2004 MAFMA Final Report

Project Title **Production of Low Glycemic Index Extruded Products with Good Functional Properties**

PI **Bruce R. Hamaker**

Co-PI **Osvaldo H. Campanella**

Academic Institution **Purdue University**

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1. Objective Summary

Factors affecting incorporation of dietary fiber into extruded products (i.e., snacks and breakfast cereals) were investigated. Reduction in particle size of insoluble fibers, such as cellulose and corn bran, improved extrusion expansion but only to a limited extent, while increase in crystallinity significantly decreased extrudate expansion and quality. A molecular weight optimum of fiber was found to enhance extrudate expansion.

2. Objective Accomplishments

Objective 1: Demonstrate the relationship between molecular weight, degree of crystallinity and extrudate functionality using purified cellulose as a fiber in a model system.

In these experiments, cellulose was used to determine the effect of particle size and degree of crystallinity on extrudate expansion properties. Carboxymethylcelluslose (CMC was used for experiments on the relationship between fiber molecular weight and extrudate properties instead of cellulose as fairly well defined CMC molecular weight fractions could be purchased commercially.

Particle size did not affect the relative degree of crystallinity of cellulose before or after extrusion with cornmeal (Figure 1). Corn bran particle sizes below 74 µm also did not result in further enhancement of SEI of extrudates (not shown).

The addition of cellulose to cornmeal significantly ($P<0.05$) increased the specific mechanical energy (SME) of extrusion. It was hypothesized that this occurred because significant portions of the crystalline regions of cellulose did not melt during the extrusion process; thereby restricting flow of the material in the extruder.

Extrudates containing amorphous cellulose (SigmaCell 101) had the highest sectional expansion index (SEI, 10.97 ± 0.03), and lowest specific mechanical energy (SME = 191 ± 3) compared to other extrudates containing crystalline cellulose. The amorphous SigmaCell 101 was blended with the highest crystallinity Sigmacell 50 to obtain mixtures with different degrees of crystallinity. Amorphous nature of the cellulose was found to be the predominant factor influencing expansion and not its particle size. An increase in degree of crystallinity corresponded to a linear decrease ($r2 = 0.9561$) in SEI (Figure 2). It is hypothesized that this occurred due to the inability of the crystalline portions of cellulose to participate in the continuous phase created by starch during extrusion, consequently reducing its ability to expand. An increase in degree of crystallinity of the extrudate blend also resulted in a linear increase in SME, Figure 3. This likely occurred because significant portions of the crystalline regions of cellulose did not melt during the extrusion process, therefore restricting flow of the material in the extruder and increasing the viscosity of the melt.

Increasing the degree of crystallinity of cellulose reduced the sectional expansion index of extrudates containing cellulose. Therefore, the molecular framework of cellulose, i.e. its degree of molecular ordering , affected the extent of its extrudate expansion. It is possible that manipulation of the supramolecular structure of cellulose, and possibly corn bran, may facilitate increased SEI of extrudates containing high concentrations of these dietary fibers.

Increasing the molecular weight of a linear polymer, such as CMC, favored increased longitudinal expansion of extrudates and resulted in increased extrudates sectional expansion index with an observed optimum (Figure 4). This new finding suggests that each fiber may have a molecular weight optimum for incorporation into puffed extruded products, and is an important finding for industrial application. The molecular architecture of laboratory extracted arabinoxylan appeared to be more favorable in facilitating extrusion expansion compared to the more linear structure of CMC.

Objective 2: The improvement of the functionality of inexpensive fiber (such as wheat bran), using knowledge gained from the model fiber system.

Work towards this objective was begun during this project period though, due to the time consuming nature of testing and making quantities of fiber necessary for extrusion experiments, results were gained only in the next project year (also MAFMA-funded). Preliminary work did show positive results with alkali treatment of corn bran to molecularly disperse polysaccharides for better incorporation at higher levels into the extrudates.

3. Unexpected findings, if any

None

4. Practical Impacts of research efforts

An extension of this project was funded for a second year, and practical impacts are given in that report.

5. Publications resulting from this research

None