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DENISE PEREIRA
JANAÍNA DE PAULA DO ESPÍRITO SANTO
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APRESENTAÇÃO

Quando lemos um bom texto e nos sentimos satisfeitos com a argumentação de qualquer autor a respeito de suas ideias, se parece coerente ou verossímil, isso acontece por que o autor ou autora foi bem sucedido em demonstrar suas ideias e sua metodologia, apresentando o seu paradigma. Mas pensar em paradigma ou ainda no que o teórico Jörn Rüsen chamou de matriz disciplinar vai além da qualidade argumentativa e metodológica das ideias de qualquer texto. Um paradigma funciona como uma espécie de base que é reconhecida por um número considerável de pesquisadores e em torno das quais muitas ideias, e hipóteses são apresentadas e testadas. São os diálogos entre os paradigmas e matrizes que ajudam o pesquisador no caminhar em busca da compreensão de questões sociais e históricas, quaisquer que sejam, que estejam movendo as pessoas que pesquisam e escrevem.

Dentro desses sistemas amplos, ou matrizes, que acabam movendo os diferentes profissionais e suas práticas, e que acabam por articular escolhas de formulação e pesquisas diversos, não podemos dizer que há sempre o consenso ou o caminho único, uma única teoria que prevaleça ou valide os olhares possíveis aos inúmeros objetos.

Justamente por sua natureza plural, o trajeto da pesquisa é permeado por consensos e dissensos… Ou seja, por mais que exista um núcleo comum em torno do método e dos valores de rigor em cada pesquisa, os diferentes caminhos possíveis marcam uma produção intelectual do campo em que multiplicidade deva ser reconhecida e respeitada como que realmente é: uma miríade de possibilidades válidas. Assim, é importante enquanto pesquisadores estarmos atentos e conhecermos a fundo tanto o que prevalece comum e consensual, como toda e qualquer possiblidade de falta desse consenso, como características da riqueza do conhecimento e da história, do fortalecimento do diálogo entre os pares e portanto, da própria ciência.

Esperamos que as leituras destes capítulos possam ampliar seus conhecimentos e instigar novas reflexões.

Boa leitura!

Denise Pereira

Janaína de Paula do Espírito Santo

SUMÁRIO

CAPÍTULO 5

SENSORY EVALUATION OF FOOD AND ITS EVOLUTION OVERTIME

Data de aceite: 23/06/2021
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ABSTRACT: Humans have used their senses to evaluate food for several thousands of years. Given that so many phytotoxins and bacterial metabolites are bitter and sour, humanity had probably used sensory evaluation since before *Homo sapiens* were human. As civilization developed and the trading and selling of goods became commonplace, the first seeds of food sensory testing as we know it was planted. Tasting methods, as a form of sensory analysis of foods, were applied for the first time in Europe, a long time ago, to control the quality of breweries and distilleries. In the United States, during World War II, it arose from the need to produce quality foods that were not rejected by army soldiers. From this need the methods of application of the tasting appeared, establishing the sensorial analysis as a scientific basis. The food industry traditionally viewed sensory evaluation in the context of the company "expert" (the N of 1) who through years of accumulated experience was able to describe company products and set standards of quality by which raw materials would be purchased and each product manufactured and marketed. Examples of such "experts" include the perfumer, flavors, brew-master, winemaker, and coffee and tea tasters. Nowadays, small-scale internal consumer tests provide a company with a cheap way to get valuable information regarding the advantages and flaws of their products. Therefore, the demand for possibilities to do this kind of test has increased. With the advance of electronics and biosensors, it is also possible to use in sensory evaluation trials, e-noses, and e-tongues, mainly when human panels cannot/ should not be used, due to ethical reasons such as poisonous or extreme condition samples.
KEYWORDS: Sensory scientist, consumer choices, sensory data analysis, e-nose, e-tongue.

AVALIAÇÃO SENSORIAL DE ALIMENTOS E SUA EVOLUÇÃO AO LONGO DO TEMPO

RESUMO: Há milhares de anos que os humanos usam os sentidos para avaliar os alimentos. Dado que muitas fitotoxinas e metabólitos bacterianos têm gosto amargo ou ácido, a humanidade provavelmente usou a avaliação sensorial desde antes que o *Homo sapiens* fosse considerado "humano". À medida que a civilização se desenvolveu e o comércio e a venda de mercadorias se tornaram comuns, começou a surgir a necessidade da realização da avaliação sensorial dos alimentos. Os métodos de degustação, foram aplicados pela primeira vez na Europa, com o objetivo de controlar a qualidade de cervejarias e destilarias. Nos USA, durante a Segunda Guerra Mundial, surgiu a

necessidade de produzir alimentos de qualidade que não fossem rejeitados pelos soldados do exército. A partir dessa necessidade surgiu a análise sensorial como base científica. Tradicionalmente, a indústria alimentar via a avaliação sensorial no contexto da empresa como sendo realizada pelo "expert" (N = 1) que através de anos de experiência era capaz de descrever os produtos e estabelecer padrões de qualidade desde a matéria-prima até ao produto final. Exemplos de tais "especialistas" incluem o mestre-cervejeiro, o enólogo, os provadores de café (baristas) e chás. Hoje em dia, os testes internos de consumidor, proporcionam à empresa uma alternativa barata para a obtenção de informações valiosas sobre as vantagens e falhas dos seus produtos. Portanto, a procura por possibilidades de fazer esse tipo de teste aumentou. Com o avanço da eletrónica e dos biossensores, também é possível usar em ensaios de avaliação sensorial, narizes e línguas eletrónicos, principalmente quando os painéis humanos não podem / não devem ser usados, devido a razões éticas, como amostras venenosas ou em condições extremas.
PALAVRAS-CHAVE: Cientista sensorial, consumidor, análise de dados sensoriais, e-nose, e-tongue

1 | INTRODUCTION

There is a class of scientists who specialize in the analysis of the sensory qualities of merchandise – the color, sound, smell, taste, and feel of things. The original name for this area of research was "organoleptic", and the person who performed the analysis the "*Organoleptician* (HOWES, 2015).

It is difficult for us to understand how people, in the past, perceived their world in sensory terms. Can we ever reach an understanding of what smells meant to 18th century Parisians? Maybe, if we read the book "Perfume: The Story of a Murderer*"* - a 1985 literary historical fantasy novel, by the German writer Patrick Süskind, we get an idea! The novel explores the sense of smell and its relationship with the emotional meaning that scents may have! Or can we ever uncover the meanings of taste in a pre-refrigerator age? The historian Mark M. Smith places these questions in his article "The explosion of sensory history" (SMITH, 2010). Of the many sectors of consumer products industries (food/beverage, personal care products, pharmaceutical, fabrics, and clothing…), it was on the food and beverage sectors that grew the interest in sensory evaluation (STONE; SIDEL, 1985). Its origins can be traced back to the 1930s when the Arthur D. Little industrial consulting firm, in the U.S., devised a "Flavour Profile Method" and "Hedonic Index" for use by commercial food and beverage companies, and the first panel on "Flavour in Foods" was presented at the 1937 meeting of the American Chemical Society (HOWES, 2015).

During the 1940s-1950s, sensory evaluation received additional motivation through the U.S. Army Quartermaster Food and Container Institute, which supported research in food acceptance for the armed forces (SIDEL; STONE, 1993). For the military, in combat, the importance of flavor and acceptability for a particular product was recognized. It was not enough to present to the military, food-products with an adequate level of nutrition. This

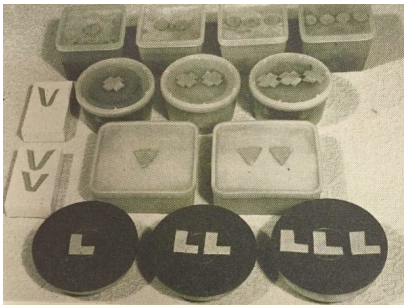
aspect of food did not guarantee food acceptance by military personnel (SIDEL; STONE, 1993). For instances, several studies were published on “Browning” – As to the objectives of the conference, those immediately apparent were: To report the status of Quartermaster Corps contract research on browning; to evaluate research progress, and to assess the value of the different approaches selected by the various investigators in attempting to understand the mechanisms and control of browning (C) and also about “Color in foods” (QFCIAF, 1953; BERENSTEIN, 2018). So, funds were assigned to studies of the problems of identifying what foods were preferred as well as the more fundamental issue of the measurement of food acceptance.

After the war, a new impulse was made in sensory science and sensory history. The White Sands Proving Ground became the center of V2 Rocket Research, and the nearby Holloman Aeromedical Field Laboratory and the associated Wright-Patterson Air Force Base Aero-Medical Laboratory began working on what would become known as the “Project Mercury”, the first U.S. space program. Soon, scientists found that the exploration and conquest of space by humans would require more than merely surviving, like a fly, a monkey, or a mouse. Once the man was “up there”, enclosed in a spacecraft alone or together with other courageous humans, a question was raised. What would they have for lunch? (BERENSTEIN, 2018). In space, every aspect of metabolism becomes a problem! Food scientists calculated that 5 pounds a day per person, or 1 ton a year is the amount of food needed (BERENSTEIN, 2018), for a man to survive in space. Given this, the conclusion was “reduce everything to its essences, the most basic form”: nutrient pellets, titrated to meet, precisely, the body’s needs, to sustain bare life and function.

Lieutenant Colonel David Simons, a medical officer, was the first human to dine in space-equivalent conditions (over 100,000 feet up, above 99 percent of the earth’s atmosphere). Dr. Simons had been one of the designers of the experiments that rocketed animals into near space. He and his co-workers, at Holloman and Wright-Patterson, developed a scheme to lift a human to the upper limits of the atmosphere using a giant, helium-filled balloon. This work was named the project “Man High” (BERENSTEIN, 2018).

Beatrice Finkelstein, research nutritionist, and dietitian at Wright AFB Aero Medical Laboratory was the scientist responsible for designing Dr. Simons’ low-residue diet (Figure 1 A) (BERENSTEIN, 2018). In a series of experiments at Wright AFB, Finkelstein confined human subjects within a sensory deprivation chamber to examine “the means they employ to defend themselves against the effects of isolation.” The test subjects spent 72 hours alone in a pitch-dark, soundproof room. The room had a cot, a chair, a chemical toilet, and a refrigerator. The refrigerator held little Tupperware-style containers of food, lids marked with tactile symbols, which indicated their contents. Subjects could palpate the lids in the dark and select the substance of their meals (Figure 1 B).

A



B

Figure 1. (A) Beatrice Finkelstein in her research lab; (B) Small Tupperware-style containers and system of coding various food-groups.

In her report, Finkelstein wrote "*The significance of food during these trials has varied (…) Some subjects have spent excessing amounts of time eating, nibbling or counting food; others have become angry at the food or overly fond of it.* (…) *While some snacked continually, others stuck to a routine of three or four meals a day. Brownies, ordinarily a favorite, lost savor; in contrast, canned orange juice, which is usually rated low, was enjoyed. All meat tasted the same* (…)" (BERENSTEIN, 2018). Moreover, she concluded: "*Evidence is strong that food is used as a tool to obtain personal satisfaction*" (BERENSTEIN, 2018). For those alone and in the dark in conditions meant to mimic the stress and isolation of high-altitude spy flights, or voyages into space, food was one of the only available comforts.

All these issues were forgotten during the 1960s and early 1970s due to the implementation of the U.S. federal government program "War on Hunger". The government's desire to feed the starving and undernourished met with frustration when product after the product was rejected by the target consumers, primarily because no one troubled to determine whether the sensory properties of these products were acceptable to the targeted groups (SIDEL; STONE, 1993).

Mainly due to the government's successes and failures in sensory evaluation, the food industry began to provide support for this developing science and various studies were custom-built to find out how to make the food more acceptable (PANGBORN, 1964).

2 | THE EVOLUTION OF THE "SENSORY SCIENTIST"

The title of "*Organoleptician*" has since been dropped and replaced by "Sensory professional" or "Sensory scientist". The sensory evaluation of food products remains central to the practice of these professionals of the "sensory science", but the scope of the products studied has expanded significantly to include everything from personal care to household cleaning (HOWES, 2015).

However, the food industry traditionally viewed sensory evaluation in the context of

the company "expert" (the N of 1) who through years of accumulated experience was able to describe company products and set standards of quality by which raw materials would be purchased and each product manufactured and marketed. Examples of such "experts" include the perfumer, brew-master, winemaker, and coffee and tea tasters (SIDEL; STONE, 1993).

Sensory professionals also have an effort to expand their role within the companies they worked for, seeking to convince management that the application of sensory evaluation techniques is crucial to every stage of product development, from product conception to product consumption. They usually use the language of driving, as in "*sensory properties drive consumer acceptance and emotional benefits*" (HOWES, 2015), and it has had the desired effect.

The science of sensory evaluation can be integrated into the "aesthetic-industrial complex" context and It is one of the "sciences of subjectivity" which, as Shapin (SHAPIN, 2012) suggests, "are world-making".

Nevertheless, one crucial question can be made: what sort of world are these sensory scientists making out of our senses? Can it be proven as an exact science?

The science of sensory evaluation rests on a vital paradox: "*Most sensory characteristics of food can only be measured well, completely, and meaningfully by human subjects*" as opposed to scientific instruments. But it is considered necessary that human subjects behave as much like scientific instruments as possible: "*When people are used as a measuring instrument, it is necessary to control all testing methods and conditions to avoid errors caused by psychological factors*" (HOWES, 2015).

Meilgaard, Carr, and Civille (2010) affirm that the key to sensory analysis is: "(…) *to treat the panelists as measuring instruments. As such, they are highly variable and very prone to bias, but they are the only instruments that will measure what we want to measure so we must minimize the variability and control the bias by making full use of the best existing techniques in psychology and psychophysics* (…)".

The controls techniques mentioned by Meilgaard and co-workers (MEILGAARD; CARR; CIVILLE, 2010) include: (i) Standardization of the test conditions, e.g. constant single lighting conditions, temperature, humidity, test station design; (ii) Elimination of all disturbance variables (sounds, odors, light-stimuli, the exertion of persons, uncomfortable sitting position); (iii) Ensuring that "irrelevant" sensory factors, such as the size of the samples, do not interrupt the panelists' judgment; (iv)Train panelists to evaluate products "monadically" (to assess one sensory characteristic at a time); (v) Isolating one panelist from another by having them perform their tasks in individual booths or cubicles (Figure 2); (vi) Instructing the panelists not to discuss samples before evaluation (since this might create expectations); (vii) Instructing the panelists to work in silence, since "comments or noises" made out loud can influence sensory judgments. Moreover, now, several industries are working on "Sensory equipment" from tasting cabins to sample preparation rooms (Figure

2), (THIEMT, 2019).

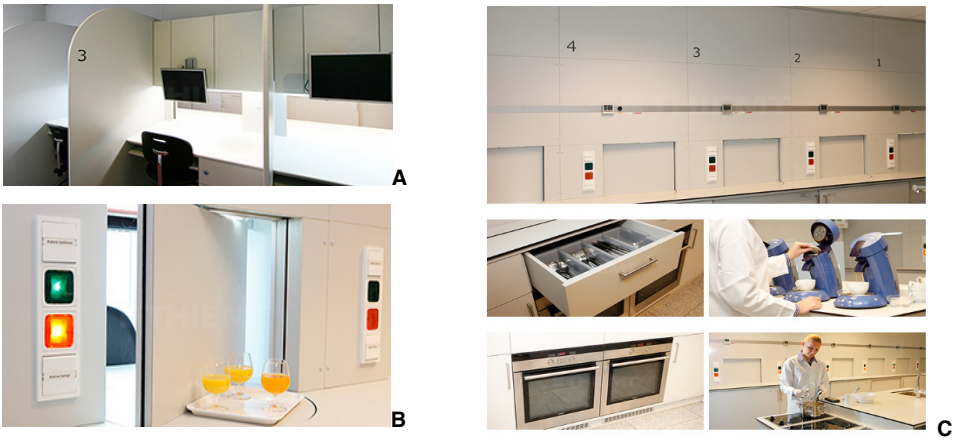


Figure 2. Individual booths or cubicles (A) and sample delivery system (B). The backside of the test cabin acts as a wall unit of the preparation room (C). The sample preparation and coding, such as the presentation takes place right here. The materials of the ceilings, walls, and floors should be odorless and olfactory inert, such as the furnishings (THIEMT, 2019).

3 I THE EVOLUTION OF THE "SENSORY TESTS" AND DATA ANALYSIS

Nowadays, there are three kinds of tests used in sensory evaluation procedures. "Discriminative tests" are used to determine if a difference exists among samples. "Descriptive tests" employed to identify and quantify sensory characteristics (descriptors) that are important in a product. "Affective" or "hedonic tests" are used to measure how much a panelist (or just a simple consumer) likes a product sample. The variability of responses is controlled using standardized questionnaires and standard numerical scales (STONE; BLEIBAUM; THOMAS, 2012) as well as through statistical analysis (MEILGAARD; CARR; CIVILLE, 2010). The results of the experiments, and the plotting of such results in the form of graphs and tables. Only results that are "statistically significant" are considered "meaningful." In other words, while sensory evaluation experiments are concerned with assessing the qualities of products, it is the quantification of sensation that counts. Averages are usually calculated so that any trace of the "subjective associations" of individual panelists can be eradicated from the overall picture of a product's sensory qualities (STONE; BLEIBAUM; THOMAS, 2012). The degree of sensory restriction to which the sensory professional is subjected allows the reproducibility of the results that are "precise and consistent" (POSTE et al., 1991).

Many of the papers published in the field are concerned with the development of "sensory lexicons". The construction of these vocabularies (a group of words, commonly called a lexicon), is essential both for standardization and communication among sensory

professionals working in different countries, and the communication of product sensory attributes to the consumers. Sensory lexicons are applied using descriptive sensory analysis techniques. They provide a source list to describe products (wine, bread, beer, coffee, chocolate). Over the years, descriptive lexicons represented in wheel form, have been developed for wine (NOBLE et al., 1984), (Figure 3 A), beer (MEILGAARD; DALGLIESH; CLAPPERTON, 1979), and spirits (LEE et al., 2001), among others alcoholic beverages like Pink Port Wines (MONTEIRO; VILELA; CORREIA, 2014) and chocolate (Figure 3 B).

A B

Figure 3 – (A) An example of the wine aroma wheel (AROMASTER, 2019) first developed by Nobel and co-workers (NOBLE et al., 1984); (B) An example of the chocolate aroma and flavor wheel and a chocolate tasting plate (SØRENSEN, 2019).

Characteristics of flavor lexicons to be used in food/beverage products sensory profiles have been discussed by Lawless and Heymann (1998). And, according to the authors, a vital characteristic of a good flavor lexicon is that it must be discriminative, as well as, descriptive, if possible. For a descriptive language to be discriminating, it must be able to differentiate the products for which it was developed. One example is the work performed by Vilela et al. (2015). The work aimed to develop strawberry, raspberry, and cherry jams with a more acceptable nutritional profile but maintaining their sensory characteristics in comparison with the traditional formulation with sucrose. Sucrose was replaced by fructose, sorbitol, or fructooligosaccharides (FOS), given the potential low glycemic index and the reduced calories in the case of sorbitol and FOS, and enrichment with dietary fiber, in the case of FOS. After sensory lexicon development sensorial and application of quantitative descriptive analysis test, the authors found that the sweeteners used interfered, significantly, in the parameters measured. For exemplification, the sensory profile, and the strawberry jam sensory attributes, prepared with different sweeteners (osmotic dehydration agents), can be seen in Figure 4, a spider graph, one of the most used types of graph for sensory profile presentation.

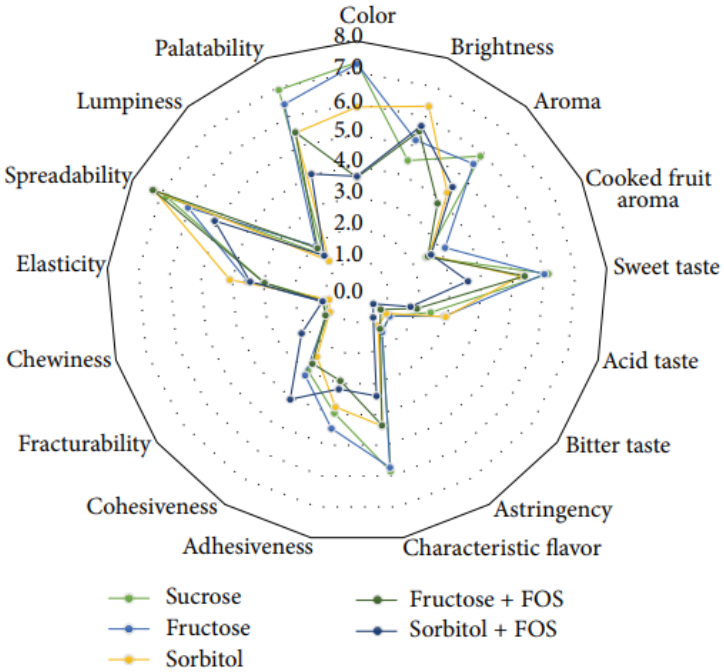


Figure 4: Sensory profile of strawberry jams prepared with five different OD agents or combinations of two. Adapted from Vilela et al.(2015).

Another interesting data analysis and representation is CATPCA (as Categorical Principal Components Analysis). In a work performed by Monteiro and co-workers (MONTEIRO; VILELA; CORREIA, 2014), the applicability of sensory techniques in the Pink Port Wine sensory evaluation was studied. The work aimed to differentiate between five Pink Port Wine brands, positioned on the Portuguese market. The authors, with the Porto Cruz company´s help, where the work was performed, selected and trained a group of panelists by using discriminative tests. Then the identification and selection of descriptors was performed and finally, the establishing of the wines sensory profile, using the developed sensory lexicon, and non-parametric multivariate analytical techniques such as CATPCA. Interestingly, from the five brands studied, three of them were similar in terms of attributes, while the other two presented different sensory characteristics. The two-dimensional CATPCA explained more than 87% of the total amount of initial variance and a scatter plot, with each attribute and each wine plotted along with Principal component 1 and Principal component 2 was obtained (Figure 5), (MONTEIRO; VILELA; CORREIA, 2014).

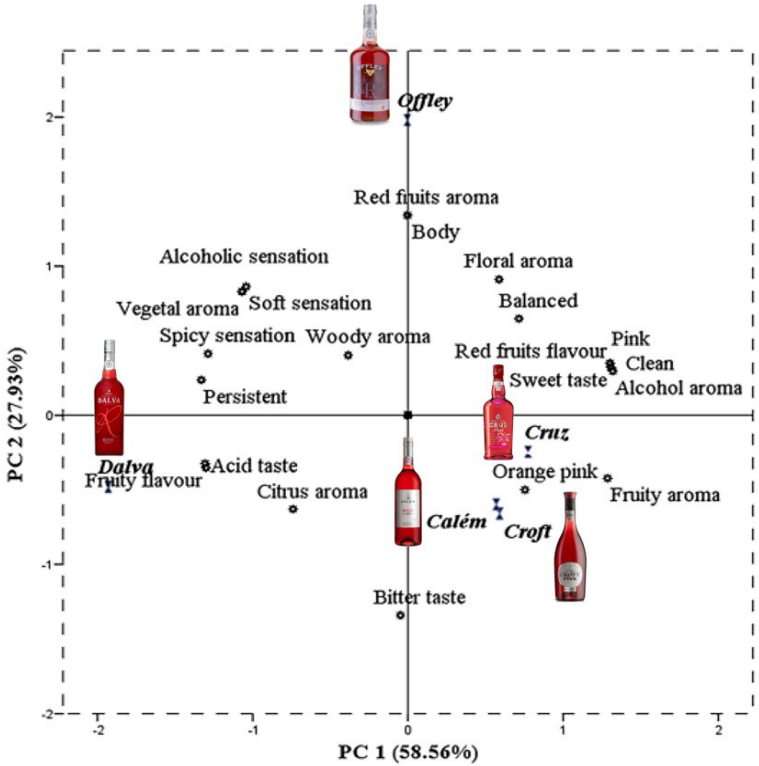


Figure 5. Principal components loadings and scores of the sensory attributes and wines for PC1 and PC2, after CATPCA analysis. Adapted from Monteiro, Vilela and Correia (2014).

In 2018, Vilela and co-workers (VILELA et al., 2018) published a study on three Vinho Verde monovarietal wines from the grape varieties, Alvarinho, Loureiro, and Arinto. The "sensory lexicon" developed by the trained panelists could be used by marketers allowing the articulation of flavor perceptions to consumers. Moreover, a second-order factor analysis statistical model (SEM) was developed for each grape-variety wine, based on the data-set of the sensory attributes, allowing a new perspective on the sensory characterization of these wines (Figure 6). This work also shows that Structural Equation Modelling (SEM), is a good statistical tool to be used in sensory analysis data treatment, once SEM explicitly considers the measurement errors associated with the variables under study, and can encompass two sub-models, according to the relational structure between the variables: a measurement model and a structural model that allowed as to characterize the monovarietal wines according to their main sensory descriptors.

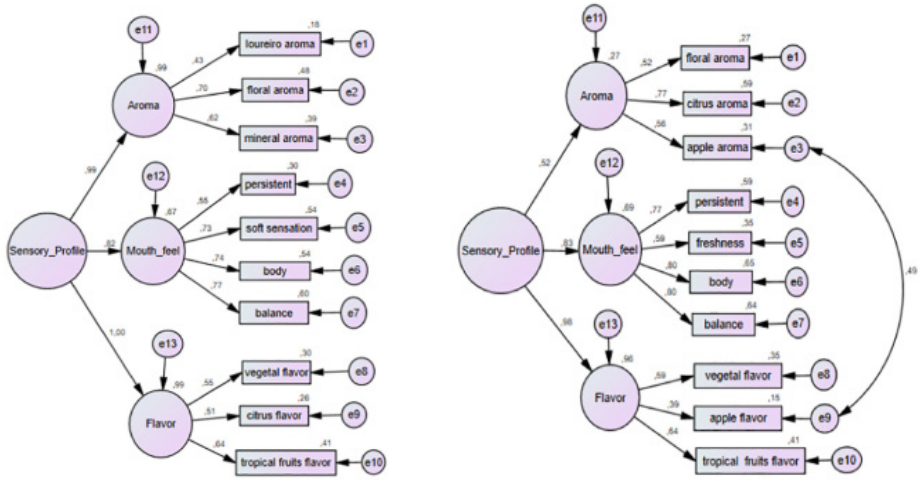


Figure 6 - Schematic representation and values of the standardized factor weights and the individual reliability of each of the items in the final second-order CFA model for the sensory profile of monovarietal Loureiro (A) and Alvarinho (B) wines. Adapted from Vilela et al. (2018).

4 I ELECTRONIC NOSES AND TONGUES

Electronic noses (e-noses) and tongues (e-tongues) are sensors designed to mimic the sensorial abilities of humans in the detection of complex mixtures of chemical substances, also of biological origin. They are created to mimic the Human nose in its ability for entrapment of odors and sensory transduction mechanisms. E-noses usually possess cross-reactive sensing displays that upon odor contact generate modeled responses and analytical algorithms that catalog these responses (LOUTFI et al., 2015). For aroma detection by the e-nose, volatile molecules must come into physical contact with the detectors. This phenomenon occurs by contact with the detectors; or by moving the carrier air to the detector or by moving the detector through the air allowing it to contact the volatiles (LOUTFI et al., 2015).

E-noses devices can contain up to 40 sensors, each one standardized for a precise chemical compound. Compounds and sensors combined to provide a measurement pattern. To be able to detect, analyze and process the information, an e-nose device must be built putting together three components, each with a specific function (VILELA et al., 2017). A sample delivery system consisting of a multisensory array; a detection system such as an Artificial Neural Network (ANN); and a computing system with appropriated software (digital pattern-recognition algorithms and reference-library databases) (WILSON; BAIETTO, 2009), Figure 7.

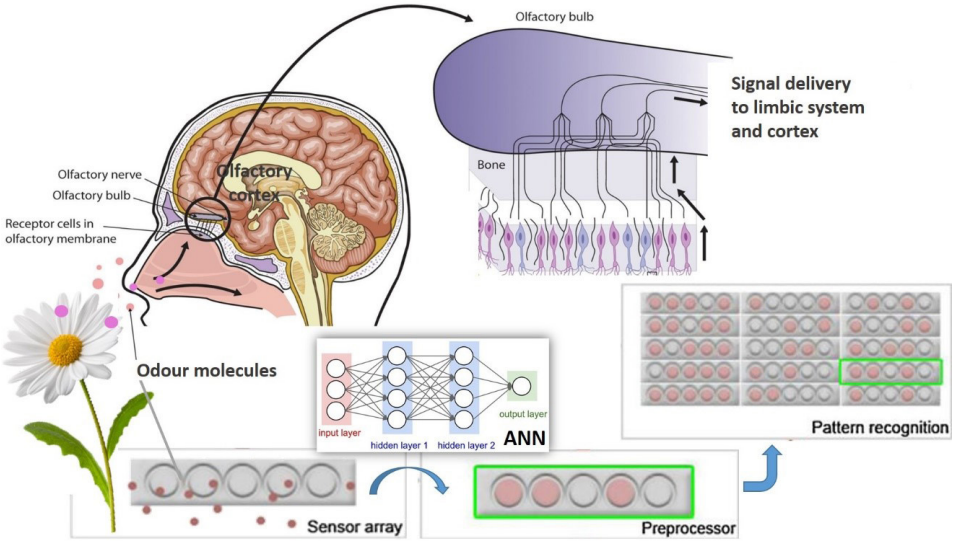


Figure 7. Schematic representation of an e-nose device, with the analogy to Human Nose. Retrieved from Vilela et al. (2019).

Besides e-noses, the sensory scientist also can use electronic tongues. They are electronic devices with specific sensors that can mimic the Human gustatory system. The first e-tongue appeared in the 1990s. They were developed for application in ions and heavy metals analysis (LAVIGNE et al., 1998) as well as in the evaluation of taste (TOKO, 1996). E-tongue is a useful instrument when human panels cannot/should not be used, due to food process circumstances; poisonous/extreme condition samples, and cost-effective reasons (PODRAZKA et al., 2018).

E-noses and e-tongues are being used to discriminate volatile aroma compounds (ZENG et al., 2021) and taste profiles, including spoilage detection in food (ZAUKUU et al., 2021) as also the possible adulteration and fraud in some processed food products, that would be unethical to be detected by Human panelists.

5 I FINAL REMARKS

Sensory evaluation involves the development and use of principles and methods for measuring human responses to food and beverages. This science depends on guidelines for the preparation and serving of samples under controlled conditions so that biasing factors can be minimized.

Sensory perception is a learned and active practice and not a passive reflex. Sensations are held to arise “neither from the food/beverage nor from the consumer, but from the encounter between them”, that is, it is neither taste nor taster, but *tasting*.

Universal objectives and universal language “lexicons” must be developed. As, also,

new statistical methods, graphical representations, and data analysis must be studied, so that sensory experts and consumers can contribute, both, for a better food/beverage sensory quality evaluation.

The world of flavor has evolved, from the sensory scientist to Human taster or panelists, to electronic sensors. The advances are not only in terms of chemistry, biochemistry, microbiology, or simple sensory analysis, but also mathematics, computer and electronics help the flavor development technologies that allow faster, safer, economic, and precise aroma/flavors compounds analysis, characterization, and quantification.

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