

# THE USE OF HURDLE TECHNOLOGY FOR THE DEVELOPMENT OF CONSUMER ACCEPTED LOW-SALT HAM WITH ENHANCED SHELF LIFE

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**Abstract - The objective of this study was to use response surface methodology (RSM) to develop consumer accepted low-salt cooked ham with enhanced shelf life using high pressure processing (HPP) and a mix of organic acids as hurdles. A Box-behnken experimental design was used to assess the effects of the independent factors salt replacer (Artisalt™) (0-100%), HPP (0.1-600 MPa) and a mix of organic acids (Inbac™) (0.2-0.4%) on the measured response of overall sensory acceptability (OSA) of the cooked ham. The optimum parameters to maximise OSA of cooked ham and produce ham with similar or better OSA was Artisalt™ (53%), HPP (535 MPa) and Inbac™ (0.3%) and the total salt content was 1.4% which is a 44% reduction compared to control samples which contained 2.6% total salt. The hurdle approach used to optimise salt reduction of cooked ham extended the shelf life significantly by 73% compared to control samples. Overall, a combination of salt replacer, HPP and organic acids showed great potential for the development of cooked ham with significantly reduced salt content and enhanced shelf life.**

**Key words – High pressure processing, response surface methodology, salt reduction**

## I. INTRODUCTION

Sodium chloride, commonly known as salt plays a significant technological role in processed meat due to its preservation and antimicrobial properties provided by its ability to reduce water activity. Moreover, salt activates proteins to increase water-binding capacity, increases the binding properties of proteins to improve texture and is also essential for flavour [1] [2]. Thus salt reduction in processed meat products is challenging as quality of the final product can be compromised. The main strategies for salt reduction in processed meat products include product reformulation, compensation by the use of substitutes, use of saltiness enhancers and the use of salt replacers [3]. Artisalt™ (a mix of potassium chloride, ammonium chloride, yeast extract, celery and onion) and Inbac™ (a mix of sodium acetate, malic acid, mono and diglycerides of fatty acids, anticaking agents, calcium phosphate, magnesium carbonate and silicon dioxide) are commercially available salt replacer and antimicrobials respectively. The objective of this study was to use RSM to develop a consumer accepted low-salt cooked ham with enhanced safety & shelf life using salt replacers (Artisalt™) and hurdles including high pressure processing (HPP) and a mix of antimicrobial organic acids (Inbac™).

## II. MATERIALS AND METHODS

The Box-Behnken experimental design used to optimise salt reduction and consisted on the manufacture of 15 different formulations of ham. The independent factors assessed were Salt replacer Artisalt™ (0-100%), HPP (0.1-600MPa) and Inbac™ (0.2-0.4%). The measured responses were texture (hardness), saltiness, flavour and overall sensory acceptability (OA). Sensory analysis was carried out in duplicate by a panel of 25 internally semi-trained assessors using a nine point hedonic scale. The attributes assessed includes the hedonics of appearance, texture, flavour and overall acceptability (1=extremely dislike and 9=extremely like) and intensities which included tenderness (1=extremely tough and 9= extremely tender), juiciness (1= extremely dry and 9 extremely juicy), saltiness (1= not salty and 9 = extremely salty), metallic taste and off-flavour (1= imperceptible and 9 = extremely pronounced). To assess the robustness of the model used for the optimisation process, a validation was carried out with three independent confirmatory trials to ascertain difference between predicted and experimental values. During storage, microbiological analysis including Total viable count (TVC), Lactic acid bacteria (LAB) and *E.Coli* & Coliforms was carried out on the optimised low-salt ham and the control ham.

### III. RESULTS AND DISCUSSION

The quality parameters of cooked ham (pH, proximate composition, cook loss, sliceability, expressible moisture, colour, texture, sensory attributes) were not affected compared to the control samples when NaCl was replaced up to 50% with Artisalt™; however, when NaCl was 100% replaced by Artisalt™ all quality parameters including OSA were negatively ( $P < 0.05$ ) affected.

The optimisation process to obtain consumer accepted low-salt cooked ham was carried out maximising the OSA and the best combination of the independent factors to obtain optimised low-salt cooked ham with similar or better OSA than control samples were: Artisalt™ (53%), HPP (535MPa) and Inbac™ (0.3%). The Pareto charts showed that the main independent factor that influenced the hardness, flavour, saltiness and OSA of the cooked hams was Artisalt™. When the optimum parameters were validated, the experimental and predicted values obtained by the RSM were similar which indicated the robustness of the model for process optimisation.

Using RSM, a 53% NaCl reduction was achieved reducing the total salt content in cooked hams from 2.6% to 1.4% which according to the FSAI [4] classifies this product as 'salt reduced'. This significant salt reduction in cooked ham without compromising the physicochemical or OSA was achieved through the use of salt replacer Artisalt™ which contains flavour enhancers and hurdles such as HPP and Inbac™.

The limit of acceptability set by the microbiological criteria of the FSAI [5] indicates an acceptable TVC limit in cooked chilled foods in the range of 5log cfu/g - < 7log cfu/g therefore in this study the limit of acceptability was set a marginal value of 6log cfu/g. Based on the set limit the shelf life of control ham was 52 days; however, the optimised low-salt cooked ham manufactured with the addition of the hurdles (HPP & Inbac™) had a shelf life of 90 days which is 73% longer than control samples. The main spoilage micro-organism in both the control cooked ham and the low-salt cooked ham was Lactic acid bacteria.

### IV. CONCLUSIONS

The optimum parameters to produce consumer accepted low salt ham with similar or better OSA than control samples were: Artisalt™ 53%, HPP (535MPa) and Inbac™ (0.3%). The use of salt replacer (Artisalt™), HPP and organic acids (Inbac™) permitted a 44% total NaCl reduction (from 2.6% to 1.4%) compared to control samples without compromising the physicochemical, OSA and safety of the product. The hurdle approach used in this study enhanced the shelf life of low salt cooked ham by 73% compared to control samples.

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