EDIBLE CRYSTALLINE PARTICLES AS MODEL FILLERS IN COMMINUTED MEAT PRODUCTS

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Abstract – The objective of this study was to characterize the effects of various insoluble, hydrophilic crystalline particles as prospective fillers in comminuted meat products. Oat fibre, walnut shell, and two sizes of microcrystalline cellulose (MCC), were selected as candidate fillers. Products were prepared with a mass fraction filler (m_f) of 0, 0.05, 0.10, or 0.15. Texture profile analysis (TPA) Hardness of the particle-filled batters were significantly higher than the control product at m_f = 0.15, with oat fibre producing the greatest increase. For all fillers, Resilience, Springiness, and Cohesiveness exhibited a gradual decrease with increasing m_f. Microstrutural analysis suggested particle-particle contacts were responsible for the changes in textural properties. Cooking losses were affected only by the smaller MCC particles, which decrease with increasing m_f. NMR T_2 relaxometry indicted that particle type had a strong impact on the apparent mobility of water, where: larger MCC < smaller MCC ≈ oat < walnut. Overall, these results indicate the effect of hydrophilic, insoluble fillers on the properties of comminuted meat products is strongly dependent on a number of factors; cooking losses were most strongly influenced by filler size, while particle crowding dominated the impact on textural properties, due to the inert nature of the fillers investigated.

Key Words –Microstructure, T_2 relaxation, water stability

I. INTRODUCTION

A variety of factors contribute to the quality and characteristics of finely comminuted meat products, at both the formulation and processing levels. Formulation changes may be necessary, for example, to cater to changing consumer demands (e.g. low fat, low salt, 'premium' products, etc.), while maintaining the desirable traits expected of the original product. To this end, binders and fillers are commonly used as bulking agents, or to modify the textural properties of processed meats [1]. Our group recently carried out an investigation using glass microspheres as a model filler particle, demonstrating that these particles have a unique ability to efficiently stabilize comminuted meat batters and improve textural properties (volume fraction of filler < 0.03) [2]. These effects were attributed to the hydrophilic nature of the particles, resulting in a preferential interaction with the water phase, thus improving product stability and maintaining the integrity of the protein matrix during cooking. The goal of the present work was to screen a set of edible, insoluble and hydrophilic crystalline particles to determine if they could be use as novel food-grade fillers in finely comminuted meat products. The particles screened were two varieties of microcrystalline cellulose (MCC; smaller: ~15μm, larger: ~130μm), walnut shell flour, and oat fibre. Functionality was evaluated by quantifying cooking losses and performing texture profile analysis (TPA) on the products. Microstructural analysis and NMR T_2 relaxometry were also carried out to assist in interpreting the effect of the candidate fillers.

II. MATERIALS AND METHODS

Comminuted meat batters (2.5 wt% NaCl, no added fat) were prepared using trimmed chicken breast meat to have a final protein content of 11 wt%. Microcrystalline cellulose (two sizes; MCC-102, ~15μm and MCC-105, ~130μm), walnut shell flour, and oat fibre were incorporated in the batters as model fillers. Particles were incorporated at mass fractions (m_f) of 0, 0.05, 0.10, and 0.15. Cooking loss and texture profile analysis (TPA) were measured to evaluate the impact of fillers on the stability and textural attributes of the products. The influence of the particles was further investigated using T_2 relaxometry [3].

III. RESULTS AND DISCUSSION

The effect of filler type and content on the cooking losses of the particle-filled comminuted poultry meat products are presented in Fig. 1A. The smaller MCC-105 particles (~15μm) produced a significant reduction in cooking losses at ≥10 wt% filler, while the larger MCC-102 particle, oat fibre, and walnut flour did not cause a significant change in the cooking losses at the incorporation levels investigated here. Microstructural analysis, combined with previous data using glass beads of varying sizes [4] indicates the ability of the particles to improve liquid retention is directly associated with the available surface area.

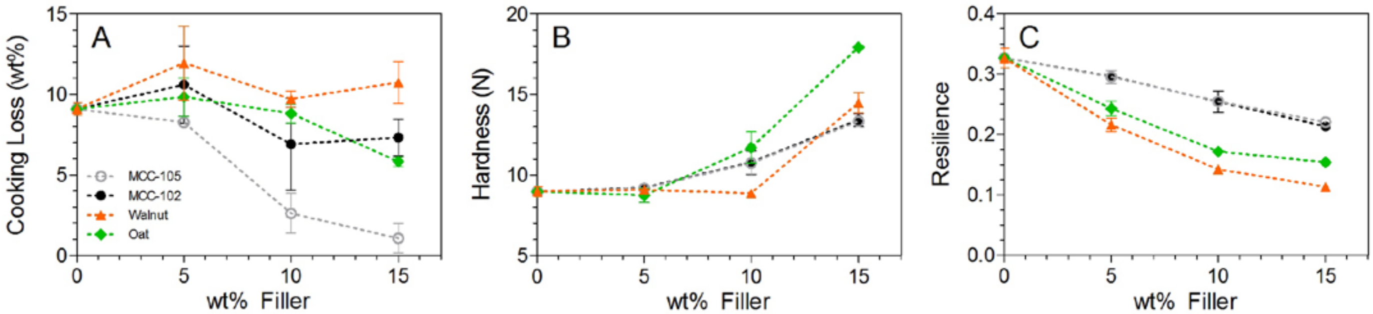

Fig. 1. Stability and texture of finely comminuted poultry meat batters containing food-grade crystalline fillers. Cooking loss (A), Hardness (B), and Resilience (C) are presented as a function of wt% filler. Dashed lines are meant only to guide the reader's eye.

The Hardness of the particle-filled products increased substantially when a high filler content was employed (15 wt%); however, below this level, the fillers only had a minor impact (see Fig. 1B). These results were attributed to particle crowding effects; i.e. contacts between neighbouring rigid particles which resist deformation to a greater extent than the surrounding protein gel matrix. Particle crowding has previously been observed at comparable concentrations to those investigated here. The greatest increase in Hardness was observed with the oat fibre, likely due to the larger size and irregular shape of these particles, which would increase the occurrence of particle-particle contacts.

The Resilience (i.e. post-deformation recovery) was inversely correlated to the filler content (Fig. 1C), and was also mirrored in the Springiness and Cohesiveness of the products (data not shown). These results are in agreement with the particle crowding hypothesis outlined above, as the presence of rigid particles in a deformable matrix results in stress concentration at the interface, thus promoting crack formation, which would negatively impact the ability of the protein network to recover after compression.

T_2 relaxation results indicate the apparent mobility of the water phase was most restricted by the walnut shell flour, followed by the smaller MCC-105 and oat fibre which had an equivalent impact. The larger MCC-102 particles had the least impact on decreasing water mobility. This is in contrast to the observed cooking loss results which suggest smaller particles (i.e. a greater total surface area) are more effective in improving product stability. This finding suggests T_2 relaxometry does not give a direct indication of how a filler will impact the stability of the final product, and therefore may not be an effective tool in screening candidate fillers.

IV. CONCLUSION

This study evaluated the potential of a set of hydrophilic, insoluble crystalline particles as a novel class of fillers for improving the stability and textural properties of finely comminuted meat products. It was shown that total filler surface area was the most important parameter in determining the effectiveness as a bulking agent, and the impact on textural properties was predominantly due to particle-particle contacts. Decreasing particle size may prove to be the most efficient strategy to improve the performance of these ingredients as fillers for processed meat products.

ACKNOWLEDGEMENTS

The authors acknowledge the financial assistance of the Ontario Ministry of Food and Rural Affairs (OMAFRA)

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