EFFECT OF HYPERBARIC STORAGE AT ROOM TEMPERATURE ON THE VOLATILE PROFILE OF STRAWBERRY JUICE

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ABSTRACT

The effect of hyperbaric storage at room temperature on the volatile profile of raw strawberry juice was evaluated. To do so, volatile profiles of strawberry juices maintained at 20 °C and different pressure levels (0.1, 50, and 200 MPa) for 15 days were analyzed by gas chromatography-mass spectroscopy and compared to those of control samples at day 0. Data corresponding to juices stored under traditional refrigeration (0.1 MPa/5 °C) for the same period are also presented for comparison. Hierarchical Cluster Analysis (HCA) and Partial Least Squares Discriminant Analysis (PLS-DA) were applied to discriminate the samples according to the storage conditions. The results clearly showed that samples stored under pressure were the most similar to the control juices at day 0. Moreover, hyperbaric storage, unlike refrigeration at atmospheric pressure, was efficient to avoid changes in all the key aroma compounds detected in the strawberry juice.

Keywords: hyperbaric storage; strawberry juice; volatile profile; high pressure; food preservation

INTRODUCTION

About 50% of total energy in the food industry is consumed by refrigeration-related facilities. The generation of this energy contributes to CO₂ production, global warming, and...
climatic change, which nowadays are considered major threats to our planet. For all these reasons, in recent decades many efforts have been made in the food-agro industry to improve the performance of conventional refrigeration systems, to find new environmentally friendly refrigeration technologies, and also to look for new energy-saving opportunities in food preservation (James & James, 2010; Tassou, Lewis, Ge, Hadawey, & Chaer, 2010).

Hyperbaric storage of food at room temperature could be one of these opportunities because it only involves energy costs during compression, and no additional energy is required to maintain the product under pressure for long times. Consequently, hyperbaric storage has attracted the attention of many researchers during the last few years, and some studies have been made recently to assess the feasibility of this technology to extend the shelf life of either fresh fruits and vegetables or processed products. In fresh fruits and vegetables, hyperbaric storage is used as a postharvest technique and it consists in subjecting the product to a pressure environment in which the proportion of air components is maintained. In this case, pressure is maintained at a relatively low level (0.1–1.0 MPa) to avoid damage to the cell structure of living tissues, and it is expected to influence the postharvest physiology and quality of the stored fruit and vegetables (Baba & Ikeda, 2003; Liplap, Boutin, LeBlanc, Vigneault, & Raghavan, 2014; Liplap, Vigneault, Toivonen, Charles, & Raghavan, 2013). In processed food (non-living tissues), pressure is transmitted by a liquid medium and it can be increased considerably (25–220 MPa), especially in homogenized products. Recently, several authors have shown that hyperbaric storage at room temperature could be an interesting technology for short-term preservation of juices from various products, such as strawberry, melon, or watermelon (Segovia-Bravo, Guignon, Bermejo-Prada, Sanz, & Otero, 2012; Fidalgo et al., 2013; Queirós et al., 2014). In strawberry juice, Segovia-Bravo et al. (2012) found that hyperbaric storage for 15 days, at pressures of 25 MPa and higher, was able to reduce the initial microbial load of the juice by more than 2 log units to levels below the limit of detection. Moreover, pressure was effective to attenuate viscosity and color losses. However, the effect of hyperbaric storage on the volatile profile of the strawberry juice was not evaluated.

It is widely assumed that high pressure does not substantially alter the fresh odor of fruits and vegetables because small molecular flavor compounds are not directly affected by pressure. Thus, different authors have reported that pressure (200–600 MPa) applied for short
times (1–20 min) at room temperature has no significant effect on the volatile profile of various
homogenized fruit products, such as strawberry coulis (Lambert, Demazeau, Largeteau, &
Bouvier, 1999) and guava (Yen & Lin, 1999) or orange (Baxter, Easton, Schneebeli, & Whitfield,
2005; Vervoort et al., 2012) juices, among others. However, there are hardly any data about the
effect of longer-term pressure exposures. Pressure storage could indirectly alter the content of
some odor compounds by enhancing or retarding enzymatic and chemical reactions, and
subsequently result in undesired changes in the overall odor (Viljanen, Lille, Heiniö, & Buchert,
2011).

The aim of this work was to study the effect of hyperbaric storage at room temperature
on the volatile fraction of strawberry juice. To do so, the volatile profiles of strawberry juices
stored at different pressure levels (0.1, 50, and 200 MPa) and 20 °C for 15 days were analyzed
by gas chromatography-mass spectroscopy (GC-MS) and compared with those of control
samples at day 0. Data corresponding to samples stored under traditional refrigeration (0.1
MPa/5 °C) for the same period are also presented for comparison. The results obtained in this
paper provide important data to evaluate the viability of hyperbaric storage at room temperature
for food preservation.

2. MATERIALS AND METHODS

2.1. Sample

Strawberries (*Fragaria x ananassa* Duch., cv. Chandler) were purchased at commercial
maturity from a local supplier. The fruits were washed with tap water and processed with a juicer
(Moulinex Frutti Pro, Moulinex, France). The liquid obtained was then centrifuged at 3500 g and
7 °C for 10 min (Sorvall Evolution RC Superspeed centrifuge, Thermo Scientific, Madrid, Spain).
The supernatant was subsequently collected, filtered through a 0.1 mm pore diameter sieve,
and stored at −80 °C until utilization. Before each storage experiment, a frozen batch of
strawberry juice was thawed overnight at 5 °C and transferred to 50 mL polypropylene tubes.
The tubes were completely filled with strawberry juice and closed with screw caps sealed by a
nitrile rubber O-ring.
Control juice at day 0 (C samples) was then characterized by measuring some of its physicochemical properties (see Table 1). Soluble solids concentration (°Brix) was approximated by using a digital refractometer (Leica AR200, Leica Microsystems Inc., New York, USA) with automatic temperature compensation, pH was measured with a pH-meter (pH-Burette 241S equipped with a pH 50 21 electrode and a C.A.T. 5531 temperature sensor, Crison Instruments, Barcelona, Spain), and color was determined, as L* (lightness), a* (redness), and b* (yellowness), with a CM-3500d spectrophotometer (Konica Minolta, Japan).

2.2. Storage experiments in strawberry juice

Storage experiments under pressure were carried out in a pilot-plant high-pressure storage system (model SV1, Institute of High Pressure Physics, Unipress Equipment Division, Poland). It was composed of two high-pressure stainless steel vessels with independent pressure control, two control terminals, and a high-pressure pump (model BP3, Institute of High Pressure Physics, Unipress Equipment Division, Poland). Both vessels had 100 mm internal diameter, 130 mm height and a working volume of 1 L and they were located in individual thermostatic chambers. Strawberry juices were stored for 15 days at 20 ± 2 °C and two different pressure levels (50 and 200 MPa) to obtain samples labeled as T20_50MPa (20 °C/50 MPa) and T20_200MPa (20 °C/200 MPa). Temperature and pressure were recorded every 30 s by a data acquisition system (MW100 Data Acquisition Unit, Yokogawa Electric Corporation, Tokyo, Japan). Storage experiments at atmospheric pressure for 15 days were performed in two thermostatic chambers tempered either at 20 ± 2 °C or at 5 ± 2 °C to obtain T20_Patm (20 °C/0.1 MPa) and T5_Patm (5 °C/0.1 MPa) samples, respectively. All the storage experiments were performed in triplicate.

2.3. Headspace analysis in strawberry juice
Immediately after storage, three grams of each strawberry juice sample was transferred into 22 mL glass vials. Then the vials were sealed with polytetrafluoroethylene (PTFE)/Butyl septa and crimp caps, and frozen at −80 °C till use.

Volatile analyses were performed using an Agilent 6890N Series gas chromatograph coupled to an Agilent 5973 Series mass selective detector (Agilent Technologies, Heilbronn, Germany) and equipped with a TurboMatrix 40 Trap Headspace sampler (Perkin Elmer, Shelton, CT, USA). Before the analysis, all the sample vials were completely thawed at room temperature and an aliquot of 10 μL of 2-octanone (32.72 mg/L in water) was added as internal standard to each vial. Samples were maintained at 80 °C for 25 min to drive the volatile compounds from the strawberry juice into the headspace. Volatile compounds were then sent to the TurboMatrix trap to be concentrated. Four trap load cycles of 5 min were carried out for each vial. The trap was subsequently dried by passing helium (99.995%) through it for 7 min to remove moisture. Finally, the analytes were thermally desorbed, through a transfer line heated at 110 °C, for 3 min and transported into the injection port of the GC column, at 240 °C and in splitless mode, for separation. Chromatographic separation was achieved on an HP-5MS capillary column (30 m x 0.25 mm i. d.; 0.25 μm film thickness, 5% Phenyl Methyl Siloxane, Agilent Technologies, Palo Alto, CA, USA), using helium as carrier gas at a constant flow rate of 1.2 mL/min. The initial oven temperature was held at 40 °C for 4 min, then increased at 4 °C/min to 110 °C and at 6 °C/min to 180 °C, maintained at 180 °C for 5 min, then again increased at 8 °C/min to 230 °C, and finally held at this temperature for 2 min.

The outlet of the column was coupled to the Agilent 5973 mass selective detector. It operated in electron impact ionization mode at 70 eV, using full-scan acquisition mode from m/z 30 to 550. MS ion source and quadrupole temperatures were 230 °C and 150 °C, respectively.

### 2.4. Data analysis

The GC-MS chromatograms obtained were evaluated and integrated using the ChemStation program (Agilent Technologies, Palo Alto, CA, USA). Identification of peaks in the chromatograms was performed by injection of commercial standards, by spectra comparison with the Wiley Registry 7th Edition Mass Spectral Library (Wiley and Sons Inc., Germany) and the National Institute of Standards and Technology (NIST) 2005 Mass Spectral Library, and by
calculation of linear retention indices (LRI) using retention time data from a series of alkane standards ($C_6 - C_{20}$) run under the same chromatographic conditions. The normalized peak area of each compound was then calculated as the ratio of its peak area to the area of the internal standard.

In a first step, Hierarchical Cluster Analysis (HCA), an unsupervised pattern recognition method, was applied to calculate similarities among the samples and establish whether a discriminant classification method could be developed subsequently. A hierarchical clustering procedure with complete linkage, using the Pearson correlation distance, was used to generate clusters.

After this exploratory analysis, data were subjected to Partial Least Squares Discriminant Analysis (PLS-DA) to look for potential differences in the volatile profiles of the juices in order to classify the samples according to storage conditions. In this analysis, compound abundances were considered as explanatory X-variables and the different classes of samples as categorical Y-variables or responses. All data were mean-centered and the variables were weighted by their standard deviation to give them equal variance. A PLS-DA calibration model was generated using all the samples to find the latent variables (LV) or factors in X that will best predict the latent variables in Y. Full cross-validation (leave-one-out) was then used to select the optimum number of latent variables or PLS-DA factors.

To evaluate the importance of each volatile compound in discriminating a specific sample, Variable Identification (VID) coefficients were estimated for each compound and response. VID coefficients were calculated as the correlation coefficient between each original X-variable and the Y-variables predicted by the PLS-DA model. In this paper, X-variables with an absolute value of the VID coefficient higher than 0.80 were considered of interest for the response examined. Moreover, to have a global view of these discriminant variables, they were plotted individually as a function of the class of juice.

All the multivariate analyses (HCA and PLS-DA) were performed with The Unscrambler® X, v. 10.2 (CAMO Software AS, Oslo, Norway).
3. RESULTS AND DISCUSSION

Thirty-one volatile compounds, including esters, aldehydes, alcohols, terpenoids, aromatic compounds, a furanone, and a ketone, were identified in the strawberry juices analyzed (Table 2). Resolution between hexanal and ethyl butanoate was too low for a proper quantitative measurement, and therefore data for the two compounds are presented together in Table 2. All the compounds detected in the samples had previously been described in the volatile profile of strawberry and strawberry products by many authors (Aubert, Baumann, & Arguel, 2005; Golaszewski, Sims, O’Keefe, Braddock, & Littell, 1998; Jetti, Yang, Kurnianta, Finn, & Qian, 2007; Kafkas et al., 2005; Pérez & Sanz, 2010).

In control juices, trans-2-hexenal, methyl acetate, methyl butanoate, and hexanal + ethyl butanoate peaks exhibited the largest abundances (data not shown). Moreover, according to other authors (Kafkas et al., 2005; Pérez & Sanz, 2010), esters were the qualitatively and quantitatively most important class of volatiles in C samples. However, from a flavor point of view, it is well recognized that the most abundant volatile compounds are not necessarily the most important sensory compounds. Some volatile compounds, usually known as key flavor compounds, are determinant in the aroma perceived, even at very low concentrations. Among the major compounds detected in control juices, methyl and ethyl butanoates, methyl hexanoate, trans-2-hexenyl acetate, and linalool have previously been identified as key flavor compounds in the typical strawberry-like odor by sensory evaluation methods (Aubert et al., 2005; Jetti et al., 2007; Larsen, Poll, & Olsen, 1992; Schieberle & Hofmann, 1997; Siegmund, Derler, & Pfannhauser, 2001). Other compounds, found in C samples at much lower concentrations, such as 3-methylbutyl acetate, 2-heptanone, hexyl acetate, and 2,5-dimethyl-4-methoxy-3(2H)-furanone, also known as mesifurane, have also been described as important for strawberry aroma (Forney, Kalt, & Jordan, 2000; Larsen & Poll, 1992; Larsen et al., 1992; Siegmund et al., 2001).

After 15 days of storage, samples maintained at atmospheric pressure and 20 ºC were clearly spoiled and stale and musty notes were detected in their aroma due to considerable microbial spoilage. Volatile compounds identified in these samples were those typical for fermented fruit products (data not shown). In contrast, samples maintained at 20 ºC under
pressure did not show any evidence of deterioration. These results could be related with a limited microbial activity during hyperbaric storage, because previous experiments in strawberry juices maintained for 15 days under pressure and at room temperature showed that pressure inhibited microbial growth (Segovia-Bravo et al., 2012).

At this point, T20_Patm samples were excluded from further testing and only C, T5_Patm, T20_50MPa and T20_200MPa samples were included in the following analyses to focus differentiation in non-spoiled samples.

3.1. Exploratory analysis

A Hierarchical Cluster Analysis of the data was first performed, as an exploratory technique, to detect groups in the samples, based on similarity or closeness measures. As shown in Figure 1, all the replicated samples were correctly grouped together. HCA allowed subdivision of the juice samples into clusters that exhibited a high degree of both intracluster similarity and intercluster dissimilarity. At the maximum distance (relative distance = 10), that is, at the highest level of differentiation, T5_Patm juices are separated from the rest and therefore they are classified as completely different from the other ones. At a relative distance of about 4.1, three clusters were established: cluster “a” consists of T5_Patm samples; cluster “b” comprises juices stored under high pressure (T20_50MPa and T20_200MPa samples) and cluster “c” corresponds to C samples. These results certainly reveal that juices preserved under pressure for 15 days are the most similar to control samples at day 0. This is a clear indicator that hyperbaric storage at 20 ºC makes it possible to preserve the volatile fraction of strawberry juices for at least 15 days, better than traditional cold storage does.

3.2. Discriminant analysis

A Partial Least Squares Discriminant Analysis of the compounds detected in the aroma profile of the strawberry juices gave some interesting information about the differences between them. The PLS-DA model performed consisted of seven latent variables or factors which explained 99.4% of the Y-variance. Figure 2a presents the correlation loadings plot for the first two latent variables, which together explained 63% of the Y-variance. It shows how the effect of storage temperature (20 ºC or 5 ºC) is mainly explained on the basis of the first latent variable,
while the effect of pressure (atmospheric or high pressure) is mainly included in the second factor.

The correlation loadings plot indicates the correlation between the original variables and the PLS-DA factors of the model, and it is very useful to determine volatiles characterizing classes of samples. As an example, the coordinates of a given type of juice on the first and second latent variables show how well this juice is correlated with these latent variables. The inner and outer ellipses in the plot represent correlation coefficients $r = 70\%$ and $r = 100\%$ (or $R^2$ values of 50\% and 100\%), respectively. Thus, for a variable located between the two ellipses, more than 70\% of its variability is explained by the first two latent variables. Figure 2a clearly shows how C and T5_Patm samples can be relatively well characterized by these two factors. Volatile compounds located between the ellipses and close to C samples, such as furan-2-methyl acetate, 2,4-hexadienal, or trans-2-hexenal should be characteristic of C samples, while those located in the opposite extreme of the plot, such as linalool or α-terpineol should present low abundances in control samples as compared to all the other juices. Obviously, both highly negatively and highly positively correlated compounds could act as potential discriminants of C samples. In the same way, volatile compounds located close to T5_Patm juices, such as 1-hexanol, present a high positive correlation with these samples while those located in the opposite extreme, such as hexanal + ethyl butanoate, trans-2-hexenyl acetate, or benzyl acetate present a high negative correlation with T5_Patm juices.

Figure 2a also reveals that two latent variables are not enough to discriminate T20_50MPa and T20_200MPa samples, which are grouped close together. Therefore, more factors are needed in the model to differentiate these samples effectively. Thus, Figure 2b presents a correlation loadings plot accounting for the third and fourth latent variables of the PLS-DA model. It illustrates how discrimination between T20_50MPa and T20_200MPa samples is mainly managed through the third latent variable of the PLS-DA model. Thus, T20_200MPa juices present a large positive loading on LV3 while T20_50MPa samples exhibit negative values just like butyl acetate.

3.3. Effect of storage conditions on the volatile profile of strawberry juice
The results obtained clearly show that the different storage conditions assayed in this paper distinctly affect the volatile profile of strawberry juice, and therefore sample discrimination by PLS-DA is possible. To evaluate the importance of each volatile compound in discriminating a specific sample, VID coefficients were calculated for each volatile and response. VID coefficients identify those compounds that are highly correlated, either positively or negatively, with a given class of juice. Thus, volatiles with a high absolute value of the VID coefficient for a class of juice present a particularly high or low abundance in that specific class as compared to all the other classes, and therefore they could act as class discriminants.

Table 3 reveals that, in control juices, furan-2-methyl acetate, trans-2-hexenal and 2,4-hexadienal have VID coefficients higher than 0.80. This means, as Figure 3 clearly shows, that the abundance of these volatiles was significantly higher in C samples than in all the stored juices. This high content in C6 aldehydes is probably due to the tissue disruption involved in the juice extraction. These compounds are formed enzymatically through the action of lipoxygenase, oxygen, and linoleic and linolenic acids, and it is widely known that tissue disruption and homogenization enhance their formation (Forney et al., 2000; Sumitani, Suekane, Nakatani, & Tatsuka, 1994). Then, during storage, these aldehydes are progressively degraded if enzymatic activities are not completely inhibited. Thus, significant decreases in C6 aldehyde concentration during cold storage of strawberry juices have been described previously in the literature (Aguiló-Aguayo, Oms-Oliu, Soliva-Fortuny, & Martín-Belloso, 2009).

The VID coefficients in Table 3 also reveal that linalool is less abundant in C samples than in the other juices. Therefore, during storage, linalool could be released from its glycosidic precursor by enzymatic hydrolysis carried out by β-glucosidase.

### 3.3.1. Storage at 5 °C: Traditional refrigeration

After 15 days of storage at 5 °C, some changes occurred in the volatile profile of the juice, as expected. The VID coefficients in Table 3 reveal that T5_Patm samples differed substantially from all the other samples in a number of volatile compounds (Figure 4a). Thus, 1-hexanol presented a large positive correlation with T5_Patm juices, while hexanal + ethyl...
butanoate, trans-2-hexenyl acetate, benzyl acetate, nerolidol, and methyl hexanoate presented a large negative correlation.

Significant increases in 1-hexanol concentration were reported by Navarro, Verret, Pardon, & El Moueffak (2002) in untreated strawberry puree stored at 4 °C. In this paper, after 15 days of storage at 5 °C and 0.1 MPa, 1-hexanol concentration increased by more than 600 times. This increase in 1-hexanol content could be related to the activity of alcohol dehydrogenase because a decrease was also observed in the relative abundance of hexanal + ethyl butanoate (Figure 4a). With regard to key aroma compounds, Figure 4a shows that refrigeration produces substantial drops in trans-2-hexenyl acetate and nerolidol abundances. The peak corresponding to hexanal + ethyl butanoate also decreased substantially, but degradation of ethyl butanoate cannot be justified from these data because, as commented above, individual contributions of hexanal and ethyl butanoate could not be differentiated. However, Aguiló-Aguayo et al. (2009) found that ethyl butanoate concentration decreased during refrigerated storage of strawberry juices. This probable ethyl butanoate degradation together with the proved decay of trans-2-hexenyl acetate and nerolidol could significantly affect the aroma perceived in T5_Patm juices.

### 3.3.2. Hyperbaric storage at 20 ºC

Detailed comparison of the volatile profiles of the strawberry juices showed that storage under pressure at 20 ºC avoided most of the changes experienced in T5_Patm samples (Figure 4a), although a decrease in the abundance of furan-2-methyl acetate, trans-2-hexenal, and 2,4-hexadienal, potential discriminators of C samples, was still observed (Figure 3). Nevertheless, the drop in these aldehydes content was substantially lower than that observed in T5_Patm samples, especially in the samples stored at 50 MPa. Various authors have proved that pressure between 200 and 400 MPa, applied for 20 min at room temperature, significantly increases hexanal and trans-2-hexenal contents in strawberry products such as coulis or purees (Lambert et al., 1999; Navarro et al., 2002). Increases in C6 aldehydes after pressure processing are widely reported in fruit and vegetable products in the literature, especially in non-homogenized products (Sumitani et al., 1994; Viljanen et al., 2011). However, it is important to
note that these increases should be attributed to an enhanced enzymatic oxidation of linoleic and linolenic acids induced by pressure, which produces tissue disruptions and favors contact between enzymes and substrates. In this paper, the content of C₆ aldehydes in T20_50MPa and T20_200MPa juices after storage was considerably higher than in T5_Patm samples. This could be due either to an increased formation of C₆ aldehydes induced by pressure or to a limited alcohol dehydrogenase (ADH) activity during hyperbaric storage. ADH, which can convert C₆ aldehydes to their derived alcohols, could present a low activity under pressure. Thus, unlike in T5_Patm samples, no increases in 1-hexanol content were detected in T20_50MPa and T20_200MPa juices (Figure 4a).

Table 3 also reveals that, after hyperbaric storage, only butyl acetate exhibited a positive VID coefficient slightly higher than 0.80 for T20_50MPa juices, and thus this compound is more abundant in T20_50MPa samples than in the other juices (Figure 4b). No more volatiles with high VID coefficients appeared in T20_50MPa samples, and T20_200MPa juices did not present any potential characteristic compound. Discrimination of samples stored under pressure is, therefore, more difficult, as previously mentioned, but this means that no substantial changes occurred in any compound in these samples as compared to all the other juices.

However, the most remarkable fact was that none of the degradations observed in key flavor compounds in T5_Patm samples occurred when the storage took place under pressure. Thus, Figure 4a shows that decreases in trans-2-hexenyl acetate, methyl hexanoate and nerolidol were not detected in T20_50MPa and T20_200MPa samples. Moreover, a significant increase in linalool concentration can be observed in samples preserved under pressure. This increase is especially noteworthy because it could be associated with relatively high levels of β-glucosidase activity during storage. β-Glucosidase is involved in the release of flavor volatiles in fruits, and various authors have previously shown that its activity in strawberry is not only not affected but even increased after pressure treatments between 200 and 400 MPa for 15 min at room temperature (García-Palazon, Suthanthangjai, Kajda, & Zabetakis, 2004; Zabetakis, Koulentianos, Orruño, & Boyes, 2000).

The evolution of methyl butanoate, 3-methyl butyl acetate, 2-heptanone, hexyl acetate, and mesifuran was also studied during the hyperbaric storage (data not shown), although
these volatiles were not classified as potential discriminants for any class of juice by the VID procedure. Nevertheless, they are considered of interest because they have been reported in the literature as key flavor compounds in strawberry (Jetti et al., 2007; Larsen & Poll, 1992; Larsen et al., 1992; Schieberle & Hofmann, 1997). The results revealed that the abundance of these compounds remained unaltered after 15 days of storage in juices preserved under pressure.

4. CONCLUSIONS

This paper offers the first data in the literature about the effect of hyperbaric storage at room temperature on the volatile profile of a homogenized fruit product. The results obtained clearly showed that pressure avoided the spoilage of samples stored at 20 °C for 15 days. Moreover, hyperbaric storage was more efficient than refrigeration to maintain the volatile profile of strawberry juices unaltered for 15 days, and thus samples stored under pressure were the most similar to control juices at day 0. In fact, no changes in any key aroma compound were detected after hyperbaric storage. Nevertheless, sensory analyses are needed to test whether the differences observed would be detectable by human perception.

The results obtained in this paper offer encouraging new data for the characterization of hyperbaric storage of food at room temperature. This new environmentally friendly technology could provide an interesting opportunity to reduce energy costs in food preservation. However, much more research is needed (microbial behavior and enzymatic activities under pressure, stability of bioactive compounds, capital and operating costs, among other things) to establish its real potential.

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