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# Electronic sensory assessment of bread enriched with cobia (*Rachycentron canadum*)

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## Abstract

The aim was to evaluate the sensory quality by electronic nose (EN) and tongue (ET) of bread added by cobia minced protein in differents times of storage. Two samples were elaborated: (a) control (FF—traditional bread); (b) added by 10% Cobia minced protein (FPN). The two samples of bread were analyzed from time "zero" (1 hr after being baked) to time "five" (120 hr). A Portable EN (PEN2) composed of 10 sensors was used. Operating conditions: flow rate 300 ml/min, injection time 60 min, flush time 180 min. To ET (Taste-Sensing System SA402B) 5 sensors were used. All samples were analyzed twice and the average was analyzed by Principal Component Analysis, showing the relationship among the samples and the variables. The greatest differences between the odors were observed after 120 hr of storage. In the first 48 h, the EN was unable to differentiate the samples. The biggest differences of taste were observed at t0. In the other evaluation times, the samples reduced their differences. The use of electronic sensory methods showed promising. Confer greater specificity in the determination of odors and taste of products. Therefore, these tools can be used to improve the sensory characteristics of the new products, as enriched foods.

**Practical Applications:** Bread is a basic food of the world population, but it does not present a big quantity/quality protein content. Using fish protein concentrate in bread improves the nutritional quality of this product, however, in function of the physico-chemical composition, fish and derivates may present a strong characteristic odor/taste, rejected by a large part of the population. The sensory characteristics of a product are determining factors for the choice and purchase by the consumers. Maintaining a permanent panel of trained evaluators takes high time and continuous costs, and is not entirely accurate. The use of technologies used by the electronic nose and tongue can assist in a greater standardization of food, especially when it involves the development of new products, ingredients, or differentiated raw ingredients, as made in this study.

## 1 | INTRODUCTION

Proteins as others nutrients availability and supply to humanity is a serious problem in the world (Henchion, Hayes, Mullen, Fenelon, & Tiwari, 2017; Moscatto, Prudencio, & Hauly, 2004). Bread is a staple food, consumed daily by people of all countries, and it is a way to improve the health of some people groups by increasing the nutritional quality of traditional bread (Cercel, Burluc, & Alexe, 2016;

  

Turfani, Narducci, Durazzo, Galli, & Carcea, 2017). According to Brazil (2005), bread is the product obtained from wheat flour and/or others flours, added with others ingredients, resulted from fermentation and cooking process, that may contain others ingredients, without modify the characteristics of the bread.

An option to protein enrichment of traditional types of bread is the fish minced protein incorporation (Coda, Varis, Verni, Rizzello, & Katina, 2017; Fagundes, Rocha, & Salas-Mellado, 2018). Cobia (*Rachycentron canadum*) has great characteristics as high growth rates, low mortality, good feed conversion, excellent meat quality, and high market value. Cobia is a marine fish, neritic and is widely present in the majority of seas and oceans (Benetti et al., 2010; Coriolano & Coelho, 2012).

Sensory characteristics have extreme importance as quality indicators. But, employing sensory trained panels to the continuous taste/odor monitoring have many limitations (Stone, Mcdermott, & Sidel, 1991). Electronic noses and tongues have potential and big capacity to performing this task. After calibration and adjustment, these electronic devices can analyze on a continuous basis at a low cost (Cayot, 2007). Bread consumers give much importance to the sensory characteristics of this product. According to Angioloni and Collar (2009), the bread sensory properties are often associated with the perception of freshness and it directly influences the purchase/consumption decision.

In this context, the aim of this work was to evaluate the sensory quality applying electronic nose and tongue on bread added by cobia minced protein and wheat flour bread in differents times of storage.

## 2 | MATERIALS AND METHODS

### 2.1 | Material

The fishes specimens were provided by Marine Aquaculture Station (MAE) of the Federal University of Rio Grande (FURG, Brazil). Commercial wheat flour type I, was provided by mill Quaglia S.p.A. (Vighizzolo d'Este/VE, Italy). Sodium chloride and dried yeast were purchased at the local market.

### 2.2 | Preparation of cobia minced protein (CMP)

CMP was obtained according to Fagundes et al. (2018) at the Food Technology Laboratory of Rio Grande Federal University (Brazil). The process is described below: Cobia was washed in chlorinated water at 5 mg/L at 4°C followed by being beheaded and gutted. Then, fishes were processed in a meat-bone separator (High Tech, HT250, Brazil) that discarded skin and bones resulting in mechanically separated meat (MSM). The CMP from MSM was obtained by washing process in distilled water (ratio 1:3 w/v minced/water) for 5 min at constant stirrer and filtered through a layer of nylon cloth. This washing was repeated three times. The CMP was centrifuged in a hydro-extractor (Anki, YL-15, Taiwan). The CMP was lyophilized (Liotop, L108, Brazil) at −55°C and 50 μHg during 48 hr, ground in a knife-mill (Tecnal, TE-633, Brazil), sieved through a 42 mesh (0.35 mm) and stored at −18°C until use.

### 2.3 | Elaboration of bread samples

Were made at Department of Food, Environmental and Nutritional Sciences of Milan University (Italy), according to Fagundes et al. (2018) with adaptations. The ingredients used to elaboration of bread samples are described in Table 1. The dry ingredients were homogenized using a planetary mixer followed by water addition at maximum speed during 10 min until the gluten net had completely developed. Bread dough was divided in pieces of 250 g, molded spherical shape and placed in metallic molds. The fermentation was carried out in a stove at 30°C for 90 min at 80% of relative humidity (controlled). The doughs were baked in a electric oven at 200°C for 20 min. After baking and 1 hr at room temperature, the loafs of bread were sliced by an electric knife for further analysis. Were elaborated two bread types: (a) control (made with wheat flour, named of FF) and (b) added 10% CMP (named of FPN). The bread samples were analyzed by electronic nose and electronic tongue during storage at time "zero" (t0 = 1 hr after being baked); time "one" (t1 = 24 hr after being baked); time "two" (t2 = 48 hr after being baked) and time "five" (t5 = 120 hr after being baked).

### 2.4 | Electronic nose analysis

A portable electronic nose (PEN2) from Win Muster Airsense Analytics Inc. (Germany) was used. It consists of a sampling apparatus, an array of chemical gas sensors producing an array of signals when confronted with a gas/vapor/odor, and an appropriate pattern-recognition software (Win Muster v.1.6) for data recording and elaboration. The sensor array of the electronic nose PEN2 is composed of 10 metal oxide semiconductor type chemical sensors: W1C (aromatic); W1S (broad-methane); W1W (sulphur-organic); W2S (broad-alcohol); W2W (sulph-chlor); W3C (aromatic); W3S (methane-aliph); W5C

**TABLE 1** Formulations of control bread (FF) and enriched bread (FPN)

| | FPN bread | | FF bread | |
|---|---|---|---|---|
| Ingredients | % | Dough (g) | % | Dough (g) |
| Wheat flour | 90 | 900 | 100 | 1,000 |
| Cobia minced protein (CMP) | 10 | 100 | — | — |
| Sodium chloride (NaCl) | 1 | 10 | 1 | 10 |
| Dry yeast | 1,5 | 15 | 1,5 | 15 |
| Water | 60 | 180 | 60 | 180 |

*Note:* FPN = enriched bread (added 10% CMP); FF = control bread (wheat flour). All values are expressed in relation to wheat flour.

(arom-aliph); W5S (broadrange); W6S (hydrogen). The sensors response is expressed as resistivity (Ω).

For the measurements, 10 g of bread samples were placed in a 100 ml airtight Pirex® bottle provided with a pierceable silicon Teflon disk on the cap. After 1 hr headspace equilibration at room temperature, the measurement sequence started. Operating conditions were: flow rate 300 ml/min, injection time = 60 min, flush time = 180 min, during which the sensors surface was cleaned with air filtered through active carbon. The samples were analyzed twice and the average of the sensor responses was used for statistical analysis.

## 2.5 | Electronic tongue analysis

Analyses were made by Taste-Sensing System SA 402B (Intelligent Sensor Technology Co., Japan) designated from now on by electronic tongue (ET). The system consists of sensors whose surface is attached with artificial lipid membranes having different response properties to chemical substances on the basis of their taste. In this work a total of 5 detecting sensors and 2 reference electrodes were used, separated in two arrays according to membrane charge: hybrid (CT0 = saltiness; CA0 = sourness; AAE = umami taste and umami richness) and positive (C00 = bitterness and acidic bitterness; AE1 = astringency).

To each 30 g of distilled water, a sample previously weighed (3 g) was added. Solutions were vortexed during 2 min and centrifuged at 5000 rpm for 5 min at room temperature. Next, the supernatants were filtered and diluted 1:4 (w/w) with distilled water. In Figure 1, the measuring process is reported:

The detecting sensors and reference electrodes were first dipped into the reference solution (30 mM potassium chloride and 0.3 mM tartaric acid) and the electric potential measured for each sensor was defined as Vr. Then the sensors were dipped for 30 s into the sample solution. For each sensor the measured potential was defined as Vs. For each sensor the "relative value" (Rv) was represented by the difference (Vs – Vr) between the potential of the sample and the reference solution. Sensors were rinsed with fresh reference solution for 6 s and then dipped into the reference solution again. The new potential of the reference solution was defined as Vr′. For each sensor, the difference (Vr′ – Vr) between the potential of the reference solution before and after sample measurement is the CPA value (Change of Membrane Potential caused by Absorption—CPAv) and corresponds to the ET "aftertastes". Before a new measurement cycle started, the electrodes were rinsed for 90 s with a washing solution and then for 180 s with the reference solution.

Each sample was evaluated twice and the averages of the sensor outputs were converted to taste information. The "taste values" were calculated by multiplying sensor outputs for appropriate coefficients based on Weber-Fechner law, which gives the intensity of sensation considering the sensor properties for tastes. In particular, the "taste values" were estimated as:

$$\text{Sourness} = 0.3316\,\text{Rv}(\text{CA0}).$$

$$\text{Saltiness} = -0.252\,\text{Rv}(\text{CT0}).$$

$$\text{Bitterness} = -0.140\,\text{Rv}(\text{C00}) + 0.084\,\text{Rv}(\text{CT0}).$$

$$\text{Aftertaste}-\text{bitterness} = -0.210\,\text{CPAv}(\text{C00}).$$

$$\text{Astringency} = 0.1575\,\text{Rv}(\text{AE1}) + 0.1575\,\text{Rv}(\text{CT0}).$$

$$\text{Aftertaste}-\text{astringency} = -0.252\,\text{CPAv}(\text{AE1}).$$

## 2.6 | Data processing

Data values collected by electronic nose and electronic tongue were analyzed using PCA (Principal Component Analysis) in order to achieve a partial visualization of the data set in a reduced dimension. PCA was performed in correlation (the variables were scaled). From the analysis, two figures were collected: PCA score plot (Figures 3a, 4a, and 5a), that represent the relationship among the samples, and the PCA loading plot (Figures 3b, 4b, and 5b), that shows the relationship among the variables and how they influence the system.

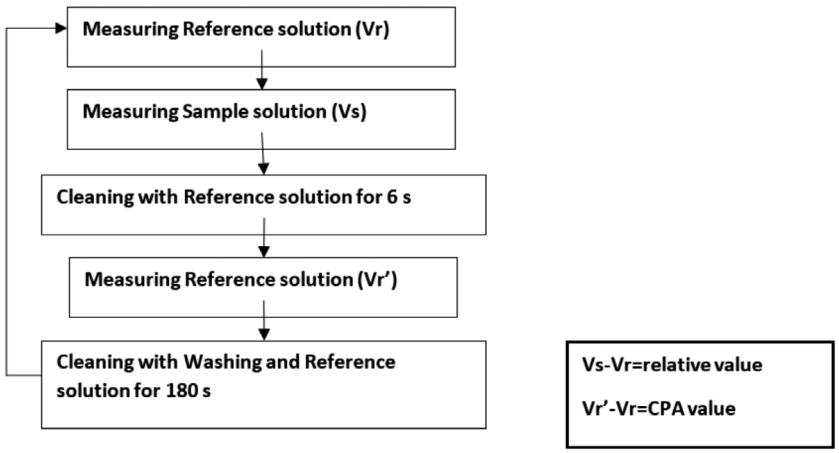


**FIGURE 1** Electronic tongue measuring process

## 3 | RESULTS AND DISCUSSION

Figure 2 shows the bread samples elaborated. Electronic nose and tongue were applied in order to evaluate the aroma and taste evolution of bread samples during storage. Figure 3a shows the PCA score plot (representing the samples distribution) and 3b loading plot (representing the variable distribution) of the data collected by the electronic nose.

By examining the score plot (Figure 3a) that represents the samples distribution in the area defined by the first two PCs that explain the 83.1% of total variance, an evolution of the bread samples along the first and second component according to storage time was found. After 5 days of storage, the electronic nose was able to discriminate the two different type of bread samples.

Considering the loading plot (Figure 3b) showing the relationship between the electronic nose variables and how they influence the system, it is clear that W1S and W1W sensors are important for samples at the beginning of the storage, while the WC sensors, W6S, W3S and W1W are relevant for discrimination of the samples at the end of the storage (t5). Bread sample denominated FF (control bread) at time 5 are characterized especially by the W2S sensor.

Figure 4a,b shows the PCA score plot and loading plot of the "taste values" collected by electronic tongue. By examining the score plot (Figure 4a) it evident a clear separation of the two type of bread (FF and FPN) on the first (PC1) and second (PC2) Principal Component (81.5% total variance explained). FF samples, clustered in the positive part of PC1, are well discriminated by FPN samples located in the positive part of PC2 and distributed on PC1 from right to left according to their storage time.

Considering the loading plot (Figure 4b), it is evident that FF samples are characterized by sourness, astringency and aftertaste astringency and are perceived as less bitter and salty. At the beginning of storage (t0) the FPN sample is characterized by bitterness and aftertaste bitterness, during storage the taste of FPN samples evolves, the bitterness decreases and saltiness and umami are more perceived.

In order to obtain a more exhaustive characterization and differentiation of the two types of bread, data obtained by electronic nose and electronic tongue were jointly elaborated by PCA. The score and loading plots in the plane defined by PC1 and PC2 (70.9% total variance explained) are shown in Figure 5a,b. In the score plot (Figure 5a), a clear separation between FF and FPN samples can be observed on PC2; moreover samples are discriminated according to their storage time along PC1 moving from left to right.

From the loading plot (Figure 5b), it can be observed that electronic nose sensors are mainly positioned along PC1 together with bitterness and aftertaste bitterness, whereas umami, astringency and sourness are predominant on PC2. Considering the sample and variable distribution on the plots, FPN samples located in the negative part of PC2 are characterized by the saltiness and umami taste and by WW1 and WS (W1S, W5S) electronic nose sensors. FF samples are located in the positive part of PC2 and are characterized by astringent sensation and by sourness; on PC1 the electronic nose sensors and the bitter taste are dominant in the discrimination of samples according to their storage time.

**FIGURE 2** Control bread—FF (left); Enriched bread—FPN (right)

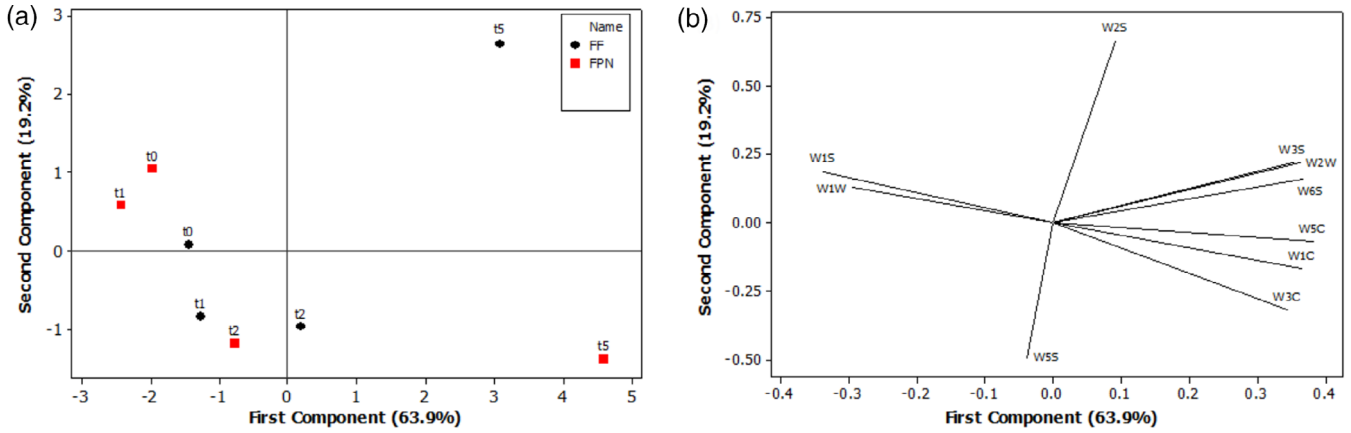


**FIGURE 3** A score plot (left) and PCA loading plot (right) of electronic nose data of control (FF) and enriched (FPN) bread

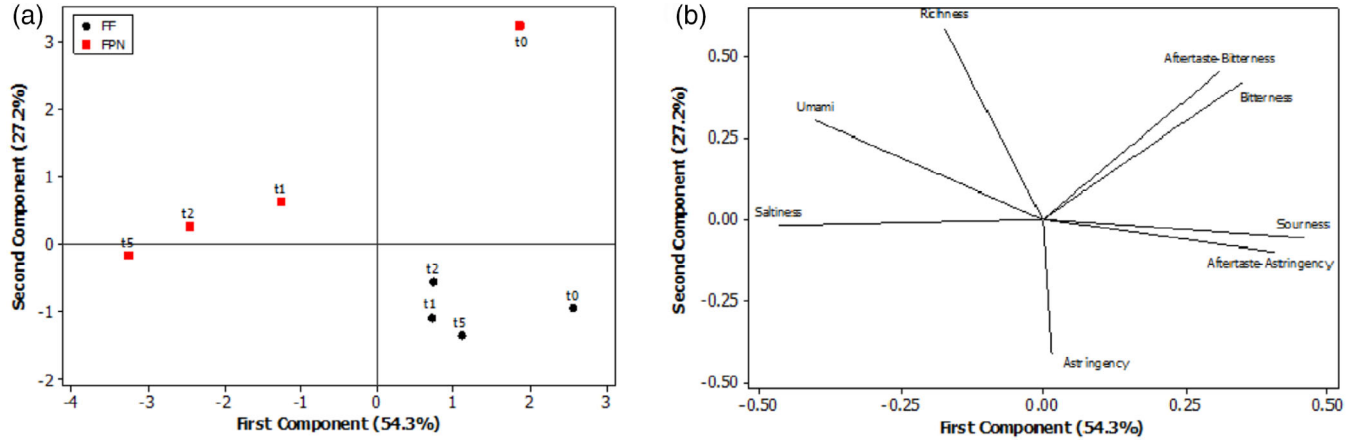


**FIGURE 4** PCA score plot (left) and PCA loading plot (right) of electronic tongue data of control (FF) and enriched (FPN) bread

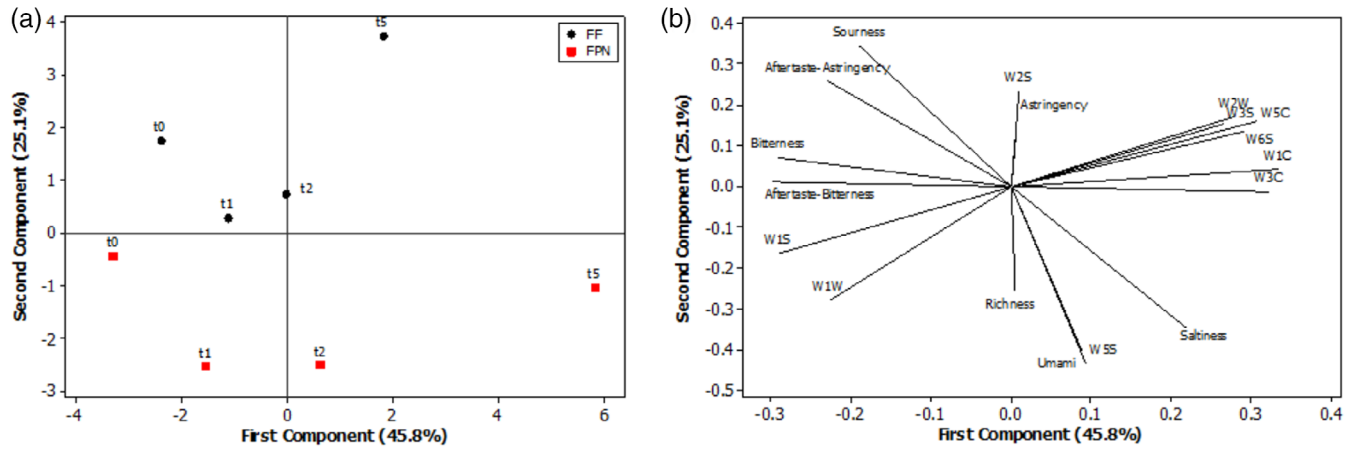


**FIGURE 5** PCA score plot of electronic nose and electronic tongue (left) and PCA loading plot of electronic nose and electronic tongue (right) data of control (FF) and enriched (FPN) bread

## 4 | CONCLUSIONS

The greatest differences between the odors of the bread samples were observed after 5 days of storage. In the first 48 hr, the electronic nose was unable to differentiate the bread samples, and it was not possible to identify the odor of fish until that moment. The bread samples were well differentiated in terms of taste, the biggest differences being observed at the first evaluation time. At the others times, the

bread samples differences were reduced. The use of electronic sensory methods showed promising. Confer greater specificity in the determination of odors and taste of products. Therefore, these tools can be used to improve the sensory characteristics of the new products, as enriched foods.

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## AUTHOR CONTRIBUTIONS

**Gilberto Fagundes:** Conceptualization; data curation; formal analysis; investigation; methodology; project administration; supervision; validation; visualization; writing-original draft; writing-review and editing. **Simona Benedetti:** Data curation; formal analysis; investigation; methodology; validation; visualization; writing-original draft; writing-review and editing. **M. Ambrogina Pagani:** Conceptualization; project administration; resources; supervision. **Angela Fiorentini:** Supervision; visualization; writing-original draft; writing-review and editing. **Joseana Severo:** Supervision; visualization; writing-original draft; writing-review and editing. **Myriam Salas-Mellado:** Conceptualization; funding acquisition; methodology; project administration; resources; supervision.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author.

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