SEASONED™

D 4.3 Policy recommendation white paper

July 2025

WP4 - Sustainability actions to step up and continuously grow UPWr's excellence

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PROJECT SUMMARY

FOOD SENSORY SCIENCE RESEARCH.

The project aims is to improve the knowledge, skills, and competencies of the research and admin staff of UPWr in the field of the sensory evaluation of food and consumer behaviour with special attention to newly designed innovative processed food products with healthrelated properties. The project also aims to establish an international network among leading universities and centres in food sensory analysis to prepare competitive research applications/proposals within the EU and global challenges (UN SDGs).

The project aims to establish an international network of leading universities, centres in food sensory analysis and innovation consultants (SDU, UMH, BCC, REDINN) to step up in science and research, improving managerial and administrative capacities, networking skills and strategies to engage society and citizens as well as public authorities and private businesses, and regional and European institutions. SEASONED will enable FBFS and its partners, leading research institutions from Spain, Denmark, and Italy, to co-develop a capacity building programme to share and integrate expertise and skills to access new research avenues and develop new approaches to prepare competitive research applications within the EU and global challenges (Green Deal, UN SDGs). Implementing Gender Balance Monitoring, Open Science, Citizen's Engagement, FAIR data research principles, and monitoring of Key Performance Indicators project will create short–to long-term societal, scientific, and economic impacts. Ultimately, UPWr's ambition is to develop and reach the top of the sensory evaluation centres' competencies and become the leading centre of excellence in Central and Eastern Europe (CEE). As a result, at the end of the project and far beyond the project duration, UPWr wants to establish a Consumer Behaviour Centre (CBC). SEASONED CBC will be a unique platform dedicated to scientists (ESRs including the MSc and PhD students, ERs, other scientists from national and international units), business partners and consumers from this part of Europe.

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[1] PU – Public, fully open (Deliverables flagged as public will be automatically published in CORDIS project's page),
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Table of Contents

INTRODUCTION ***5***

MAIN TECHNIQUES OF SENSORY ANALYSIS 6

SENSORY ANALYSIS IN SOSTENIBILITY ***8***

DIETARY HABITS 9

WATER EFFICIENCY 11

FOOD WASTE 13

SENSORY ANALYSIS IN PRODUCT CERTIFICATION ***16***

SENSORY ANALYSIS IN INCLUSIVENESS ***18***

SENSORY ANALYSIS IN PUBLIC HEALTH ***22***

EDUCATION 22

SUGAR AND FAT CONSUMPTION 23

OLFACTORY DYSFUNCTIONS 24

AUTISM 26

ORAL PROCESSING 27

CONCLUSION ***29***

REFERENCES ***32***

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INTRODUCTION

Sensory analysis is a scientific discipline concerned with the systematic evaluation of the organoleptic properties of products -such as taste, aroma, texture, color, and appearance - through the use of human senses. This science has become an essential tool in food research and development, as well as in quality control and consumer acceptance studies. Despite technological advancements, no instrument currently matches the complexity and sensitivity of human perception, making sensory analysis a crucial component in the characterization of food products.

Sensory analysis not only enables the assessment of organoleptic quality but also provides valuable insights into consumer preferences, product reformulation, market differentiation, and the optimization of production processes. In an increasingly competitive market driven by consumer preferences, this discipline serves as a bridge between subjective perception and scientific objectivity.

Sensory Analysis is based on Three Key Methodological Principles:

1. Influence of Environment and Prior Experience

   Human sensory perception is inevitably influenced by both external and internal factors, such as past experiences, expectations, emotional state, and environmental stimuli. Although these influences cannot be entirely eliminated, they can be controlled through standardized protocols, controlled testing conditions (e.g. lighting, temperature, acoustic isolation), and proper training of panelists. These measures aim to minimize unwanted variability and ensure the reliability of the results.

2. Inherent Variability in Sensory Response

   Sensory responses naturally vary among individuals due to physiological differences (e.g., taste bud density, olfactory sensitivity) and psychological factors (e.g., attention, motivation, mood). Moreover, the same individual may

exhibit inconsistent responses at different times. However, through a rigorous selection and training process, it is possible to form sensory panels with high internal consistency and refined discriminatory ability, enabling the collection of reproducible and comparable data.

3. Control of Bias and Systematic Errors

   Bias in sensory studies can arise from various sources, including experimental design, question formulation, sample presentation order, or interactions among evaluators. These biases can distort results and lead to erroneous interpretations. Therefore, it is essential to apply robust experimental designs (e.g., randomized and double-blind tests) and use appropriate statistical tools for data analysis. Only then can the scientific validity of the conclusions be ensured.

MAIN TECHNIQUES OF SENSORY ANALYSIS

Sensory analysis of food is primarily classified into three main types: discriminative, descriptive, and affective. Each type serves a distinct purpose in the evaluation of products:

1. Discriminative Analysis

   This type of analysis focuses on determining whether perceptible differences exist between two or more food samples. It is commonly used for quality control, to assess the impact of changes in ingredients or processing methods, or to verify whether a product meets specific specifications. Common discriminative tests include the triangle test, duo-trio test, and paired comparison test.

2. Descriptive Analysis

   Descriptive analysis aims to identify and quantify the sensory characteristics of a food product, such as flavor, texture, aroma, and color. It is used to gain a deeper

understanding of a product's properties, to develop new products with targeted attributes, or to evaluate the effects of ingredients or processes on sensory perception. This type of analysis requires trained panelists capable of providing detailed and consistent evaluations. Although various techniques have recently emerged that allow for the characterization of a product without the need for trained panelists (flash profile, CATA, RATA, etc.), these rapid methods focus on the use of actual consumers of the product. They enable the identification of the main sensory differences without delving into fine-grained details. These approaches are particularly useful for obtaining quick, cost-effective insights into consumer perception, especially during early stages of product development or market testing.

3. Affective or Consumer Analysis

   This type of analysis focuses on measuring consumer acceptance, preference, or liking of a product. Tests such as the hedonic scale are used to assess consumer satisfaction. Affective tests are particularly useful in new product development and in evaluating the commercial viability of a product.

With these premises, sensory analysis techniques have become a fundamental tool in many areas of research, particularly in the scientific endeavors that are currently being developed and systematically funded by public institutions to improve quality of life

SENSORY ANALYSIS IN SUSTAINABILITY

In 1987, the United Nations defined sustainability as the ability to "meet the needs of the present without compromising the ability of future generations to meet their own needs". Achieving this goal requires concrete efforts from all sectors of society.

On September 25, 2015, world leaders adopted the 2030 Agenda for Sustainable Development (United Nations, 2015). This agenda includes 17 Sustainable Development Goals (SDGs) (Fig. 1), which outline specific targets to be achieved over the next 15 years in order to eradicate poverty, protect the planet, and ensure prosperity for all. These goals encompass a wide range of issues, from poverty eradication and climate change mitigation to education, gender equality, environmental protection, and urban planning.

Many of the 17 SDGs are directly or indirectly linked to the sustainability of the agri-food system. Notably, the following goals stand out: Goal 2: Zero Hunger; Goal 6: Clean Water and Sanitation; Goal 12: Responsible Consumption and Production; Goal 13: Climate Action; Goal 14: Life Below Water; and Goal 15: Life on Land.

Figure 1. Sustainable development goals

A “sustainable food system” is defined as one that ensures food security and nutrition for all without compromising the economic, social, and environmental foundations of food security for future generations (HLPE, 2014).

Numerous global data sources indicate that the current food model, including food production and consumption patterns, is unsustainable. The agri-food sector has a significant environmental impact. According to a recent study, between 21% and 37% of global greenhouse gas emissions originate from food systems (IPCC, 2022).

Humanity thus faces the immense challenge of meeting the food and nutritional needs of a growing, increasingly affluent and urbanized global population, while simultaneously preserving natural and productive resources. To address this, food systems must undergo transformations in both production models and consumption patterns, aiming for greater efficiency and equity in resource use and food consumption, and steering the system toward more sustainable and healthy diets.

To enable individuals, as consumers, to effectively address growing environmental challenges, robust science-based guidelines and recommendations are essential.

DIETARY HABITS

The identification and understanding of shared aromatic and flavor compounds among different food items play a crucial role in the development of appealing and nutritionally balanced combinations (Figure 2). This approach, commonly referred to as food pairing, is increasingly being explored not only for its culinary potential but also for its contribution to sustainable dietary practices. By analysing the molecular composition of foods, researchers and sensory professionals can identify common volatile compounds that contribute to flavor compatibility. These insights enable the creation of innovative pairings that enhance palatability while promoting the consumption of diverse and locally available ingredients. Such combinations can improve adherence to sustainable diets by making them more enjoyable and culturally relevant.

In this context, sensory analysis becomes a powerful tool for guiding consumer choices. By designing food pairings that are not only nutritionally adequate but also sensorially satisfying, professionals can influence dietary behaviour in favour of sustainability. This

requires a multidisciplinary approach, combining food science, nutrition, environmental studies, and consumer psychology.

Ultimately, understanding the sensory synergies between foods allows for the creation of meals that are both environmentally responsible and gastronomically appealing, contributing to the broader goals of sustainable development and public health.

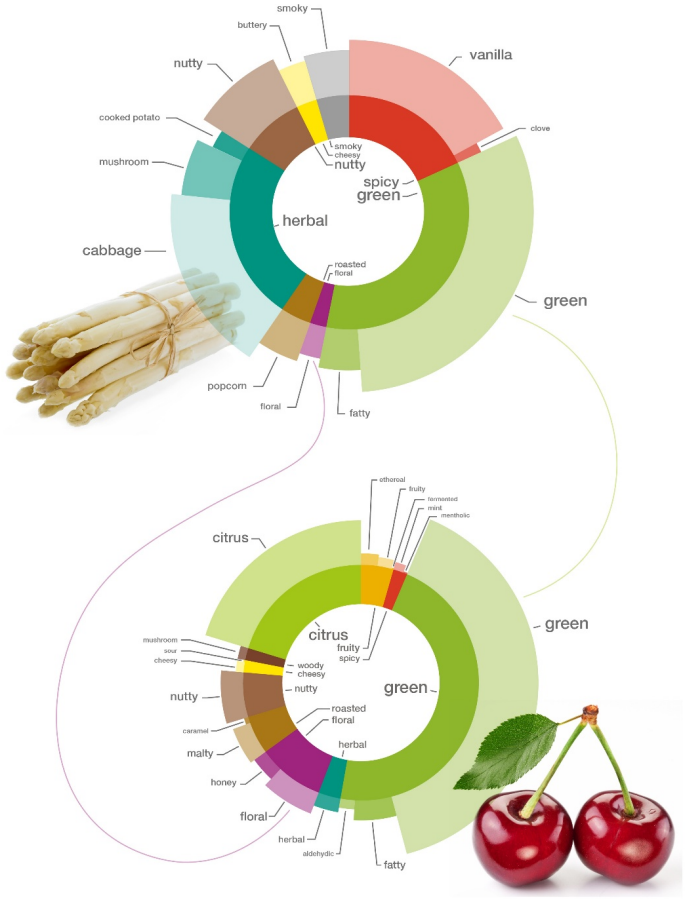

Figure 2. Aromas and flavours in food pairing. Source: foodpairing.com

WATER EFFICIENCY

On the other hand, the production and quality of fresh fruit and vegetable crops may be directly and indirectly affected by high temperatures, limited irrigation water availability, and elevated levels of carbon dioxide and ozone (United Nations, 2025). To mitigate these effects, farmers must implement strategies that allow them to maintain production levels as much as possible without compromising fruit quality. At this point, consumer opinion becomes crucial. It is essential to define quality indicators for agri-food products through sensory analysis strategies. Consumers are aware of the decline in sensory quality in favour of improved microbiological safety (mainly through shelf-life extension strategies) yet they often feel excluded from these decision-making processes.

A prominent example of research focused on agri-food sustainability is the development of the hydroSOS product concept (Noguera-Artiaga et al., 2016). This term refers to food products grown using regulated deficit irrigation techniques, which optimize water use without compromising the final product's quality. These techniques are particularly relevant in regions affected by water scarcity, such as many agricultural areas in southern Europe, and represent a key strategy for adapting the agri-food sector to climate change.

HydroSOS products are not only characterized by a reduced water footprint but also by maintaining (or in some cases even enhancing) their organoleptic properties, such as taste, texture, and aroma. This is because controlled water stress can trigger physiological responses in plants that enhance certain beneficial compounds or intensify sensory characteristics.

From the consumer's perspective, various studies have shown that the willingness to pay a premium for these products increases significantly when clear and accessible information is provided about their production methods. For instance, the use of a distinctive logo (Figure 3) or informative labeling that certifies the use of sustainable practices can positively influence purchasing decisions (Sánchez-Bravo et al., 2020). This behavior reflects a pro-environmental attitude, where the consumer values not only the product itself but also the environmental impact associated with its production.

Figure 3. HidroSOS logo in food products

However, this willingness to pay more is not based solely on the perceived sustainability. It is essential that consumers are assured that the sensory quality of the product has not been compromised. The combination of sustainability and quality is therefore a key factor in the commercial success of hydroSOS products.

Therefore, it is vital to develop research lines that explore consumer perceptions in order to implement strategies that enhance product sustainability without compromising organoleptic quality. In other words, all research projects addressing changes in food production methods for the sake of sustainability should be accompanied by sensory studies to characterize the products, as well as consumer studies to support informed decision-making.

FOOD WASTE

Food waste is defined as agricultural and food products that are discarded from the food supply chain despite being perfectly edible and suitable for human consumption. In many cases, these products are disposed of as waste due to the absence of viable alternative uses, whether logistical, economic, or related to consumer perception. This issue has become a global concern due to its significant environmental, economic, and social implications. Food waste not only represents a direct loss of natural resources such as water, soil, and energy, but also contributes substantially to greenhouse gas emissions. Moreover, it is ethically troubling that vast quantities of food are wasted while millions of people around the world suffer from food insecurity.

Food waste occurs at every stage of the food supply chain (Figure 4), from primary production (harvesting and processing) to storage, distribution, retail, and final consumption. Therefore, addressing this challenge requires a comprehensive and multi-sectoral approach, focusing both on prevention and on the recovery and reuse of unavoidable surplus.

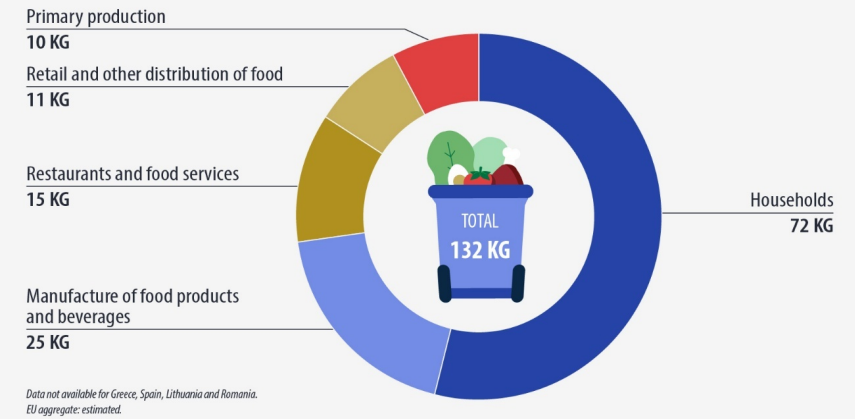

Figure 4. Food waste in the EU by main economic sectors (kg per inhabitant). Source: Eurostat.

According to estimates from the Food and Agriculture Organization of the United Nations (FAO), approximately one-third of all food produced globally is lost or wasted. The highest waste rates are found in perishable products such as root crops, fruits, and vegetables (40–50%), followed by fish (35%), cereals (30%), and, to a lesser extent, oilseeds, meat, and dairy products (20%) (Todd & Faour-Klingbeil, 2024). To combat this issue, the FAO is working in collaboration with governments, international organizations, the private sector, and civil society to raise awareness about the consequences of food waste and to implement concrete actions aimed at reducing it. These actions include the development of public policies, educational campaigns, incentives for food donation, and improvements in logistics and storage systems. One of the key challenges for governments (particularly in Europe) is to analyze consumer behaviour to identify the main factors influencing food waste habits. Understanding these dynamics will enable the design of effective intervention strategies, based on education, social awareness, and the promotion of best practices. Citizen participation is essential to achieving structural change and reducing waste at its source.

Sensory analysts play a crucial role in mitigating food waste, particularly in the stages of food processing, marketing, and consumption. Their expertise contributes to optimizing product quality, consumer acceptance, and resource efficiency through the following approaches:

1. Revalorization of Aesthetically Imperfect Products

   Sensory analysis can objectively demonstrate that food items with visual imperfections (such as irregular shapes, discoloration, or minor surface defects) retain acceptable sensory attributes (e.g., flavor, texture, aroma). By validating the sensory integrity of these products, analysts support their marketability and help shift consumer perceptions, thereby preventing unnecessary rejection and disposal.

2. Determination of Actual Shelf Life

   Through longitudinal sensory evaluations, analysts can assess the true sensory degradation timeline of food products. This allows for:

- More accurate labeling of “best before” or “use by” dates.
- Reduction of premature disposal of still-edible products.
- Promotion of dynamic shelf-life labeling based on sensory quality rather than conservative estimations.

3. Development of Value-Added Products from Surplus

   Sensory analysts contribute to the formulation and optimization of new products derived from surplus or by-products (e.g., juices, jams, snacks). Their role ensures that these upcycled products meet consumer expectations in terms of sensory quality, enhancing their commercial viability and reducing waste.

4. Consumer Acceptance and Behavioral Studies

   Using hedonic testing and preference mapping, sensory analysts identify which sensory attributes are most valued by consumers and determine tolerance thresholds for deviations in quality. These insights inform quality standards and help prevent the discard of products that remain sensorially acceptable despite minor imperfections.

5. Education and Awareness Campaigns

   Findings from sensory studies can be integrated into public awareness initiatives to educate consumers about the real sensory quality of food products. This helps correct misconceptions and encourages more sustainable consumption behaviors, particularly in domestic settings where food waste is prevalent.

In summary, sensory analysts provide essential data and insights that support more sustainable food systems. Their work enables the redefinition of quality standards, promotes the valorisation of food resources, and fosters informed consumer choices all of which are critical to reducing food waste across the supply chain.

SENSORY ANALYSIS IN PRODUCT CERTIFICATION

The European Union is rich in food culture, largely rooted in the strong connection between its products and their territories of origin. For this reason, the EU protects and identifies its agri-food products through quality labels such as Protected Designations of Origin (PDO), Protected Geographical Indications (PGI), and Traditional Specialities Guaranteed (TSG) (Figure 5). Geographical indications establish intellectual property rights for specific products, whose qualities are specifically linked to the area of production.

The European Union's Geographical Indications (GI) system safeguards the names of products that originate from specific regions and possess qualities, characteristics, or a reputation inherently linked to their geographical origin. The distinction between Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI) lies primarily in the extent to which the raw materials and production processes are tied to the designated area. PDO products must be entirely produced and processed within the defined region, whereas PGI products require that at least one stage of production, processing, or preparation takes place in the region. In contrast, Geographical Indications (GI) for spirit drinks are governed by a separate regulation, which ensures that the name of the spirit is protected when it is associated with a specific geographical origin and traditional production methods.

Figure 5. Identifying logo of quality schemes

Currently, there are 3,954 registered products in Europe under the PDO or PGI labels. Of these, 1,714 are food products, 1,648 are wines, and 264 are spirits. In Poland, for example, there are 42 protected products, including 2 vodkas, 1 fermented beverage, and the rest are food items such as cheeses and vegetables.

To issue certifications in accordance with their product specifications, certification bodies must conduct organoleptic evaluations of the products. These sensory assessments are carried out under the framework of UNE-EN ISO/IEC 17025:2017 (General requirements for the competence of testing and calibration laboratories) and UNE-EN ISO/IEC 17065 (Conformity assessment – Requirements for bodies certifying products, processes, and services).

Most of these certification bodies have had to train their own sensory panels to ensure that products meet the standards outlined in their specifications. However, this has led to a lack of standardization in methods. For instance, even for the same product, inter-comparative studies are not feasible, as different panels use distinct sensory lexicons, reference products, and scaling systems.

While this approach has allowed compliance with quality standards, it does not guarantee adherence to a scientifically validated method that ensures reproducibility and comparability of results.

Therefore, it is essential that public institutions promote consensus-based solutions, such as the development of standardized sensory lexicons for specific food products. This would enable sensory panels to integrate into collaborative networks, ensuring consistent and reliable quality assessments across regions and countries.

Additionally, the creation of open-access sensory databases for various products is necessary to facilitate the sharing and joint exploitation of sensory data, following the FAIR principles: Findable, Accessible, Interoperable, and Reusable.

SENSORY ANALYSIS IN INCLUSIVENESS

Approximately 27% of the EU population aged 16 and over, equating to an estimated 101 million individuals or one in four adults, lives with a disability, according to Eurostat projections. The International Convention on the Rights of Persons with Disabilities (Decision 2010/48/EC) defines 'persons with disabilities' as those with long-term physical, mental, intellectual, or sensory impairments that, when interacting with societal barriers, hinder their full and equal participation.

The European Charter of Fundamental Rights reinforces this by guaranteeing the 'equality of persons before the law' (Article 20), 'prohibiting all discrimination, including disability' (Article 21), and mandating a 'high level of consumer protection' (Article 38). Specifically, Article 26 emphasizes the 'integration of disabled persons,' requiring the EU to ensure measures that support their autonomy, social and professional integration, and community participation.

The EU defines 'consumers' functionally, as 'natural persons acting outside their business or professional activity.' This broad definition encompasses people with disabilities as market participants, purchasing goods and services. The Court of Justice of the European Union (CJEU) recognizes consumer protection as an objective of 'general interest' (Case C-58/08, Vodafone).

Despite these legal frameworks, people with disabilities frequently encounter discrimination due to unmet needs. Their rights as citizens and consumers are often compromised by societal oversights. Product design plays a crucial role in fostering inclusion or exclusion. We often take for granted accessibility features like entry ramps, Braille signage, accessible door handles, wider public toilets, easy-open packaging, and tactile paving, and only recognize their importance when they are absent.

There is a systemic neglect of disabled persons' needs in product and service design. Paradoxically, addressing these needs can lead to improved products and services for everyone.

Sensory analysis evaluates a product's attributes like taste, smell, texture, appearance, and sound. It is crucial for understanding consumer interaction with products. Sensory sensitivities can be heightened or altered in individuals with disabilities. Sensory analysis is vital in new product development to meet consumer preferences and needs, especially for those with sensory processing disorders.

While many people are familiar with the five traditional senses, there are eight sensory systems that work together to help us understand our bodies and the world around us. These systems are crucial for learning, development, and navigating daily life. They are called the Three "Internal" or "Hidden" Senses (Interoception & Proprioception/Vestibular) (6). These senses gather information from within our bodies:

1. Vestibular System (Balance and Movement):
    a. What it does: Located in the inner ear, this system helps us understand our head position, movement, balance, and spatial orientation. It tells us about speed, direction, and rotation of movement, and helps us maintain an upright posture.
    b. How it works: Fluid and tiny hairs in the semi-circular canals of the inner ear respond to head movements and gravity, sending signals to the brain.
2. Proprioceptive System (Body Position and Awareness):
    a. What it does: Provides information about where our body parts are in space, how our muscles are stretched or contracted, and how much force we are using. It's often called "body awareness." This sense allows us to perform movements smoothly and without constantly looking at our limbs (e.g., clapping with eyes closed).
    b. How it works: Receptors in our muscles, joints, tendons, and ligaments send information to the brain.
3. Interoceptive System (Internal Sensations):

a. What it does: This is our "eighth sense," providing information about the internal state of our body. It helps us recognize internal feelings and needs like hunger, thirst, pain, temperature, nausea, heartbeat, breathing rate, and the need to use the bathroom. It also contributes to our awareness of emotional states (e.g., "butterflies in the stomach" when nervous).

Z komentarzem [A1]: We use to say 'when you fall in love'

b. How it works: Receptors near internal organs send signals to the brain.

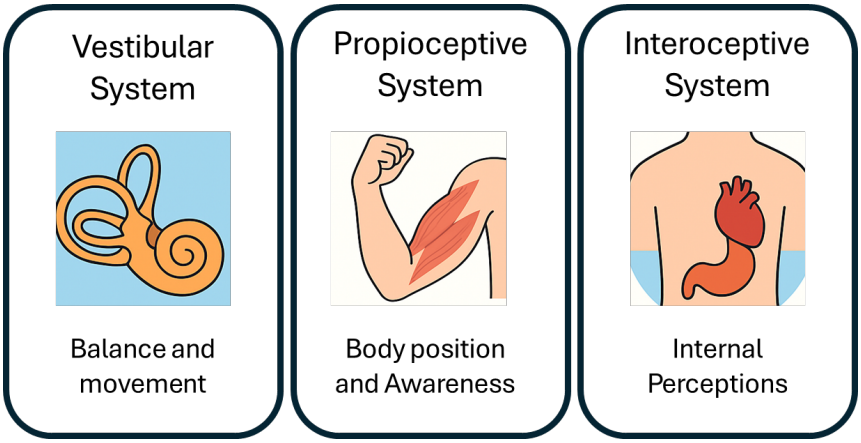

Figure 6. Hidden senses

Z komentarzem [A2]: 6

It is important to integrate these sensory systems because all eight sensory systems work together in a complex interplay called "sensory integration" . They help our brain organize and interpret sensory information, allowing us to respond appropriately to our environment and regulate our bodies and emotions. Difficulties in processing information from any of these systems can impact learning, social interactions, emotional regulation, and daily functioning.

Disabilities can affect sensory perception in various ways, with some individuals being hypersensitive to certain stimuli and others hyposensitive. Recognizing the diversity of sensory needs within the disability community is essential, and new product

development should prioritize accessibility and inclusivity. Examples of this include products with adjustable sensory features, packaging that is easy to open and handle, and clear and concise labelling. Sensory integration, the neurological process that organizes sensation for effective body use within the environment, is often disrupted in people with sensory processing disorders, leading to difficulties in daily life. Product development that accounts for this disruption can improve the quality of life for these individuals.

Involving individuals with disabilities the design process is crucial, as user feedback can provide valuable insights into sensory needs and preferences, ensuring that products are truly accessible and meet the needs of the target audience. Universal design aims to create products and environments that are usable by all people, to the greatest extent possible, without the need for adaptation or specialized design. Applying universal design principles to new product development can lead to more inclusive and accessible products. Technology plays a significant role in creating accessible products, such as assistive technologies, smart devices with customizable sensory settings, and digital interfaces adaptable to different sensory needs. Moving beyond mere accommodation to achieve true inclusion requires a deep understanding of sensory processing and the diverse needs of individuals with disabilities. Collaboration between designers, engineers, and individuals with disabilities is essential for successful new product development.

Disability inclusion when consuming a product, service, or space can be conceptualized using three levels based on the degree of discrepancy between the individual and the designed object (a product, service, or space). Level 1 of Inclusive Design simply addresses accessibility and generally reflects industry regulations. Level 2 of Inclusive Design incorporates greater engagement and evokes positive emotions from consumers. Level 3 of Inclusive Design represents the ideal where there is little to no discrepancy between any consumer and the designed object.

SENSORY ANALYSIS IN PUBLIC HEALTH

EDUCATION

Education is a foundational pillar of society, essential for preparing individuals to face current and future environmental, social, and economic challenges. Incorporating sensory science into educational curricula represents a strategic investment in public health and consumer awareness. Understanding how our senses shape perception can empower individuals to critically evaluate consumption patterns, production systems, and lifestyle choices, ultimately fostering more informed and responsible decision-making.

Currently, early educational stages provide minimal instruction on the functioning of the human senses. Sensory evaluations are typically limited to cases where deficits significantly impair development, such as visual or auditory impairments. However, subtle sensory dysfunctions, particularly those affecting taste (e.g., hypogeusia, ageusia) and smell (e.g., hyposmia, anosmia), are rarely assessed despite their potential long-term impact on dietary habits and overall health.

These sensory impairments, though mild, can significantly influence food preferences and nutritional choices. For example, individuals with reduced taste sensitivity often gravitate toward processed foods with intense flavours, especially sweet and umami profiles, while neglecting nutritionally superior options such as fruits and vegetables. This behaviour contributes to poor dietary patterns and increased risk of chronic diseases.

Moreover, research has shown that early stimulation of the olfactory system can enhance recovery from olfactory deficits, suggesting that sensory education and training may have therapeutic benefits. Therefore, it is imperative to establish public policies that promote sensory awareness and evaluation from early childhood, including:

- Routine sensory screenings in schools to detect early dysfunctions.
- Educational modules on sensory perception and its role in food choice and health.

- Integration of sensory training activities to support sensory development and recovery.
- Cross-disciplinary collaboration between educators, health professionals, and sensory scientists.

Such initiatives would not only improve individual health outcomes but also contribute to long-term public health savings by preventing diet-related diseases. By equipping future generations with a deeper understanding of their sensory systems, societies can foster healthier, more conscious consumers and promote sustainable food systems.

SUGAR AND FAT CONSUMPTION

Establishing public strategies to reduce the intake of added sugars and saturated fats is essential for improving population health and mitigating the economic and social burden of chronic non-communicable diseases (NCDs), such as obesity, type 2 diabetes, and cardiovascular conditions. While numerous nutritional programs and regulatory initiatives have been implemented in recent years (many of which focus on reformulating food products to reduce these components) they often overlook a critical factor: consumer acceptance.

Current policies tend to emphasize nutritional reformulation by mandating or encouraging the food industry to reduce sugar and fat content in processed foods. However, these efforts frequently lack accompanying sensory and consumer research to evaluate whether such changes are perceptible to consumers, and more importantly, whether they influence purchasing behaviour or product preference. Without this insight, reformulated products may be rejected by consumers, ultimately undermining the intended public health impact.

This is where sensory scientists and consumer researchers must play a central role. Sensory analysis provides the tools to assess how reformulations affect the organoleptic properties of food (such as taste, texture, aroma, and appearance) and how these changes are perceived by different consumer segments. Understanding these sensory

impacts is essential to ensure that healthier alternatives are not only nutritionally improved but also socially and culturally acceptable.

To support this integration, it is necessary to establish dedicated funding lines and research programs aimed at:

- Identifying realistic and acceptable substitutes for sugars and saturated fats.
- Conducting sensory profiling and consumer acceptance testing of reformulated products.
- Developing evidence-based guidelines for reformulation that balance health objectives with sensory quality.
- Promoting cross-sector collaboration between public health authorities, food technologists, sensory scientists, and the food industry.

The goal is to ensure that consumers do not perceive a negative change in their eating habits, while still benefiting from improved nutritional profiles. This approach not only enhances the effectiveness of public health strategies but also contributes to long-term behavioural change by aligning health goals with consumer satisfaction.

OLFACTORY DYSFUNCTIONS

Olfactory capacity is trainable, a principle that underpins the training of professional sensory panels. This same approach can be applied to individuals who experience olfactory dysfunctions (dysosmias) following illness or injury. These disorders include:

- Anosmia (total loss of smell; prevalence: 3.6–5.8% at some point in life),
- Hyposmia (reduced sensitivity; 13–18% prevalence),
- Parosmia (distorted odor perception; 19% prevalence),
- Phantosmia (perception of odors without stimuli; 11% prevalence).

These conditions can significantly impair quality of life and pose serious safety risks, such as the inability to detect spoiled food, gas leaks, or smoke.

Olfactory training is a non-invasive, low-risk therapy that has shown promise in improving olfactory function. However, it remains underutilized in public healthcare systems, particularly in otolaryngology departments, due to high clinical workloads and the time commitment required (typically twice daily sessions), which limits its feasibility in hospital settings.

Although diagnostic tools for assessing olfactory function have been validated, there is a lack of robust, standardized protocols for olfactory rehabilitation. Effective training requires that the selected odors be:

- Culturally familiar to the patient,
- Pleasant and recognizable, and
- Potentially paired with visual cues to enhance perception and memory.

While commercial aroma kits for home use exist, they are often cost-prohibitive, lack scientific validation, and are rarely accompanied by structured guidance or follow-up.

To address this gap, public funding initiatives should prioritize research and development of:

- Validated aroma collections designed for therapeutic use,
- Standardized training protocols with measurable outcomes,
- Accessible tools for home-based olfactory rehabilitation,
- Digital platforms for monitoring progress and providing support.

Such efforts would contribute not only to the restoration of sensory function, but also to the prevention of diet-related health issues, as olfactory impairments are closely linked to poor dietary choices and reduced nutritional quality.

Investing in olfactory health through early detection, education, and rehabilitation could yield significant public health benefits, improve well-being and reduce long-term healthcare costs.

AUTISM

It has been shown that the use of sensory analysis can be a fundamental pillar of quality of life for populations suffering from chronic or acute illnesses. Autism, Asperger's, cancer, anosmia, liver disorders, obesity, and diabetes are some of the diseases that can cause a lack of sensory perception, which can lead to an unhealthy diet. Understanding these individuals as consumers is a major challenge for researchers, as it can be a significant incentive to optimize the development of foods, diets, and eating habits recommendations focused on their specific condition.

Sensory processing disorders are among the most common challenges associated with autism spectrum disorder (ASD). These alterations significantly contribute to behavioural difficulties and are currently a subject of growing scientific interest and clinical relevance. Individuals with autism may exhibit either hypersensitivity or hyposensitivity to sensory stimuli, meaning that their perception of touch, sight, smell, taste, and sound may be either more intense or less intense than typical.

Such sensory differences often lead to food aversions, particularly related to texture, flavor, and appearance, which can result in nutritional imbalances and selective eating behaviours. Identifying these aversions and linking them to specific sensory stimuli is essential for developing personalized interventions that support both the health and daily functioning of individuals with autism.

In educational settings, it is critical to consider the food preferences and aversions of students with ASD. Providing sensory-adapted food options (tailored to individual needs) can promote adequate nutrition and foster a positive and inclusive mealtime experience. This approach not only supports physical health but also contributes to emotional well-being and social integration.

Moreover, visual perception differences, such as sensitivity to colour and shape, can affect how autistic students process information in the classroom. Implementing visual strategies, including the use of food photographs, color-coded materials, and varied textures, can enhance comprehension and engagement.

Integrating sensory-based activities into the school curriculum may offer substantial benefits. Activities such as tactile exploration, texture experimentation, and multisensory food experiences (involving diverse shapes, colours, and flavours) can stimulate interest and participation, while also supporting sensory development and adaptive behaviour.

To maximize the impact of these strategies, collaboration between educators, healthcare professionals, nutritionists, and sensory scientists is essential. Developing structured programs that address sensory needs in both dietary and educational contexts can significantly improve the quality of life and learning outcomes for individuals with autism.

ORAL PROCESSING

Texture perception and oral processing are fundamental components of the eating experience, playing a critical role in food choice, dietary habits, and nutritional health. While traditional sensory research has focused primarily on taste and smell, texture has gained increasing attention due to its direct influence on oral behavior, satiety perception, and its implications for public health issues such as obesity.

Food texture is a key determinant of product acceptance or rejection. It influences not only the initial selection of food but also the estimation of portion size and the quantity consumed. Texture modulates the rate of ingestion, which in turn affects satiety signals during and after a meal. For instance, foods with harder or more fibrous textures typically require longer chewing times, which can slow down eating, enhance satiety, and potentially contribute to appetite regulation and weight management.

Oral processing, the mechanical and physiological actions involved in chewing, grinding, and mixing food with saliva, not only prepares food for swallowing and digestion but also plays an active role in sensory perception and preference formation. The way food is processed in the mouth affects the release of volatile compounds, influencing both flavor and aroma perception, and ultimately shaping the overall eating experience.

Furthermore, texture has a physiological impact on digestion and metabolism. By influencing the oral phase of digestion, texture can alter the metabolic response to nutrient intake. This highlights the importance of considering texture in the design of foods aimed at promoting satiety, glycemic control, and nutritional adequacy.

In conclusion, a deeper understanding of texture and oral processing is essential for developing evidence-based strategies that promote healthier eating behaviors. This includes the design of foods that are not only nutritionally balanced but also sensorially optimized to support sustained dietary adherence, particularly in populations at risk of overconsumption or poor dietary choices.

CONCLUSION

The SEASONED project has demonstrated the strategic relevance of sensory analysis as a multidisciplinary tool capable of addressing complex challenges across food systems, public health, sustainability, and social inclusion. Through a comprehensive exploration of sensory methodologies and their applications, this deliverable has highlighted how sensory science bridges the gap between technological innovation, consumer behaviour, and societal well-being.

In the context of sustainability, sensory analysis enables the development of food products that are not only environmentally responsible but also organoleptically acceptable to consumers. This dual focus is essential for the success of initiatives such as hydroSOS, which aim to reduce water usage while maintaining product quality. Sensory evaluation ensures that sustainable practices do not compromise consumer satisfaction, thereby enhancing market viability and supporting climate adaptation strategies.

Regarding food waste, sensory science plays a pivotal role in revalorizing imperfect products, extending shelf life through perceptual validation, and guiding the development of value-added products from surplus. These interventions contribute to circular economy models and reduce the environmental footprint of the agri-food sector.

In the domain of product certification, sensory analysis underpins the credibility and consistency of quality schemes such as PDO and PGI. However, the lack of harmonized methodologies across certification bodies presents a barrier to comparability and transparency. The establishment of standardized lexicons and open-access sensory databases is therefore critical to ensuring scientific rigor and fostering collaborative networks across Europe.

The project also emphasizes the importance of inclusiveness and accessibility in food design. Sensory analysis offers valuable insights into the needs of individuals with disabilities, neurodivergent conditions, and sensory impairments. By integrating

universal design principles and inclusive sensory strategies, food products can be tailored to diverse populations, promoting equity and autonomy in consumption.

In the field of public health, sensory analysis supports the development of healthier food options by evaluating consumer acceptance of reformulated products with reduced sugar and fat content. It also contributes to therapeutic interventions, such as olfactory training for individuals with anosmia or hyposmia, and dietary support for populations with altered sensory perception due to chronic illness.

The integration of sensory education into early learning curricula is proposed as a long-term investment in health literacy and consumer empowerment. Teaching children how their senses influence food choices and perception can foster critical thinking, healthier habits, and greater engagement with sustainable consumption.

Finally, the project underscores the need for interdisciplinary collaboration, robust funding mechanisms, and policy frameworks that recognize sensory analysis as a cornerstone of innovation in food systems. By aligning sensory science with the objectives of the European Green Deal, the Sustainable Development Goals, and the EU Disability Strategy, SEASONED contributes to building a more resilient, inclusive, and health-oriented future.

To maximize the impact of these contributions, policymakers are encouraged to:

- Recognize sensory analysis as a cross-cutting enabler in national strategies related to food innovation, public health, and sustainability.
- Facilitate knowledge exchange platforms connecting universities, research centers, food producers, and certification bodies.
- Support methodological harmonization at national and EU levels to improve interoperability and transparency.
- Fund inclusive innovation projects that consider the sensory needs of vulnerable populations.
- Promote sensory education as part of health and sustainability strategies.
- Integrate sensory science into existing funding schemes, including structural funds, Horizon Europe, and regional innovation programmes.

These actions will enable Poland to align with the objectives of the European Green Deal, the Sustainable Development Goals, and the EU Disability Strategy, positioning the country as a leader in inclusive and sustainable food system transformation.

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