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CORRELATION OF PHYSICO-CHEMICAL AND SENSORY PROPERTIES OF COOKED HAM AND THE EFFECTS OF NITRITE LEVELS, PACKAGING SYSTEMS, AND HIGH-PRESSURE PROCESSING

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I. INTRODUCTION

Cooked ham is a popular meat product that traditionally incorporates nitrites for preservation, colour and flavour development. However, the use of this additive presents challenges due to its association with health concerns. Incremental reduction of nitrites is one of the approaches to solve this alongside with the application of emerging food processing technologies, and packaging systems. High-pressure processing (HPP) is a non-thermal technology widely used to extend the shelf life of various food products, including meat products, by inactivating the vegetative cells of spoilage microorganisms [1,2]. Other studies have shown that the common range of pressure treatment for meat products is from 250 – 600 MPa in order to inactivate microorganisms [3].This study aimed to investigate the correlations of the physico-chemical, and sensory attributes of cooked ham with varying nitrite levels (0, 40 and 80 mg NO_2^-/kg), packaging system and the application of high pressure processing (HPP) treatment (600 MPa for 3 min).

II. MATERIALS AND METHODS

Pork topside muscles (n=36) were processed into cooked ham following the industry processing and technological procedures. For each of the brining treatments based on the calculated input nitrite ion: (1) 80 mg/kg NO_2^-; (2) 40 mg/kg NO_2^-; (3) 0 mg/kg NO_2^- (nitrite-free), 12 muscles were used. Cooked ham slices with varying amounts of nitrite were packaged under modified atmosphere packaging (MAP) (70% N_2 and 30% CO_2), vacuum skin packaging (VSP), and VSP subjected to HPP at 600 MPa for 3 min. Instrumental colour and odour of the samples were measured using Ultra Scan Pro dual beam xenon flash spectrophotometry (Hunterlab, U.S.A.), and Portable Electronic Nose (PEN) 3 with 10 metal oxide sensors (Airsense, Germany), respectively. Other physico-chemical properties analysed included proximate composition, salt content, water activity (a_w), pH and thiobarbituric acid reactive substances (TBARS) value, expressible moisture (EM) and Warner Bratzler shear force (WBSF). Descriptive sensory analysis (cured ham colour, cured ham odour and off-odour) by trained panellists was performed. The Research Ethics Committee at Technological University of Dublin (REC-23-146) approved the protocol. All participants were provided with informed consent form at the beginning of the trial for their data to be used and analysed. Principal component analysis (PCA) based on Pearson correlation was conducted using XLSTAT Premium version 2023.1.6 1410 (Lumivero, U.S.A.) to explore and visualise the correlation among the treatments and each variable under study.

III. RESULTS AND DISCUSSION

The correlations between nitrite level, packaging system, and HPP treatment, and the measured quality parameters were explored using principal component analysis (PCA) (Figure 1). From this plot, it is evident that samples H80 HPP and H40 in VSP were closely associated with colour-related parameters such as redness (*a*),* cured colour ratio, and sensory-perceived cured ham colour intensity, all of which exhibit positive correlations. Other samples containing nitrite (H80 and H40) are similarly located in the upper half of the plot, suggesting that HPP treatment did not influence colour characteristics, even at reduced nitrite concentration. In contrast, cooked ham samples without nitrite (H0) regardless of packaging system, were located in opposed quadrants, a positioning attributed to elevated lightness (*L*),* yellowness (*b**), and hue angle, which is an indicative of a lesser extent of the typical cured colour.

For odour, H40 HPP, H40 VSP, H80 HPP and H80 VSP were clustered together in the upper portion of the PCA plot, driven by their association with sensory perceived off-odours and e-nose sensor responses from W5C, W3C, and W1C sensors, which are known for their sensitivity to aromatic compounds. Toluene, the reference gas for sensor W1C, was identified as the predominant aromatic compound in both of the studies by del Olmo (2014) and Theron (2010) on cured cooked meat [4, 5]. These non-MAP samples were positioned in opposite to the responses

from sensors W2W, W1W, W5S, W2S, and W1S, which exhibit sensitivity to sulphurous and ammoniac volatile compounds. H80 MAP, H40 MAP, and H0 MAP were clustered in the lower-left quadrant of the plot, demonstrating that PCA effectively distinguished MAP-packaged samples, regardless of nitrite content. Thus packaging system showed greater influence on the cured odour than the nitrite incorporation, as shown by both instrumental and sensory analyses. Chroma, proximate composition (moisture, protein, fat and ash), salt content, a_w, pH, EM and WBSF were not affected by the applied treatments.

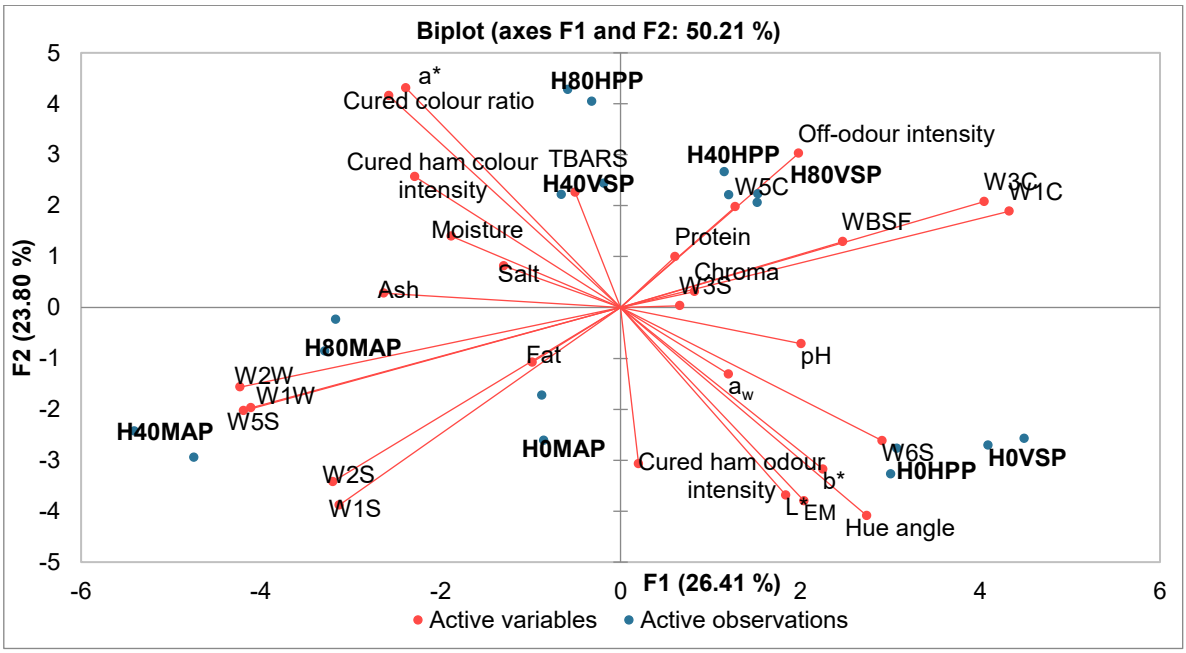


Figure 1. Principal component analysis (F1 & F2) of cooked ham samples with varying levels of input nitrite, different packaging systems and HPP treatment, and correlations among the physico-chemical and sensory attributes.

IV. CONCLUSION

This study showed the similarities of cooked ham with 40 mg/kg input NO_2^-, and with 80 mg/kg input NO_2^-, in VSP, and VSP with HPP treatment, respectively. This demonstrates the feasibility of reducing nitrite levels while maintaining similar quality parameters, regardless of the use of HPP. Furthermore, it was interesting to note that the packaging system showed greater influence on the cured odour than the nitrite incorporation. The complete removal of nitrites significantly affected the colour, although odour remained relatively unchanged.

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