Application of optimized extract of *Citrus sinensis* Osbeck epicarp and *Ocimum basilicum* L. leafs in orange fermented beverage

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INTRODUCTION

Aromatic plants and edible leftovers from the agri-food sector are of great interest to the industry due to the large amount of biologically active substances they contain [1]. Adding these elements to food products is an important market strategy, as they are often associated with various health benefits and are promising for health promotion. Additionally, they contribute to the circular economy and reduce environmental impacts [2-3]. The present study aimed to explore citrus residues, using an optimized extract from the epicarp of *Citrus sinensis Osbeck* (OE) and, an extract from *Ocimum basilicum L.* (BE) a popular spice of the Iberian Peninsula.

METHODOLOGY

From which five different fermented beverages (OE_0, OE_25, OE_50, OE_75, OE_100) were subsequently formulated to test the bioactive properties. These extracts were mixed in different concentrations in the formulations of the fermented beverages: OE_0 (100% BE), OE_25 (25% OE / 75% BE), OE_50 (50% OE / 50% BE), OE_75 (75% OE / 25% BE), and OE_100 (100% OE). The five beverages were produced according to Decree-Law no. 288/94, of November 14, using a concentration (w/w) of 8% nectar, with 50% of the nectar consisting of citrus juice and 50% of extracts, agave syrup, and plant extracts (OE and BE). The five formulations were then left to ferment for three days before being transferred to other containers for refrigeration to evaluate their shelf life over five days. Various parameters were evaluated, including pH (which remained stable), color (changes in *ΔE*), antimicrobial activity, and Brix degree.

RESULTS

The evaluation of the antimicrobial capacity results of the extract blends showed that the bacteria *Yersinia enterocolitica a*nd *Staphylococcus aureus* were the most sensitive to all extracts, while *Pseudomonas aeruginosa* showed no sensitivity. EO_0 exhibited the highest sensitivity to *Staphylococcus aureus*, with an MIC of 0.6 mg/ml.

After five days of shelf-life analysis of the fermented beverages, it was noted that the basil extract, which was most abundant in EO_0 (**Figure 1**), was responsible for reducing the development of fermenting microorganisms, resulting in a less pronounced sedimentation.

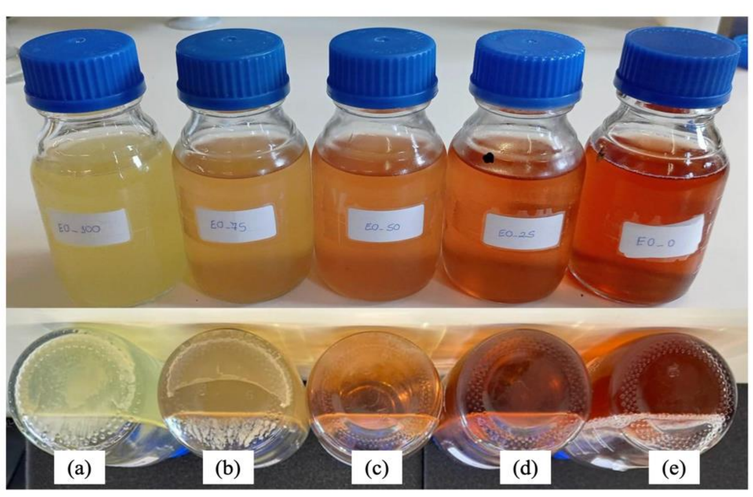


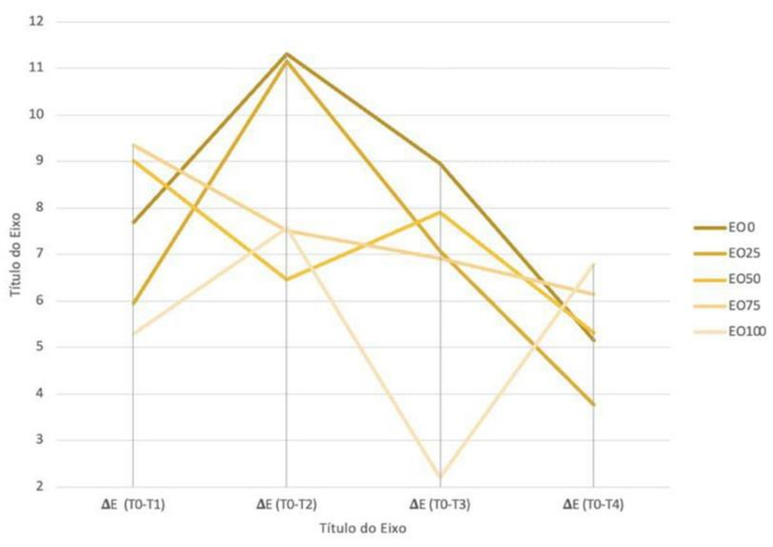
Figure 1. Final beverages for shelf-life evaluation (a) EO_100, (b) EO_75, (c) EO_50, (d) EO_25, and (e) EO_0.

Measurements taken during the shelf-life analysis allowed us to observe variation in beverage color (**Table 1**) (**Graph 1**). Previous studies [4] have shown that the packaging used in this study, particularly when transparent glass is used, can influence the color due to light exposure. Additionally, other factors such as microbial presence, product formulation, storage time, and pH variations can also contribute to color changes.

Table 1. Variation in color and ΔE .

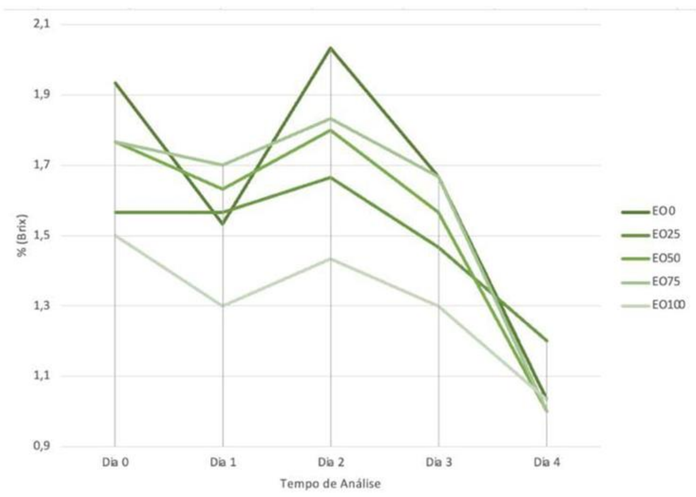
Tempo	EO 0	EO25	EO50	EO75	EO100
Dia 0					
T0	0	0	0	0	0
Dia 1					
ΔE (T0-T1)	7,69	5,95	9,01	9,35	5,29
Dia 2					
ΔE (T0-T2)	11,31	11,15	6,45	7,51	7,57
Dia 3					
ΔE (T0-T3)	8,95	7,08	7,91	6,92	2,2
Dia 4					
ΔE (T0-T4)	5,15	3,76	5,32	6,14	6,79

Graph 1. Variation of ΔE over study days

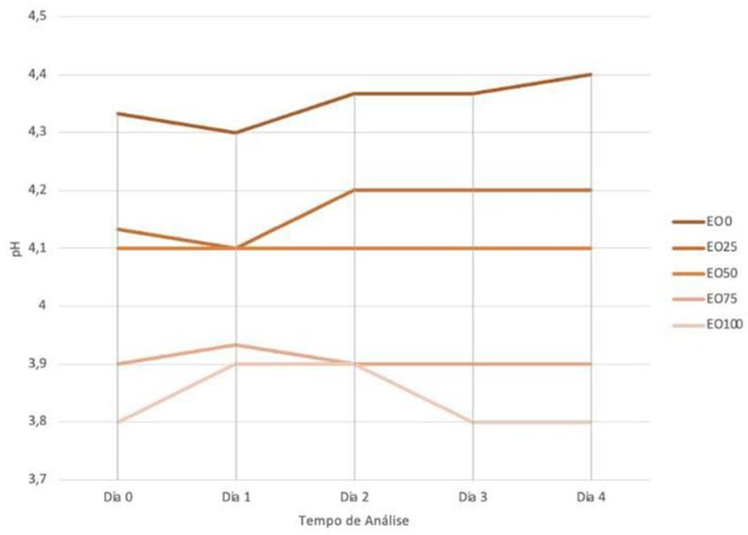


The values obtained from Brix (**Graph 2**) show that the sugar levels in the beverage decreased over the days, indicating consumption by present microorganisms, as the beverage undergoes natural fermentation and has not been pasteurized.
Regarding pH (**Graph 3**), we can conclude that the beverage formulated with EO_50 extract exhibited greater stability compared to others, maintaining its pH throughout the study period, whereas the pH variation in the other beverages was minimal.

Graph 2. Variation of Brix over study days.



Graph 3. Variation of pH over study days.



CONCLUSIONS

This study aimed to advance better management of food industrial waste, as well as study the bioactive properties of the extracts; however, some scientific gaps still need to be filled since the insertion of the extract affected some of the evaluated parameters. Based on this premise, future research could be conducted to evaluate the acceptability of the sample through a non-trained sensory panel.

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This work aims to utilize agro-food waste and valorize local plant matrices to develop safe, healthy, and natural food products in accordance with the UN Goals 3 and 12.

3 GOOD HEALTH AND WELL-BEING

12 RESPONSIBLE CONSUMPTION AND PRODUCTION