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"SALCHICHÓN" WITH PRICKLY PEAR PEEL. ANTIOXIDANT CAPACITY AND FLAVONOID BIOACCESIBILITY

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I. INTRODUCTION

"Salchichón" is a traditional fermented sausage from Spain, whose elaboration is based on the transformation of a mixture of meat (usually pork), fat, salt, and spices through fermentation and drying processes. However, consumer trends have changed in recent years, with an increasing preference for organic, sustainable, and helthier foods. Thus, the meat industry has to adapt to the demands of the market, reducing the use of additives or replacing synthetic additives with natural alternatives. Within the agri-food sector, the processing of fruits and vegetables generates a large amount of waste, including leaves, peels, seeds or unwanted pulp, which often contain a hight amount of bioactive compounds with antioxidant, anti-inflammatory, colorant or antimicrobial properties [1]. Prickly pear (*Opuntia ficus-indica*) peel is rich in fiber and bioactive compounds, such as betalains and polyphenols [2]. Therefore, its incorporation as a food additive could improve the physicochemical characteristics and increase the stability of foods. The aim of this study was to incorporate this co-product into a "salchichón" in order to determine its influence on the antioxidant capacity and the bioaccessibility of the main flavonoid compounds contained in the "salchichon" matrix.

II. MATERIALS AND METHODS

Two bacthes of "salchichón", each weighing 4 kg, were prepared. They were differentiated by the addition of prickly pear peel (30 g/kg) in the experimental batch (P-CON), while the control batch (N-CON) did not contain any added antioxidants. Both batches were fermented and dry-ripened for 34 days, following a standardize process. Samples were taken at the end of the maturation period for analysis. The chemical composition was determined following ISO procedures (moisture, protein, ash) and AOAC methods (fat content). Color was measured in the CIELAB space using a portable colorimeter (CR-600d, Minolta Co. Ltd., Osaka, Japan), while pH was determined using a digital pH meter (Hanna Instruments Inc., Romania). Lipid oxidation was evaluated using the thiobarbituric acid reactive subtances (TBARS) assay, and antioxidant capacity was measured using DPPH method [3]. To evaluate the bioaccessibility of flavonoids, *in vitro* digestions were performed following the procedure described by Gullón et al. [4]. Significant differences between batches were determined using Generalized Linear Models (GLM) in SPSS software (version 25.0, SPSS Inc., Chicago, USA).

III. RESULTS AND DISCUSSION

The results indicated that prickly pear peel, characterized by its antioxidant capacity (DPPH: 6662.74±427.39 µg Trolox/g), induced significant changes in the "salchichón" matrix. No substantial differences were observed in moisture levels (N-CON: 31.55 ± 1.78%; P-CON: 30.96 ± 1.38%) or protein content (N-CON: 33.42 ± 4.19%; P-CON: 32.23 ± 1.93%) between the two batches. However, the batch with prickly pear peel exhibited a decrease in fat content (N-CON: 24.72 ± 4.26%; P-CON: 21.69 ± 2.82%) and an increase in ash content (N-CON: 6.12 ± 0.32; P-CON: 7.26 ± 0.33%), probably due to the mineral composition of the peel. The pH was also significantly more acidic in P-CON compared to N-CON (4.98±0.14 and 5.36±0.11, respectively), mainly related to the carbohydrate content of the peel which promotes fermentation intensity and could influence both the organoleptic properties and the microbiological stability of the final product. Regarding color parameters, P-CON batch showed significantly lower *L** values than N-CON (38.82±3.08; 43.94±3.15, respectively), while it presented significantly higher values in *a**

(12.87±1.84; 9.79±1.38, respectively) and *b** (13.03±1.16; 8.41±1.10, respectively) parameters. This aspect could be explained to the high betalain content in the peel (Table 1) associated to reddish hues.
Regarding antioxidant activity, P-CON showed significantly higher DPPH levels (524.61±82.39 µg Trolox/g) compared to N-CON (166.82±34.54 µg Trolox/g), confirming the antioxidant effect of the prickly pear peel. Nevertheless, higher levels of lipid oxidation (TBARS: P-CON 0.57 ± 0.12 mg MDA/kg *vs*. N-CON 0.15 ± 0.05 mg MDA/kg) were observed in P-CON. In any case, these values were below the limit for the detection of off-odors by the consumers. Concerning the bioaccessibility of the main flavonoids present in the prickly pear peel matrix, quercetin was not detected in the digested "salchichón" due to its low initial concentration. However, other glycosylated forms, quercetin-3-beta-glucoside and quercetin glycosylated (Table 1) showed moderate bioaccessibility (40-50%), according to Roselli et al. [5]. These findings indicate that a considerable proportion of these bioactive compounds could be potentially absorbed during the digestive process, contributing to the possible health benefits associated with the consumption of this enriched meat product.

Table 1. Main flavonoids present in prickly pear peel and sausage with prickly pear peel before and after *in vitro* gastrointestinal digestion.

Bioactive compounds	Prickly pear peel (µg/g)	"Salchichón" + prickly pear (µg/g)	Digested "salchichón" + prickly pear (µg/g)	% Bioaccessibility (%)
Quercetin	8.19±1.93	1.39±0.00[a]	nd[b]	-
Quercetin-3-beta-glucoside	349.72±51.34	31.90±1.38[a]	14.19±2.43[b]	44.48±1.37
Quercetin glycosylated	197.12±13.68	27.54±1.63[a]	13.91±2.03[b]	50.50 ± 1.37

Different letters in the same row indicate significant differences among formula ($p < 0.05$). nd: not detected.

IV. CONCLUSION

The addition of prickly pear peel did not significantly modify the moisture and protein content, but it caused a reduction in the fat content and an increase in the ash content. Significant differences were also found in the physicochemical parameters (pH and color) due to the presence of carbohydrates and betalains in the peel. These changes in the color parameters could affect the visual perception of the product by the consumer. P-CON batch showed significantly higher antioxidant activity compared to N-CON, evidencing the antioxidant potential of prickly pear peel. However, slightly higher levels of lipid oxidation were observed in the P-CON batch. Regarding the bioaccessibility of flavonoids, two glycosylated derivatives of quercetin with moderate bioavailability were identified.

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REFERENCES

1. Gullón, P., Gullón, B., Romaní, A., Rocchetti, G., & Lorenzo, J. M. (2020). Smart advanced solvents for bioactive compounds recovery from agri-food by-products: A review. In *Trends in Food Science and Technology* 101, 182–197. Elsevier Ltd. https://doi.org/10.1016/j.tifs.2020.05.007
2. Amaya-Cruz, D. M., Pérez-Ramírez, I. F., Delgado-García, J., Mondragón-Jacobo, C., Dector-Espinoza, A., & Reynoso-Camacho, R. (2019). An integral profile of bioactive compounds and functional properties of prickly pear (*Opuntia ficus indica* L.) peel with different tonalities. *Food Chemistry*, *278*, 568–578. https://doi.org/10.1016/J.FOODCHEM.2018.11.031
3. Lorenzo, J. M., Domínguez, R., Pateiro, M., & Munekata, P. E. S. (2022). Methods to assess the quality of meat products. ISBN 978-1-0716-2001-4, Humana Press (Springer Nature). https://link.springer.com/book/10.1007/978-1-0716-2002-1
4. Gullon, B., Pintado, M. E., Fernández-López, J., Pérez-Álvarez, J. A., & Viuda-Martos, M. (2015). In vitro gastrointestinal digestion of pomegranate peel (*Punica granatum*) flour obtained from co-products: Changes in the antioxidant potential and bioactive compounds stability. *Journal of Functional Foods*, *19*, 617–628. https://doi.org/10.1016/j.jff.2015.09.056
5. Roselli, C., Meli, M. A., Fagiolino, I., & Desideri, D. (2020). Bioaccessibility assessment of stable elements and 210Po in food. *PLoS ONE*, *15*(8). https://doi.org/10.1371/journal.pone.0236871