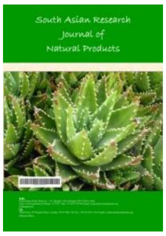


*South Asian Research Journal of Natural Products*

*5(4): 1-8, 2022; Article no.SARJNP.94556*

# Broad Bean and Carob Flours, Alternative Ingredients to Amplify Sensory Notes

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

***Article Information***

**Open Peer Review History:**
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***Short Research Article***

***Received 17 October 2022***
***Accepted 19 December 2022***
***Published 23 December 2022***

## ABSTRACT

**Objectives:** Determine the volatile compounds present in flours obtained from regional fruits and correlate them with sensory descriptors. These legume flours present bioactive compounds that could enhance gluten-free foods by improving sensory and nutritional quality.
**Study Design:** Cross-sectional experimental. Carob (*Prosopis alba*) flour was obtained from fruits collected from Arraga, Santiago del Estero, Argentina and broad bean (*Vicia faba*) flour, provided by the CAUQUEVA Cooperative in the province of Jujuy, Argentina. These were subjected to the study of volatile composition and sensory profile of aromas.
**Place and Duration of the Study:** It was carried out at the Institute of Chemical Sciences and the Institute of Food Science and Technology, National University of Santiago del Estero. Argentina during the year 2019.
**Methodology:** Suspensions were made with the flours. Eight trained panelists between the ages of 23 and 60 participated, and worked with the quantitative Descriptive Profile methodology. To determine the volatile compounds in the flours, the manual technique of solid phase microextraction (SPME) and a 100 μm fiber coated with polydimethylsiloxane (PDMS) (Supelco, Bellefonte, PA, USA) were used, followed by gas chromatography. coupled to mass spectrometry (MEFS-CGMS).
**Results:** Acids, esters, ketones, hydrocarbons, terpenes and sulfur compounds were identified. 22

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compounds were found in carob flour and 16 in broad bean flour, 12 are common. Broad bean flour aromatic descriptors: fresh bean, bitter, grassy, rancid, yeasty. The ketones would be linked to the smell of grass and fresh beans, the alcohols to the descriptors rancid, bitter and yeast. Carob flour descriptors: toasted, cocoa butter, melon, sweet, spicy, almond. The decanal is related to the smell of melon. The toasty smell is linked to the pyran group of ketones.

**Conclusions:** The volatile composition of both flours and the sensory aromatic profile were determined.

*Keywords: Volatiles; broad bean flour; carob flour; sensory profile.*

## 1. INTRODUCTION

The smell is one of the first characteristics perceived by the human senses, crucial for the acceptance of food by consumers. The most widely consumed baked goods have traditionally been made with wheat or rye flour, which provide pleasant notes with compounds that come mainly from fermentation, lipid oxidation or Maillard processes. However, it is well known that baked goods made with gluten-free (GF) flours have decreased sensory characteristics concerning traditional wheat counterparts.

Differences in proteins, sugars, lipids, enzymes and antioxidants between the different gluten-free flours/starches could lead to important differences in the volatile profile. Until now, research on the aroma of gluten-free baked goods has focused on understanding the origin of volatile compounds compared to wheat bread, but no sensory data on broad bean and carob flours that could be used in the formulation of GF baked goods were found.

The partial replacement of GF flours by other flours with greater power and aromatic richness —such as alternative cereal flours (teff, millet or sorghum), pseudo-cereals (buckwheat, quinoa or amaranth) or leguminous flours— has a clear impact on the aromatic profile of the bread [1,2].

In the ecosystem of the Gran Chaco Americano, there is an extraordinary plant biodiversity, with an important production of wild fruits with attractive nutritional qualities [3].

The Food and Agriculture Organization of the United Nations (FAO) recommends promoting the care, production and cultivation of underexploited native plants, to broaden the food base [4].

Despite the beneficial properties of the fruits of native plants, they are still underutilized raw materials. An alternative to overcome this limitation is the transformation of these fruits into flours (F) that can be incorporated into food products and/or fodder for human and/or animal consumption.

From a nutritional point of view, cereals are the main energy providers in the human diet, they are foods widely consumed by the population, but they are not suitable for people with intolerant to gluten, so rice flour is generally used as a base bakery for these individuals.

However, the volatile odorant profile of rice flour is flat and without attractive notes. Recent studies reflect the latent dissatisfaction among celiac consumers regarding the sensory quality of the bread they consume [5,6].

At present, various authors have focused on the search for flours rich in nutritional compounds of interest such as proteins, fibers, minerals and polyphenols, but free of GF [7-15].

Thus, flours composed of cereals and legumes have a double beneficial effect: higher protein content in the mix and a better balance of essential amino acids. The composition of the compound flours affects not only the nutritional quality but also the functional, sensory and phytochemical qualities of the food products made from them.

On the other hand, knowing the profile of volatile odorant components of the flours of these legumes becomes important since it would be useful to incorporate them into GF formulations and design improved foods compared to market counterparts with a different sensory profile, which would expand the food supply to the gluten-intolerant segment of the population.

The sensory profile of baked goods will be strongly influenced by the flour and/or starch used, since the ingredients contain the precursors that will give rise to the volatile compounds responsible for their organoleptic characteristics [16].

## 2. MATERIALS AND METHODS

The broad bean flour (BF) was provided by the CAUQUEVA Cooperative from Jujuy, Argentina.

The fruits of Prosopis alba selected, clean and dry were collected from Arraga, Silípica Department, Santiago del Estero, Argentina.

For the process of obtaining carob flour (CF), the selected and cleaned fruits were dried at 48±2 ºC in a forced-air oven (DALVO, DHR/F/I) at a speed of 2 m/s for 340 hours. Subsequently, they were ground for 90 s at 2900 rpm in CROYDON blade mechanical action equipment. The endocarp was separated from the mesocarp and epicarp using an ASTM 8 sieve (2380 µm). The endocarp milling product was sieved through a set of ASTM sieves (35, 80), the fractions used for the different tests were from the fraction that passes the ASTM 35 sieve and is retained on the ASTM 80 sieve (R80) with a particle size between 500 and 177 µm.

Storage conditions were especially careful to avoid the loss of volatiles, so they were vacuum packed (-690 mmHg) in 200 µm bags and stored at refrigerated temperature (4°C).

### 2.1 Sensory Profile of Odor in Broad Bean and Carob Flour

To carry out the aroma profile, we worked with 8 trained panelists, between 23 and 60 years old. Before the definitive determinations, training sessions were carried out, following the techniques of the quantitative descriptive analysis (QDA) method developed by Stone [17].

A total of 2.5 hours were organized before the sensory test. During the first 90-minute session, the different flour samples were presented to the panelists. They described the samples individually and then discussed them with the rest of the judges and with the leader of the panel, Norma 20002 [18]. The 8 panelists verbalized their impressions regarding the two samples presented. For the selection of the descriptors, the objective of the study was taken into account and those of similar meaning and those that were used with a frequency of less than 40% were eliminated [19]. After the training in the use of scales, we worked on measuring the intensity of the descriptors on 10 cm scales. Anchored at the ends. Three repetitions were performed.

The resulting data were submitted to the analysis of variance of two factors: sample and evaluators.

### 2.2 Identification of Volatile Compounds

For the identification of volatile compounds, the samples were analyzed by applying the manual technique of solid phase micro-extraction (SPME) and a 100 µm fiber coated with polydimethylsiloxane (PDMS) (Supelco, Bellefonte, PA, USA), followed by gas chromatography coupled to mass spectrometry (MEFS-CGMS).

For the extraction of volatile compounds, 1 g of flour was placed in a 5 ml vial covered with a PTFE/silicone septum and sealed with aluminum caps (Supelco) for headspace analysis. Before taking the sample, the fiber was conditioned in the CG injector at 250 °C for 3 minutes.

The vial with each of the samples was placed in a bath at a temperature of 60 °C to allow the volatilization of the flour components and their equilibrium with the headspace. The SPME fiber was inserted into the sealed vial by manual penetration of the septum and exposed to the headspace for 30 minutes. After that time, the fiber was inserted into the GC injector and the organic compounds were thermally desorbed (250 °C) for 1 minute.

Chromatographic analyzes were carried out on a Thermo Scientific Focus GC coupled to a DSQII mass detector. The GC was operated in split-less mode. A TR-5MS capillary column (30 m× 0.25 mm× 0.25 µm) (Thermo Fisher Scientific) was used under the following analytical conditions: initial temperature 50°C for 5 min, a temperature ramp of 7°C $min^{-1}$ until a final temperature of 250°C, which was kept constant for 10 min.

The samples were analyzed in triplicate. The identification of the compounds was carried out using the NIST-08 spectral library (Software Xcalibur 2.0.7, Thermo Fisher Scientific Inc.), the calculation of the retention indices (Kovats indices, KI), data reported in literature (Adams and Sparkman, 2007), and the comparison with commercial standards. Retention indices were calculated using linear interpolation relative to retention times of C7–C25 of n-alkanes and then compared with those commercial standards and data from the literature. The commercial standards used were limonene, dodecane, tridecane, 3-methyltridecane, α-caryophillene, 2-pentadecanone, pentadecane, hexadecane, heptadecane, octadecane and nonadecane, 3-methyldodecane, decanal. The identification of *t*-muurolene, α-copaene, 5,6-Dihydro-2H-pyran-2-one, 5,6-dihydro-6-propyl-2H-pyran-2-one, and γ-nonalactone is tentative but were reported in literature for Carob flour [20,21].

## 3. RESULTS AND DISCUSSION

The mechanical damage of the elaboration process contributes to the development of the characteristic reactions of the constituents and the generation of aromas, because its cellular structure is broken and the enzymes come into contact with its precursors and can hydrolyze them.

### 3.1 Sensory Profile of Odor in Broad Bean and Carob Flour

A list of 12 odor descriptors for CF and 10 for BF was obtained. Those with the highest frequency of responses issued by the judges were selected and those with a similar meaning were discarded. Figs. 1 and 2 present the results for CF and BF respectively.

It can be seen in the figure that the toasted aroma is the one that is perceived with the greatest intensity, which is attributable to the drying process of the carob fruit prior to grinding.

The smell of grass predominates over the sui generis smell of fresh broad beans. It is noteworthy that, although in a small proportion, a slight rancid odor was detected due to the type of lipids present in beans that are sensitive to oxidation.

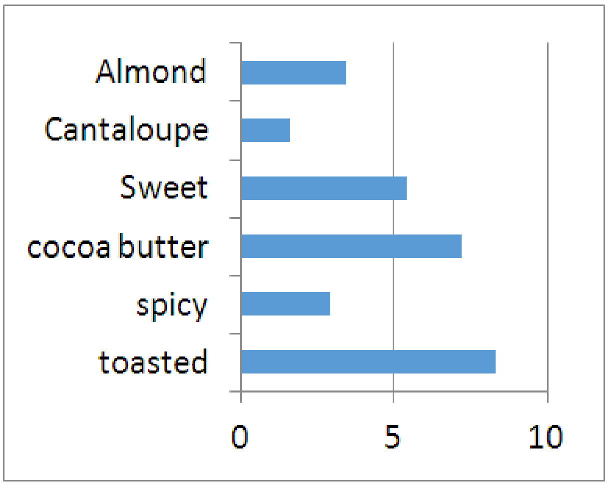


**Fig. 1. Representation of CF descriptors**

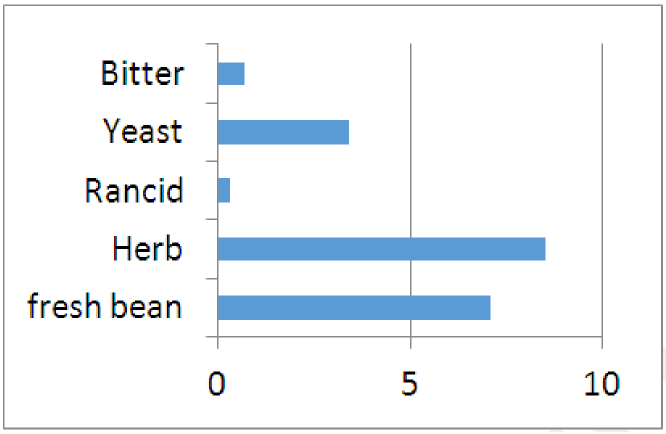


**Fig. 2. Representation of BF descriptors**

### 3.2 Identification of Volatile Compounds in Bean and Carob Flours (gluten-free)

Compounds of different chemical families, acids, esters, ketones, hydrocarbons, terpenes and sulfur compounds among others, associated with enzymatic and non-enzymatic reactions and lipid oxidative reactions, were identified. Among the major compounds, 22 compounds were found for CF and 16 compounds in BF, of which 12 are common to the two flours under study.

Among the common compounds are: limonene, dodecane, benzothiazole, tridecane, 3- methyl tridecane, α–caryophillene, *t*-muurolene, pentadecane, hexadecane, heptadecane, octadecane and nonadecane, these are found in different proportions as shown in Fig. 3.

Fig. 3 shows that the flours of these legumes under study have a similar qualitative radial representation in their shape, showing the bean flour with a higher concentration in 10 of the 12 common compounds, except for octadecane and tridecane, which in HA is found in greater amount.

BF has 3 compounds that were not found in CF: undecane, gamma nonalactone, and n-Hexyl hexanoate, as shown in Table 1.

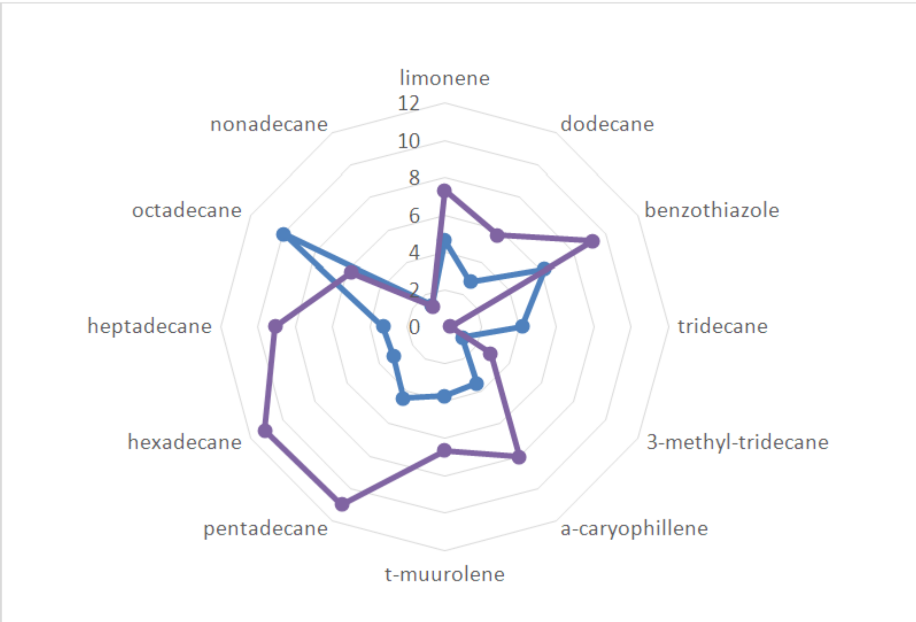


**Fig. 3. Radial representation of the percentage areas of the BF ( ▬ ) and CF (▬) volatile compound peaks**

**Table 1. Exclusive components present in CF and BF**

| CF | | BF | |
|---|---|---|---|
| **Component** | **%Area** | **Component** | **%Area** |
| 1,2,4-trimethylbenzene | 4,57 | undecane | 4,28 |
| (2-methoxyethyl)-benzene | 5,17 | γ-nonalactone | 0,48 |
| 5,6-dihydro-2H-pyran-2-one | 8,28 | n-Hexyl hexanoate | 10,93 |
| decanal | 1,41 | | |
| 3-methyldodecane | 1,55 | | |
| □-copaene | 2,49 | | |
| tetradecane | 4,09 | | |
| 2-pentadecanone | 2,14 | | |

γ-nonalactone is naturally present in many fruits, including pineapple, blackberries, and some melons; and it is also a component of bourbon whiskey [22] and wines aged in oak barrels. γ -nonalactone is widely used in the creation of sweet fragrances and flavors for foods.

N-hexyl hexanoate: odor, herbaceous, fresh. Hexyl hexanoate belongs to the class of organic compounds known as fatty acid esters. Hexyl hexanoate has an odor of apple peel, cut grass, and a fresh taste. This could make hexyl hexanoate a potential biomarker for the consumption of these foods.

Regarding CF, the areas of 6-Propyl-5,6-dihydro-2H-pyran-2-one and 5,6-Dihydro-2H-pyran-2-one stand out according to what is shown in Fig. 4.

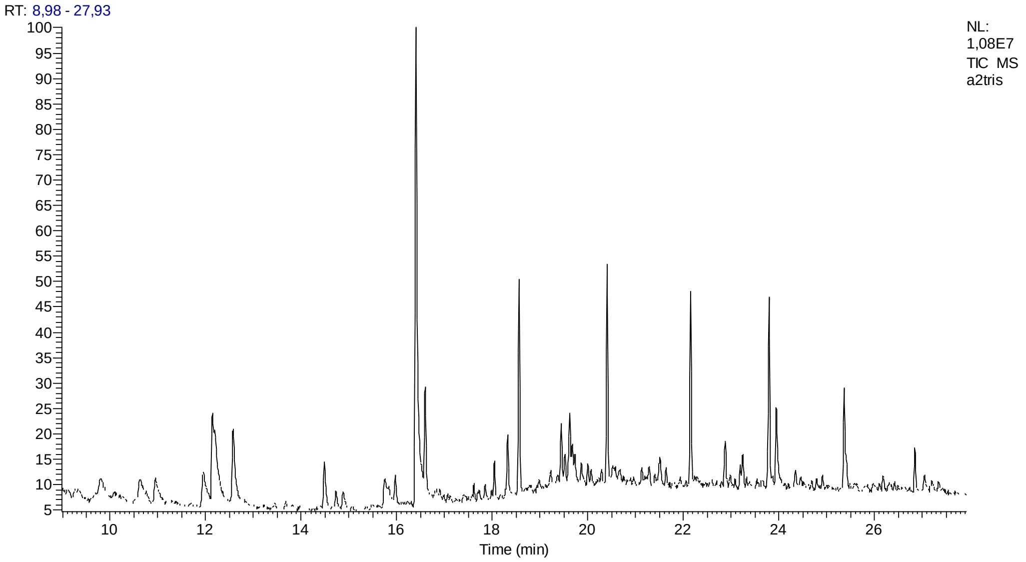


**Fig. 4. Chromatogram obtained by SPME extraction (100 µm coated with polydimethylsiloxane (PDMS)) and GC/MS determination on CF**

**Table 2. Volatile compounds identified in the chromatogram of Fig. 3**

| Compound | RT | KI | KIcal | %Area |
|---|---|---|---|---|
| 1,2,4-trimethylbenzene | 9,78 | 1006 | 1003 | 4,57 |
| limonene | 10,61 | 1034 | 1036 | 4,63 |
| 1-bromoheptane | 10,93 | nc | 1049 | 2,18 |
| (2-methoxyethyl)-benzene | 11,94 | 1083 | 1089 | 5,17 |
| 5,6-dihydro-2H-pyran-2-one | 12,12 | 1094 | 1096 | 8,28 |
| dodecane | 14,48 | 1200 | 1199 | 2,80 |
| decanal | 14,86 | 1208 | 1217 | 1,41 |
| benzothiazole | 15,72 | 1258 | 1258 | 6,20 |
| 3-methyldodecane | 15,96 | 1270 | 1269 | 1,55 |
| 5,6-dihydro-6-Propyl-2H-pyran-2-one | 16,39 | 1290 | 1290 | 19,88 |
| tridecane | 16,59 | 1300 | 1299 | 4,17 |
| 3-methyl-tridecane | 18,04 | 1373 | 1373 | 1,12 |
| α -copaene | 18,32 | 1382 | 1387 | 2,49 |
| tetradecane | 18,56 | 1400 | 1399 | 4,09 |
| α -caryophillene | 19,44 | 1447 | 1447 | 3,49 |
| *t*-muurolene | 19,62 | 1457 | 1457 | 3,71 |
| pentadecane | 20,41 | 1500 | 1499 | 4,41 |
| hexadecane | 22,15 | 1600 | 1599 | 3,14 |
| heptadecane | 23,79 | 1700 | 1699 | 3,30 |
| 2-pentadecanone | 23,93 | 1703 | 1706 | 2,14 |
| octadecane | 25,36 | 1800 | 1800 | 9,94 |
| nonadecane | 26,85 | 1900 | 1899 | 1,32 |

The compound 5, 6-dihydro-6-propyl-2H-pyran-2-one, found among the volatiles present in CF, contributes to an aroma of chocolate and coconut, which is related to what was stated by the trained judges who describe this smell like cocoa butter. In addition, the compounds that present pyrano groups in their structure, due to the magnitude of their odor threshold, probably contribute strongly to the odor of carob flour, linked to the roasted descriptor found by the sensory panelists.

The odor notes attributed to volatile compounds together with other sensory characteristics are interesting properties as a strategy to improve the sensory quality of gluten-free products on the market.

## 4. CONCLUSIONS

Being the aroma one of the most important sensory attributes of food, in this study it was possible to characterize in a preliminary way the volatile composition of these flours and the profile of odorants determined by the panel of trained judges.

The results found would be very useful when considering the formulations of LG products, especially in baked goods, suggesting studies of volatile compounds in these foods after their preparation.

## ACKNOWLEDGEMENT

The authors thank the project “Study and characterization of autochthonous food resources (fruits and exudates) of NOA tree species. Development of processes for food production”, directed by Dr. Ing. Myriam Villarreal for providing the samples to carry out these studies.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Campo E, Del Arco L, Urtasun L, Oria R, Ferrer-Mairal A. Impact of sourdough on sensory properties and consumers´ preference of gluten-free breads enriched with teff flour. Journal of Cereal Science. 2016;67:75-82.
2. Hager AS, Wolter A, Czerny M, Bez J, Zannini E, Arendt EK. Investigation of product quality, sensory profile and ultrastructure of breads made from a range of commercial gluten free flours compared to their wheat counterparts. European Food Research Technology. 2012;235:333-44.
3. Escudero NL, Arellano ML, Mucciarelli S. Taraxacum officinale as a food source. Plants Foods for Human Nutrition. 2004;1–10.
4. FAO, 1993 Conference at its 27th session in November 1993, Multilateral agreement, 24 November 1993, United Nations Treaty Series. 22214; (91):120-129
5. Do Nascimento AB, Fiates GM, Dos Anjos A, Teixera E. Gluten free is not enough—perception and suggestions of celiac consumers. International Journal of Food Science and Nutrition. 2014; 65:394-8.
6. O’Shea N, Arendt E, Gallagher E. State of the art in gluten-free research. Journal of Food Science. 2014;79:1067-1076.
7. Cattaneo F, Costamagna MS, Zampini IC, Sayago J, Alberto MR, Chamorro V, et al. Flour from Prosopis alba cotyledons: A natural source of nutrient and bioactive phytochemicals. Food Chemistry. 2016;208:89–96.
8. Cattaneo F, Sayago JE, Alberto MR, Zampini IC, Ordoñez RM, Chamorro V, et al. Anti-inflammatory and antioxidant activities, functional properties and mutagenicity studies of protein and protein hydrolysate obtained from Prosopis alba seed flour. Food Chemistry. 2014;161:391–399.
9. Freyre M, Astrada E, Blasco C, Baigorria M, Rozychi V, Bernardi C. Valores nutricionales de fruto de vinal (*Prosopis ruscifolia*) Consumo humano y animal. Ciencia y Tecnologia Alimentaria-Sociedad Mexicana de Nutricion y Tecnologia de Alimentos. 2003; (4) 41–46. Spanish.
10. Jimenez ME, Rossi A, Sammán N. Health properties of oca (*Oxalis tuberosa*) and yacon (*Smallanthus sonchifolius*). Food & Function. 2015;1–9.
11. Praderes G, García A, Pacheco, E. Caracterización físicoquímica y propiedades funcionales de harina de quinchoncho (Cajanus cajan) obtenida por secado en doble tambor rotatorio.

Revista Facultad de Agronomía. Universidad Veneezuela. Spanish. 2009;35(2):79–84.
12. Resende M, & Franca AS. Flours Based on Exotic Fruits and Their Processing Residues — Features and Potential Applications to Health and Disease Prevention. In Flour and Breads and their Fortification in Health and Disease Prevention. 2019;387–401.
13. Ribotta PD, Ausar S, Morcillo M, Pérez G, Beltramo D. León A. Production of gluten-free bread using. Journal of the Science of Food and Agriculture. 2004;1969–1974.
14. [14] Torres Gonzáles MP, Jiménez Munguía MT & Bárcenas Pozoz ME. Harinas de frutas y/o leguminosas y su combinación con harina de trigo. Temas Selectos de Ingenieria de Alimentos. Spanish. 2014; 8:94–102.
15. Vázquez Ovando A, Rosado Rubio G, Chel Guerrero L, Betancur Ancona D. Physicochemical properties of a fibrous fraction from chia (*Salvia hispanica* L.). LWT - Food Science and Technology. 2009;42(1):168–173.
16. Pico Carbajo J. Analysis of volatile compounds in breads and related product. Improvement of gluten-free breads aroma. Tesis Doctoral; 2018.
17. Stone H. Sensory evaluation by quantitative descriptive analysis. Food technology. 1974;28 (11):24-32
18. IRAM. Directivas generales para la metodologia. Norma 20002; 1995.
19. Damasio M and Costell E. Ananlisis sensorial descriptive: generacion de descriptors y seleccion de cataxdore. Revista Agroquimica. Tecnologia alimentaria. 1991; 31(2): 165-178. Spanish.
20. Takeoka GR, Wong Y, Dao LT, Felker P. Volatile constituents of mesquite (Prosopis) pods. Food Chemistry. 2009;115(3):1025-1027.
Available:https://doi.org/10.1016/j.foodchem.2008.12.081
21. Sparkman D. Identification of Essential Oil Components by Gas Chromatography/Mass Spectrometry, 4th Edition, Robert P. Adams. Allured Publishing Corporation, USA; 2007. ISBN: 978-1-932633-21-4.
22. Ferron P, Thibon C, Shinkaruk S, Darriet P, Allamy L, Pons A. Aromatic potential of Bordeaux grape cultivars: Identification and assays on 4-Oxononanoic acid, a γ-Nonalactone precursor. Journal of Agricultural and Food Chemistry. 2020; 68(47):13344-13352.



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