cancer, pre-treatment taste and smell changes did not reduce energy and protein intake. They hypothesised that patients may have increased their food intake to achieve a certain level of sensory stimulation\textsuperscript{85}.

Understanding and addressing the association between irregular chemosensory function, related symptoms and dietary intake may improve nutritional status in cancer patients. In the elderly, sensory enhancement of food increased dietary intake\textsuperscript{86} and improved functional status\textsuperscript{87}. This is particularly important since malnutrition significantly reduces cancer survival rates. In addition, it predicts poor tolerance of treatment\textsuperscript{88}. There is an increased frequency and severity of CT\textsuperscript{89,89} and RT toxicity\textsuperscript{90, 91} and post-operative complications\textsuperscript{92}. Furthermore, economic burden may be greater due to increased length of stay and treatment costs\textsuperscript{93}. Finally, malnutrition in cancer has been associated with irreversible muscle and weight loss\textsuperscript{94}. Early recognition is, therefore, vital.

4.2 Impact on Quality of Life
Chemosensory alterations can induce stress, anxiety and depression and contribute to a poor quality of life for patients and caregivers\textsuperscript{5, 19}. Patients may feel guilty when unable to participate in meal preparation or attend social events, for example, due to intolerable food odours\textsuperscript{1}. A caregiver may become anxious and frustrated after a carefully prepared meal is rejected, generating conflict. Thus, chemosensory changes can affect patients physiologically, psychologically and socially, and reduce overall quality of life\textsuperscript{1}. 

9
5. CONCLUSIONS
Most research about taste and smell changes in cancer involves patients undergoing CT or RT. Prevalence estimates of chemosensory changes range from 14-80% in the former and 50-100% of the latter. Probable mechanisms for such therapy-induced changes have been identified. However, there is little literature on taste and smell changes in treatment-naive cancer patients, and variation exists in published studies. The pathophysiology and characteristics of such changes in this patient group are unknown, despite research which shows an association between chemosensory dysfunction, malnutrition and poor psychosocial wellbeing.

Chemosensory dysfunction can be part of a cluster of symptoms, the categorisation of which may affect treatment options. However, the relationship between symptoms has not been clearly defined. Management of taste and smell changes in cancer remains a challenge, particularly given the lack of experimental research. Given the heterogeneity of chemosensory changes in cancer, a greater understanding of these abnormalities may allow earlier intervention, prevent weight loss complications, enhance quality of life, and ultimately increase survival time.
Table 1: Studies of Taste and Smell Changes in Treatment-Naive Cancer Patients.

<table>
<thead>
<tr>
<th>References</th>
<th>Patient Population</th>
<th>Instruments</th>
<th>Prevalence of TSCs</th>
<th>Characterisation of TSCs</th>
</tr>
</thead>
</table>
| DeWys and Walters, 197556   | N=50 metastatic Ca (mixed). N=23 controls. | Semi-structured interviews. Henkin’s 3-drop forced-choice test96. | TCS: 50% (patients). | Taste: Ca vs. controls:  
- Elevated sweet threshold.  
- Lowered bitter threshold.  
- Meat aversion: 32%.  
- Bitter taste with coffee or chocolate: 20%. |
| Williams and Cohen, 197856  | N=30 lung Ca. N=30 controls. | NA Henkin’s 3-drop forced-choice test96. | NA | Taste: Ca vs. controls:  
- Significant reduction in sour acuity.  
- Elevated sweet recognition threshold (NS). |
| Kamath et al., 198350       | N=12 oesophageal Ca. N=14 controls. | NA Henkin’s 3-drop forced-choice test96. | NA | Taste: Ca vs. controls:  
- NS differences in detection and recognition thresholds between groups. |
| Ovesen et al., 199185      | N=31 Ca (mixed). | NA -Electrogustometry. Odour thresholds for dilutions of pyridine in mineral oil. | TCs: 16%. SCs: 10%. | NA |
| Harris et al., 200397      | N=99 Ca post upper GI surgery. | Questionnaire. | TCS and/or SCs: 45%. TSCs: 18%. | NA |
| Hutton et al., 20075       | N=66 advanced Ca (mixed). | -3-day food record. -FAACT Questionnaire. -Taste and Smell Survey6 | TCs and/or SCs: 86%. TCS: 52%. TCS only: 30%. SCs only: 5%. | Taste: Increased bitter (23%) and sour (27%) sensitivity.  
-11% reported TCS as ‘severe’ or ‘inincapitating’.  
Smell: Increased sensitivity (20%).  
-5% reported SCs as ‘severe’ or ‘inincapitating’. |
| Steinbach et al., 201098    | N=69 breast Ca. | NA 'Taste Strips'. 'Sniffin' Sticks'. | NA | Compared to normative data:  
Taste: Significantly lower sour sensitivity.  
Smell: NS difference in thresholds. |
| Mahmoud et al., 201134     | N=15 advanced Ca (mixed). | -Questionnaire. -TC checklist. Modified Henkin’s 3-drop forced-choice test96. | TCs: 80%. | Taste: All food tasteless: 53%.  
- All food bitter: 20%.  
- Persistent chocolate taste: 13%.  
- Meat aversion: 33%.  
- Alcohol aversion: 33%.  
- Dislike for sweet food: 67%. |

Ca, Cancer; CT, Chemotherapy; FAACT, Functional Assessment of Anorexia/Cachexia Therapy; GI, Gastrointestinal; NA, Not Assessed; NS, Not Significant; PG-SGA, PatientGenerated Subjective Global Assessment; RT, Radiotherapy; SC, Smell Changes; TC, Taste Changes; TSCs, Taste and Smell Changes.
### Table 3: Objective Measures of Chemosensory Function.

<table>
<thead>
<tr>
<th>TASTE:</th>
<th>Test Description</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application of dilutions of basic taste substances of varied strengths&lt;sup&gt;18, 99, 100&lt;/sup&gt;</td>
<td>Assesses whole mouth or localized sensitivity and recognition of taste of exponentially increasing strength.&lt;sup&gt;101&lt;/sup&gt;</td>
<td>• Reproducible&lt;sup&gt;56&lt;/sup&gt;.</td>
<td>• Reliability and validity not established&lt;sup&gt;102&lt;/sup&gt;. • Time consuming and laborious&lt;sup&gt;103&lt;/sup&gt;.</td>
</tr>
<tr>
<td>Electrogustometry&lt;sup&gt;103, 104&lt;/sup&gt;</td>
<td>Electrical current (microampere range) applied to receptors by an electrode to assess taste detection.&lt;sup&gt;53&lt;/sup&gt;</td>
<td>• Reliable&lt;sup&gt;104&lt;/sup&gt;. • Reproducible&lt;sup&gt;104&lt;/sup&gt;.</td>
<td>• Limited clinical use due to poor correlation between electrically and chemically induced taste perception&lt;sup&gt;105&lt;/sup&gt;. • Does not measure recognition&lt;sup&gt;53&lt;/sup&gt;.</td>
</tr>
<tr>
<td>‘Taste Strips’&lt;sup&gt;22&lt;/sup&gt;</td>
<td>Filter paper impregnated with taste solution applied to receptors to measure detection and recognition.&lt;sup&gt;53&lt;/sup&gt;</td>
<td>• Reproducible&lt;sup&gt;104&lt;/sup&gt;. • Normative data available&lt;sup&gt;106&lt;/sup&gt;. • Time and cost-effective&lt;sup&gt;53&lt;/sup&gt;.</td>
<td>• Thresholds may differ depending where on the tongue the stimulus is applied.&lt;sup&gt;103&lt;/sup&gt;</td>
</tr>
<tr>
<td>SMELL:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inhalation of solutions of phenyl methyl-ethyl-carbinol&lt;sup&gt;85, 100&lt;/sup&gt; or phenethyl and menthol&lt;sup&gt;100&lt;/sup&gt;</td>
<td>Administered via nasal spray to assess odour detection.&lt;sup&gt;107&lt;/sup&gt;</td>
<td>• Reliable&lt;sup&gt;107&lt;/sup&gt;. • Reproducible&lt;sup&gt;107&lt;/sup&gt;.</td>
<td>• Significant within- and across-subject variability.&lt;sup&gt;108&lt;/sup&gt; • Significant day-to-day variability&lt;sup&gt;109&lt;/sup&gt;.</td>
</tr>
<tr>
<td>Sniffin’ Sticks&lt;sup&gt;22, 110&lt;/sup&gt;</td>
<td>Pen-like odour dispensing devices for identification, recognition and discrimination thresholds.&lt;sup&gt;22&lt;/sup&gt;</td>
<td>• Validated in various populations.&lt;sup&gt;111, 112&lt;/sup&gt; • Normative data available&lt;sup&gt;113&lt;/sup&gt;. • Cost-effective&lt;sup&gt;114&lt;/sup&gt;.</td>
<td>• Needs cultural adaptation&lt;sup&gt;111, 112&lt;/sup&gt;. • May be prone to learning effects.&lt;sup&gt;111&lt;/sup&gt;</td>
</tr>
<tr>
<td>University of Pennsylvania Smell Identification Test&lt;sup&gt;115&lt;/sup&gt;</td>
<td>Impregnated odour cards, scratched to determine odour identification.&lt;sup&gt;116&lt;/sup&gt;</td>
<td>• Normative data available&lt;sup&gt;116&lt;/sup&gt;.</td>
<td>• Does not measure detection thresholds&lt;sup&gt;115&lt;/sup&gt;.</td>
</tr>
</tbody>
</table>
6. REFERENCES


