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Characterization of the interactions between a sucrose fatty acid ester emulsifier and starches

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CHARACTERIZATION OF THE INTERACTIONS BETWEEN A SUCROSE FATTY ACID ESTER EMULSIFIER AND STARCHES

by

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GRADUATE COLLEGE
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Advisors: Randy L. Wehling and John H. Rupnow

The effects of a hydrophilic (HLB 15) sucrose ester (SE) emulsifier on native starches from maize, potato, tapioca and wheat (normal starches with approximately 20-25% amylose) and mutant waxy (100% amylopectin) and Hylon VII (high amylose) maize starches were studied.

The SE reduced iodine binding capacity (IBC) and glucoamylase digestibility of native, normal starches and high amylose maize starch, presumably due to starch-SE inclusion complex formation. A weak, limited interaction was observed between waxy maize starch (amylopectin) and the SE.

The SE reduced the enthalpy of gelatinization of the normal starches, but not waxy maize starch, as measured by differential scanning calorimetry (DSC), indicating that complex formation between the SE and amylose occurred during starch gelatinization. Complex formation was further confirmed by the presence of a complex melting endotherm during rescanning (reheating) of samples by DSC.

Starch fractions solubilized by boiling and sonication of normal, waxy and Hylon VII maize starches were evaluated by high performance size exclusion chromatography. Addition

of the SE to presolubilized starch samples preferentially removed amylose from solution, presumably due to precipitation of insoluble starch-SE complex. Weak interactions between SE and amylopectin resulting in formation of soluble aggregates was suggested but not confirmed.

Unique cooking properties of each of the starches studied were demonstrated in Rapid Visco-Analyzer viscosity profiles. The SE increased time to peak for the normal starches and waxy maize starch, suggesting interaction between the starch and SE due to complex formation at the granule surface during gelatinization. Hot and cold viscosities of the normal starches were also affected by the SE but the direction and magnitude of the effect varied with starch type.

X-ray diffraction confirmed V-hydrate (inclusion) complex formation between the SE and normal maize but not waxy maize starch. Preliminary NMR data indicated some interaction between normal and waxy maize starches and the SE during starch gelatinization although the nature of the interaction could not be determined.

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I. INTRODUCTION

Starch is a major component of ingredients used in many food systems, especially baked goods in which flour, the major ingredient, is approximately 70% starch. Purified starch ingredients are also used widely in the food industry in formulated foods. Starch in food may have a number of functions such as providing texture, structure, viscosity, body, flavor and color.

Ultimate performance of a starch ingredient depends on the inherent chemical and physical properties. However, many other ingredients can be present in the food system as well, and can alter the properties of the starch. Equally important to starch performance, then, is the effect of interactions between the starch and other ingredients.

In a food product development situation, specific ingredients are used together in tightly controlled ratios to yield a desired end product. Choosing ingredients and ingredient levels, however, is often done quite randomly. Very often, trial and error attempts involving many ingredient combinations are made to identify the optimum formula. It is the opinion of this author that a more systematic, educated approach would be more effective and efficient. That type of approach would require an in-depth knowledge of food ingredient interactions. However, such information is very limited or not available.

The major objective of this research was to study the interactions between purified food starches and a sucrose fatty acid ester emulsifier. Commercial starch ingredients from different botanical sources and a commercial sucrose ester (SE) emulsifier were used. The specific goals were:

1. To study the response of native, normal (those with approximately 20-25% amylose) starches to the SE,

2. To study the interaction of amylose and amylopectin fractions of starch with the SE using normal, waxy (100% amylopectin), and Hylon VII (high amylose) maize starches,

3. To demonstrate the ability of different chemical and physical analyses to measure starch-SE interactions, and

4. To identify, if possible, the mechanism(s) of starch-SE interaction(s).

II. LITERATURE REVIEW

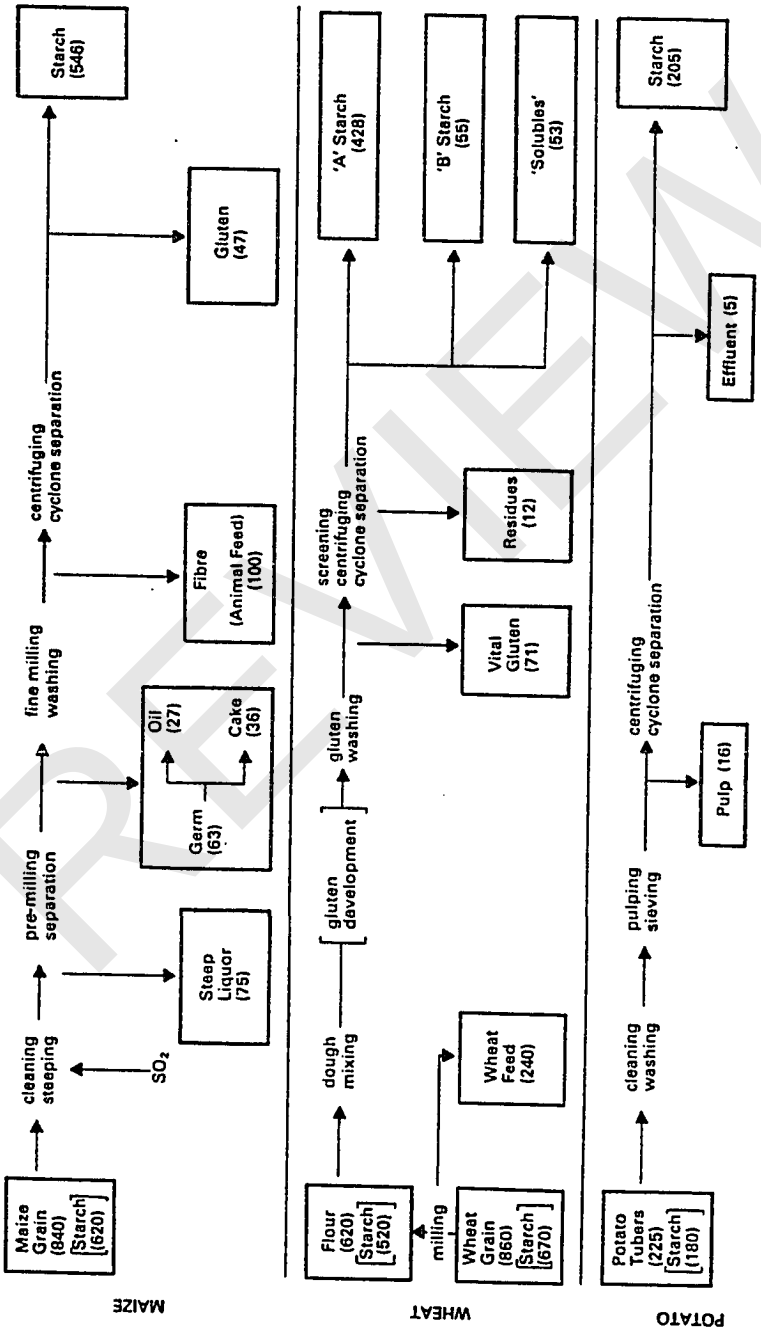
Starch

Sources of Starch

Starch is a naturally occurring organic compound that is widely distributed in nature. Green leafed plants deposit starch in a number of locations including roots, tubers, stem-pith, leaves, seeds, fruit and pollen (Zobel 1988a). Starch serves as a food reserve for the plant during dormancy and germination (Smith 1982). Starch is also key to human survival as it contributes more calories to the diet than any other single nutrient (Anon. 1985).

Starch is often isolated from crop materials, the process used being dependent on the quality and functional properties of the co-products obtained (Galliard 1987). Wet milling processes commonly used for isolation of starch from wheat, maize and potato are diagrammed in Figure 1. Industrial production of starch is approximately 17 million tons annually, which represents utilization of only about 1.5% of the annual world crop of starch-containing raw materials (Swinkels 1985a). In the United States, maize (Luallen 1988) and waxy mutant varieties of maize (Smith 1982) are the predominant sources of commercial starch. Approximately three billion pounds of normal maize starch are produced annually in the U.S. and another one-half billion pounds produced from waxy and high amylose maize varieties (Snyder 1984). Tapioca (also called cassava or manioc) starch is imported mainly from Thailand and Brazil, but because of the expenses of harvesting and importing

Figure 1. Simplified diagrams of typical starch production processes from maize, wheat and potato (Galliard 1987).



tapioca it is used quite selectively (Smith 1982). The European communities utilize potato and maize starches extensively and, more recently, wheat starch (Galliard 1987, Munck et al 1988).

Components of Starch

The building block of starch is the α-D-glucopyranosyl unit in the minimum energy $^4C_1$ chair conformer (Whistler and Daniel 1984). Starch molecules are polymers formed by the enzymatic condensation of glucose units (Smith 1982).

Most starches contain amylose and amylopectin as the major fractions. Starches from different sources vary in their ratio of amylose to amylopectin. Most native starches contain 20-30% by weight of amylose (Young 1984). The ratio of amylose to amylopectin in the starch fraction of certain plants can be controlled genetically. Waxy varieties of maize, sorghum, barley and rice starches contain essentially all amylopectin and little or no amylose. Amylotype hybrids of maize and wrinkled seeded pea contain starch with 80% or more amylose.

Linear amylose molecules are composed of anhydroglucose units connected by α-(1-4) linkages. Some amylose molecules have limited, long-chain branching involving α-(1-6) linkages (Banks and Greenwood 1975; Greenwood 1976). The total amylose fraction is a mixture of linear and lightly branched molecules. The molecular weight (MW) of amylose polymers ranges from 150,000 to 1,000,000 depending on the