INTERPROFESIONAL DEL ACEITE DE ORUJO DE OLIVA

Olive Pomace Oil as an ingredient in bakery products (tortas and cupcakes): resistance to oxidative degradation and evaluation of bioactive components.

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ORIVA
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Summary of the report on the results from the IG-CSIC's research on the use of olive pomace oil as an ingredient in bakery products (tortas and cupcakes).

1. RESEARCH DESCRIPTION

Study

"Olive Pomace Oil as an ingredient in bakery products (tortas and cupcakes): resistance to oxidative degradation and assessment of bioactive components".

Research center

Instituto de la Grasa (IG) attached to the Consejo Superior de Investigaciones Científicas (CSIC).

Lead researcher

- Joaquín Velasco Jiménez, CSIC Research Scientist.

Objective of the study

This study is presented in response to the need to improve the nutritional properties of industrial bakery foods, traditional cupcakes and oil-based cakes with anise essence, which from now on the latter will be referred to as *tortas*.

Recent nutritional studies have shown that regular consumption of olive pomace oil (45 g/day) contributes to cardiovascular and metabolic disease prevention, as a healthier alternative to other common vegetable oils such as sunflower and high oleic sunflower. Partial or total substitution of sunflower oil, commonly used in bakery foods such as *tortas* and cupcakes, with pomace oil, could improve the products' nutritional value and resistance to oxidation. Aiming to **obtain scientific evidence of the potential of refined olive pomace oil as an ingredient in bakery products,** the objectives of this study are:

- To determine the **resistance to alteration** of refined olive pomace oil in relation to sunflower oil, as well as sunflower and pomace blends, under the conditions of the baked food production process and to evaluate possible losses of bioactive components.
- To determine the degree of **acceptability of new products** by means of a consumer panel test.
- To determine the **resistance to oxidative changes** during the shelf life of the products and assess potential losses of bioactive components.

Methodology

To fulfill the objectives of this study the following tasks have been conducted:

1) **Preparation of oil samples:** 5 different batches of sunflower oil and 5 batches of refined pomace oil were acquired from a local supplier. Blends of sunflower oil and pomace oil were made with pomace content of 25% and 50% by weight, respectively. **Twelve samples of *tortas* and twelve samples of cupcakes** were made, that is three samples from each type of oil, sunflower, pomace, pomace25 and pomace50.
2) **Preparation of bakery products:** The cupcakes were prepared in a pilot plant, while the *tortas* were produced on an industrial scale. In both cases, the usual ingredients employed in the industrial preparation of these products were used, and the only change was the type of oil. Both products were packaged in their usual containers.

3) **Characterization of the oils**: The oil samples were analyzed in triplicate applying the following parameters:

Characterization of oils	
1	Free acidity (UNE-EN ISO 660:2020)
2	Fatty acid composition (IUPAC Method 2.301 and 2.302)
3	Tocopherol content (UNE-EN ISO 9936:2016).
4	Polymer content (IUPAC Method 2.508)
5	Polar compound content (UNE-EN ISO 8420:2002)
6	Distribution of polar compounds (Dobarganes et al., 2000)
7	Hydroperoxide content by HPLC (Velasco et al., 2018).
8	Peroxide index (UNE-EN ISO 3960:2017).
9	Sterols and triterpenic dialcohols content (EC Protocol 2568/91)
10	Fatty alcohol content (EC Protocol 796/2002)
11	Squalene content (Internal procedure based on IOC/T.20/DOC. 28)
12	Triterpenic acid content (Pérez Camino et al., 1999).
13	Oxidative stability in Rancimat at 100 and 110 ° C (AOCS Cd 12b-92)

4) **Characteristics of bakery products**: Both types of products were characterized by the following parameters.

Characterization of bakery products	
1	Moisture in Ohaus MB45 analyzer with halogen heat source.
2	Fat richness according to ISO 734:2016.
3	Color index (Castellano et al., 1993).
4	Stability in Rancimat at 100 ° C (cakes) or 110 ° C (cupcakes) from 5 g of product ground in a mortar (cakes) or crumbled (cupcakes) (AOCS Cd 12b92).

5) Evaluation of **thermoxidative resistance to baking conditions and losses of bioactive components**: The degree of deterioration of the fat produced by thermoxidative alteration during baking was determined and possible losses of bioactive components were evaluated. For this purpose, the fat extracts of the final products were compared with those obtained from the dough immediately before entering the oven.

6) Determining the **degree of acceptability of the new products**: Selected samples of each type of food were sent to the company AINIA for organoleptic assessment through a consumer panel test.

7) **Resistance to rancidity** during the storage period: A controlled temperature storage test was carried out on the 12 samples of *tortas* and 4 of the 12 samples of cupcakes (sample 1) packaged in their usual containers. The mean storage temperature was 23 ± 2 ° C, with minimum and maximum temperatures of 16.5 and 26.5 °C, respectively. Periodic sampling was performed during the shelf life of these products, 6 months for both. The *tortas* were also analyzed after 9 months of storage.

2. RESULTS

Characterization of oils

The oils used presented fatty acid compositions characteristic of conventional sunflower oils or high linoleic (32.3 - 38.0% oleic, 50.3 - 55.9% linoleic) and of olive oils (70.2-71.5% oleic, 10.7-11.8% linoleic).

The **bioactive components** analyzed in the pomace oils presented usual amounts of total sterols (2495-3051 ppm), triterpenic alcohols (18.5-24.6% over total sterols), squalene (953-1674 ppm), triterpenic acids (59-118 ppm, characteristic of refined oils) and fatty alcohols (1145-2201 ppm), while relatively high amounts of α-tocopherol (332-412 ppm) were found. Sunflower oils also showed expected levels of total sterols (2144- 3688 ppm), squalene (62- 145 ppm) and α-tocopherol (694-845 ppm).

The **acidity and peroxide index parameters** indicated that both sunflower oils and pomace oils were well refined fresh oils of high quality. The pomace oils had acidity levels (0.07-0.08 %) and peroxide value (1.7-3.8 meq/kg) characteristic of refined oils.

Characterization of bakery foods

For each type of product, the processing procedure was carried out under the same thermal conditions, obtaining samples with different oils that presented similar characteristics of moisture, fat content and color index.

Resistance to oxidative degradation and losses of bioactive compounds in the processing

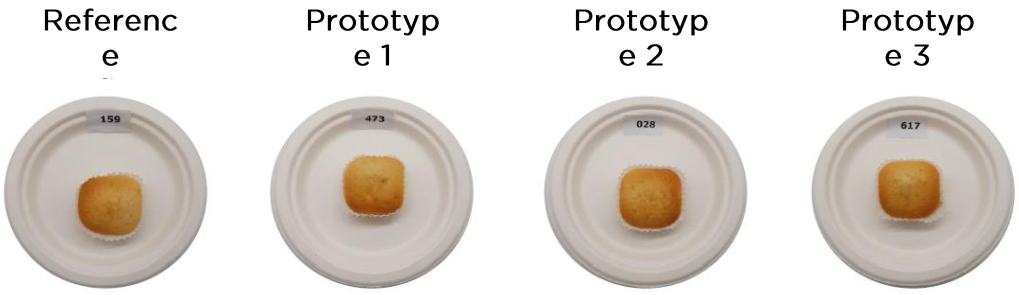
The results of this study clearly demonstrate that olive pomace oil has a high resistance to thermoxidative degradation in both types of foods and that this is much higher compared to sunflower oil and to sunflower and olive pomace blends. Partial or total substitution of sunflower oil by olive pomace considerably reduces the levels of degradation compounds in both products (**Figure 1**).

Pomace oil retains levels of its bioactive components during the processing of both types of foods practically intact. Only slight significant losses of α-tocopherol (≤ 7%) in the preparation of *tortas* and of squalene in cupcakes (≤ 8%) have been found. Therefore, it can be said that the oils retain practically all their bioactive components during the processing.

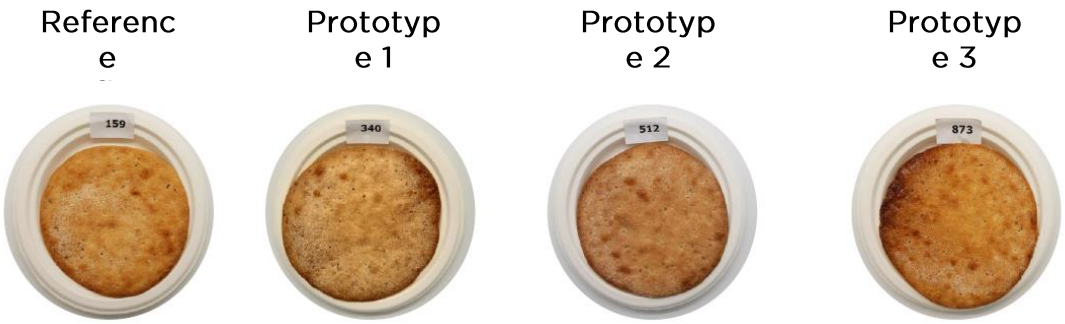
Degree of acceptability of new products

Of the 12 samples of each product, four were selected, one for each type of oil. The aim was to study at the sensory level whether the type of oil affects consumer acceptance and preferences. For this purpose, the samples were assessed respectively by two panels made up of **61 habitual consumers of cupcakes and 60 consumers of bakery products in general**, selected because they liked *tortas* with anise flavor. This study was carried out by the company AINIA.

- The **attributes assessed for the cupcakes** were overall rating, appearance, freshness, color, odor, flavor, texture, fluffiness, hard/soft texture, dry/juicy texture, fresh mouthfeel, flavor intensity and sweetness. Overall, all four cupcake products received a good overall rating. On a 9-point hedonic scale, the scores achieved for overall rating (0 for "do not like at all" and 9 for "like very much") ranged from 6.5 to 6.7.



- The **attributes assessed** in the *tortas* were overall rating, appearance, color, odor, flavor, texture, crunchy texture, flaky texture, flavor intensity and sweetness. In general, for the different attributes studied, the four types of *tortas* presented good overall rating scores (6.7-6.1) and very good overall rating scores (>6.7) products.



The results of this study show that the type of oil did not affect the organoleptic properties of the foods studied. Consumers do not distinguish between products made with different oils.

Resistance to oxidative degradation and losses of bioactive compounds during the shelf-life period

During the shelf-life period, the oxidative deterioration of the cupcake samples was relatively low, although the levels of oxidized lipids were significantly lower for the pomace sample (OPO) and considerably higher for the sunflower sample (**Figure 2A**). The samples containing 25% (OPO25) and 50% (OPO50) olive pomace oil presented intermediate values, higher for OPO25. Thus, the level of oxidative degradation was clearly dependent on the degree of unsaturation of the oil. No signs of rancidity were detected in any case, although there were significant losses of quality related to texture. The cupcakes showed evidence of slight hardening with time, but this was independent of the type of oil used. Finally, consumers showed no clear preference for any of the 4 products studied. As for the bioactive components, due to low oxidative deterioration, only slight losses of tocopherol (13-18%) were found regardless of the type of oil used, while no significant losses were observed in the rest of the components studied.

The oxidative deterioration in the *tortas* was relatively high in the sunflower samples and extremely low in the pomace samples at the end of the shelf life (6 months) (**Figure 2B**). The levels of oxidized lipids decreased progressively with the partial replacement of sunflower oil by pomace oil. The sunflower samples showed signs of rancidity via the orthonasal route (nose), but not via the retronasal route (mouth), after 4 months, and clear evidence of rancidity in aroma and flavor at the end of shelf life (6 months). However, the pomace *tortas* showed no rancidity in flavor throughout the study, including the samples stored for 9 months. Therefore, these results clearly show that pomace oil can increase the shelf life of *tortas*.

In terms of bioactive components, substantial losses of tocopherol were found in the sunflower and OPO25 *tortas*, with losses ranging from 30% to 50% at the end of the shelf life compared to losses of 15% found in the OPO50 and OPO samples. Significant losses of squalene were also found, which were relatively lower in the OPO samples, where losses of 8% were found versus 15-20% in the rest of the samples. However, no significant changes were detected in the levels of the other bioactive components studied.

3. CONCLUSIONS

- Refined pomace oil has shown a **high resistance to thermoxidative degradation** during the processing of traditional cupcakes and *tortas*, much higher compared to sunflower oil and sunflower and pomace blends. The levels of degradation compounds can be reduced in both products by partial or total substitution of sunflower oil with olive pomace oil. These compounds negatively affect the quality of the products during storage, as they are transformed into volatile compounds responsible for rancidity.

- Despite the high temperatures used in the processing of both products, **the oils retained almost all of their bioactive components**. Only slight significant losses of tocopherol were found and, in cupcakes, slight losses of squalene were also observed as a result of the baking process.

- The type of oil used did not affect the organoleptic properties of fresh foods. Consumers did not distinguish between products prepared with different oils. However, they did show a clear preference for pomace *tortas* after 3 months of storage, due to the rancidity detected in the sunflower *tortas*. Therefore, **pomace oil significantly improves the organoleptic quality** of this product. The partial or total substitution of sunflower oil by refined pomace oil does not introduce perceptible changes in the organoleptic properties of cupcakes during the whole shelf-life period.

- Partial or total substitution of sunflower oil by pomace oil **improves the nutritional properties** of traditional cupcakes and *tortas*, due to the improved fatty acid profile and bioactive components of pomace, which are not found in sunflower oil, such as alcohols and triterpenic acids, as well as aliphatic alcohols, or are present in substantially lower amounts, such as squalene. The levels of these components in pomace oil remain practically unchanged in both products at the end of shelf life.

- As a final conclusion, it can be said that **refined pomace oil retains its organoleptic and nutritional properties intact** during the preparation and storage of traditional cupcakes and *tortas*. Therefore, it presents great potential as an ingredient in the industry of bakery products.

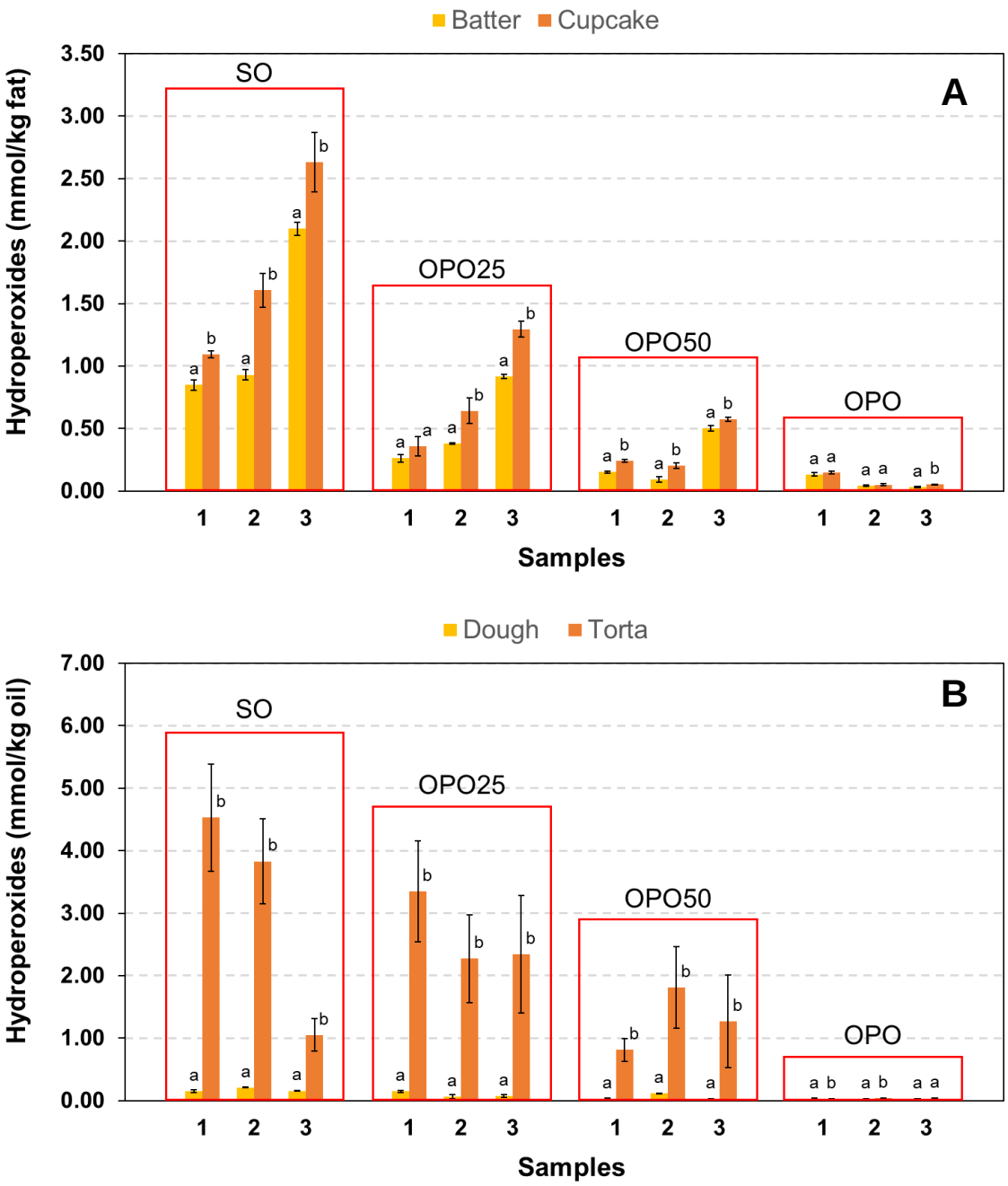


Figure 1 Influence of the baking process on the levels of primary oxidation compounds in traditional cupcakes (A) and *tortas* (B). SO, sunflower oil; OPO25, sunflower-pomace blend with 25% pomace oil; OPO50, 50% sunflower-pomace blend; OPO, pomace oil. The results represent the mean and standard deviation of 3 analytical determinations on the same fat extract (Masa) or on extracts from 3 independent samples (Cupcake or *Torta*). Different letters for a given sample indicate significant differences according

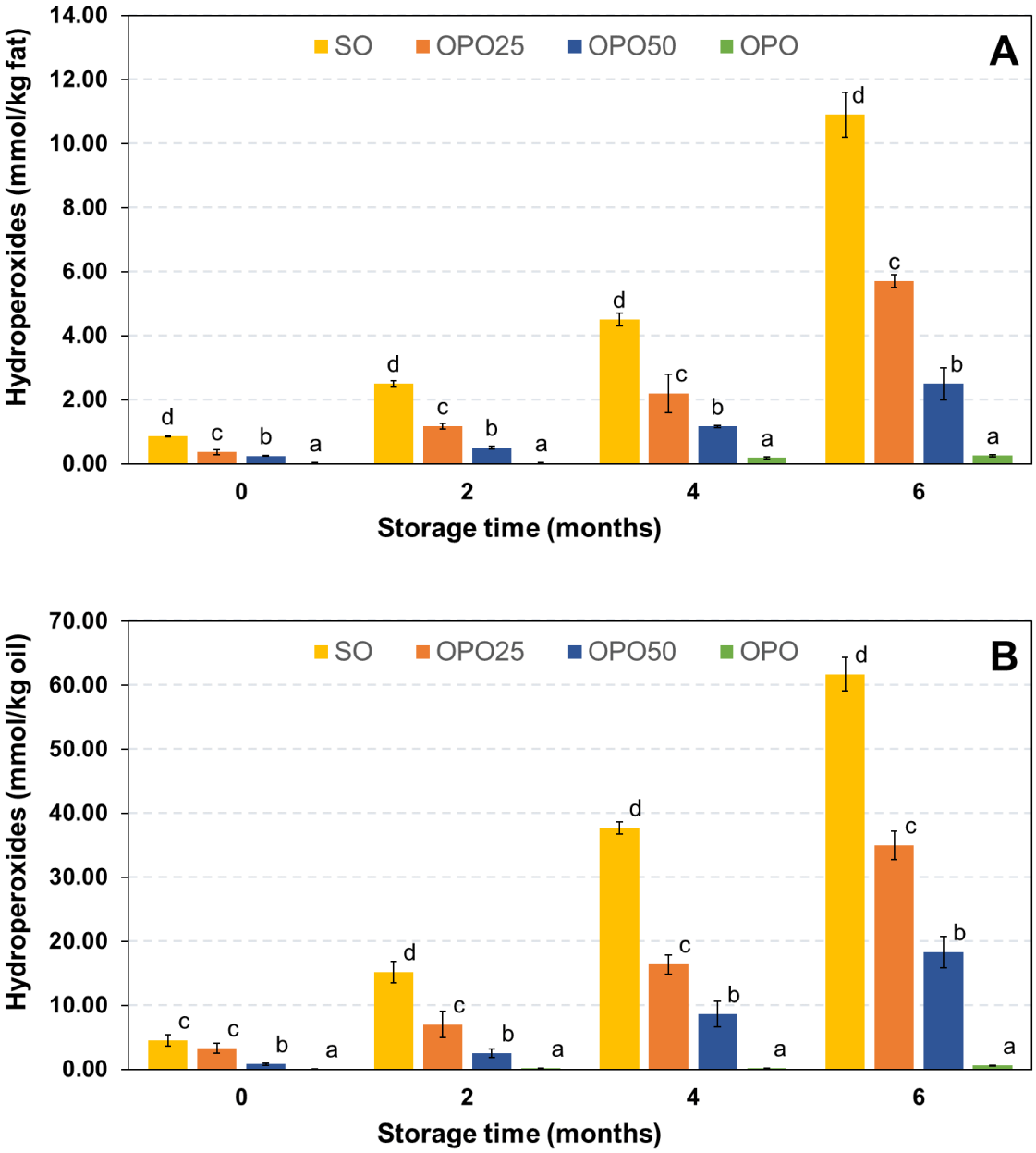


Figure 2 Influence of storage on levels of primary oxidation compounds in cupcakes (A) and traditional *tortas* (B). SO, sunflower oil; OPO25, sunflower-pomace blend with 25% pomace oil; OPO50, 50% sunflower-pomace blend; OPO, pomace oil. Results represent the mean and standard deviation of 3 analytical determinations on extracts from 3 independent samples (Cupcake or *Torta*). Different letters for a given storage time indicate significant differences according to Duncan's test ($p < 0.05$).