CHAPTER I

INTRODUCTION

Mexican food products, such as tortillas, corn chips and taco shells, are made from corn by the nixtamalization process. This process involves alkaline-cooking, steeping, washing, and stone-grinding of the kernels to produce masa. Corn masa can be kneaded, molded, and either baked on a hot griddle to produce table tortillas, baked and fried for tortilla chips or taco shells, or dried to produce dry masa flours.

Sorghum is an acceptable replacement for corn in some Latin American countries because it is less expensive, produces higher grain yields under hot, dry conditions, and has a similar nutritional value (Khan et al., 1980). Improved sorghum varieties with a secondary tan plant color and white pericarp are comparable to those traditional populations and produce tortillas with good color and flavor attributes (Khan et al., 1980; Bedolla et al., 1983; Choto et al., 1985).

Although tortillas are traditionally prepared by hand in rural areas of Latin America, medium and large-scale mechanized processing has been adopted in many communities. In the U.S. and Mexico, dry masa flours are prepared commercially and sometimes are used for making tortillas in homes and in tortilla plants.

Tortilla production is a time and energy consuming process. Attempts to design efficient, continuous, alkaline processes that would achieve acceptable textures and flavors in masa products have had limited success. Conventional and alternative nixtamalization technologies have been studied (Molina et al., 1977; Bazua et al., 1979; Johnson et al., 1980; Bedolla and Rooney, 1982; Khan et al., 1982; Trejo-Gonzalez et al., 1982;

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Bedolla et al., 1983; Paredes-Lopez and Saharopulos-Paredes, 1983), including characterization of corn flours (Bedolla and Rooney, 1984), and chemical and structural changes occurring during the process (Bressani et al., 1958; Saldana and Brown, 1984; Serna-Saldivar and Rooney, 1987; Vivas et al., 1987; Pflugfelder et al., 1988; Gomez et al., 1988). However, limited information is available regarding effects of nixtamalized macronutrients, starch and proteins, on functionality of the masa.

Alkaline-cooking and grinding of corn and sorghum produce masa as the major product, which is composed of particulate and dissolved solids fractions. Distributions of starch, protein, fat and minerals in each fraction are determined by the structure of the raw material and by process variables. A detailed physicochemical analysis of masa components could provide a better understanding about masa and better correlations between masa characteristics and process variables. Therefore, the objectives of this research were:

1. To determine effects of cooking time and stone grinding conditions on the microstructure and composition of different masa fractions.

2. To determine the structural changes that occur in corn and sorghum during nixtamalization processing by analyzing changes in the kernels as they were alkaline-cooked and ground by X-ray diffraction and various microscopic techniques.

3. To solubilize the corn and sorghum masa starches in water and determine their solubility characteristics using high perfomance liquid- size exclusion chromatography (HPLC-SEC).

4. To analyze and characterize coarse and fine dry masa flours and their fractions and characterize changes in starch during processing.

LITERATURE REVIEW

Corn or maize (*Zea mays*) is the largest of all the cereal grains, having an average kernel weight of 324 mg. The mature caryopsis of corn is composed of the pericarp, germ, endosperm and tipcap. The pericarp and testa are fused to form the hull or bran, which constitutes about 5.3 % of the kernel. The germ, about 11.5 % of kernel weight, contains a small embryo and a large, oil-rich, scutellum. About 82 % of kernel weight is the endosperm, which contains 86 % starch. The tipcap, where the kernel is attached to the cob, is less than 1 % of kernel weight (Paredes-Lopez and Saharopulos-Paredes, 1983; Kent, 1983).

Sorghum (*Sorghum bicolor* (L.) Moench) is the fifth major cereal produced worldwide. It is the staple food in warm, arid regions of Asia, Africa and some parts of Central America. Sorghum seed is a naked caryopsis, small and rounded, varying from 10 to 30 g for 1000 grain weight, and may be white, red, yellow, or brown. The caryopsis is composed of three fractions: pericarp (7.9%), endosperm (82.3 %) and germ (9.8 %) (Hoseney, 1986).

Nixtamalization Process

The traditional method to process corn into tortillas (nixtamalization) was developed by Latin American Indians (Cravioto et al., 1945). In this process, corn is cooked in boiling lime solution for 5-50 min and then steeped overnight. The steep liquor (nejayote) is discarded; the cooked-steeped corn (nixtamal) is washed to remove excess alkali and loose pericarp; and the nixtamal is ground into a dough (masa) (Bedolla and Rooney, 1982; Khan et al., 1982). Masa can be flattened into thin disks that are baked on a hot griddle to produce tortillas, can be flattened, baked and fried to produce chips, or can be dried to produce dry masa flours.

Although corn is preferred for nixtamalization processes, sorghum is substituted for part or all of the maize in tortillas prepared in parts of Honduras, Guatemala, El Salvador, Nicaragua and Mexico.

The optimum degree of cooking-steeping is determined by subjectively evaluating the extent of hull disintegration, kernel softening and the "moist-cooked" appearance of the corn (Martinez-Herrera and LaChance, 1979). Plasticity, cohesiveness and stickiness are some of the rheological properties of masa used to evaluate the effectiveness of the process. The texture of the masa is determined by endosperm type and texture, drying and storage conditions and soundness of the corn, as well as the amount of water uptake and extent of starch gelatinization during processing. (Bedolla and Rooney, 1982). The major criteria for selection of corn hybrids for nixtamalization processing are: hard endosperm with a small dent; white cob; no tendency to form red streaks in the pericarp; easily removable pericarp; uniform, sound kernels; and low dry matter losses during processing (Gomez et al., 1987).

Rooney (1985) suggested that sorghum varieties with a thick, white pericarp, no testa, an intermediate to corneous texture and tan secondary color plant produce the highest quality of tortillas.

Microstructural changes during alkaline-cooking and steeping of corn were studied by Paredes-Lopez and Saharopulos (1982) using scanning electron microscopy. Degradation of the cuticle and outer pericarp layers was apparent during cooking and steeping. Pitting and corrugation of the surface layers suggested hydrolysis of hemicelluloses in the hull. Surface views of washed nixtamal showed that the aleurone and some inner pericarp layers remain attached to the endosperm and germ. Endosperm cell walls appeared to be structurally altered by the alkaline cooking and steeping.

The grinding of nixtamal yields masa which is a complex mixture of fractions whose composition and physicochemical characteristics determine its behavior during baking and frying (Pflugfelder et al., 1988). Information regarding the microstructural changes that occur during alkaline-cooking and steeping of corn has been published by Paredes-Lopez and Saharopulos (1982) and Khan et al. (1982). Pflugfelder et al. (1988) reported that corn masa is comprised of larger particles of endosperm, germ, pericarp and tipcap dispersed in a mass of cell fragments and partially gelatinized starch. The particulate fractions of masa is held together by dissolved solids and dispersed lipids.

Structural changes occurring in nixtamalized corn and sorghum as they progresses from the raw kernel to tortillas, were reported by Gomez et al. (1988). Alkali: weakened the cell walls, facilitating removal of the pericarp; solubilized cell walls in the peripheral endosperm; caused swelling and partial destruction of starch granules; and modified the physical appearence of the protein bodies. The masa consisted of small pieces of germ, pericarp, aleurone, endosperm, free starch granules, cell fragments, and dissolved solids and lipids in the water. During baking of tortillas additional degradation of cell walls, further loss of starch crystallinity and partial destruction of protein bodies occurred.

The effects of nixtamalization on solubility, digestibility and amino acid availability of corn proteins have been studied. Bressani et al. (1958) reported that nixtamalization greatly decreased the solubility of zein, thereby increasing the biological value of soluble proteins. Increased availability of some essential amino acids was found. A decrease in all soluble protein fractions and a large increase in the insoluble residue was reported by Trejo-Gonzalez et al. (1982). In a more recent study, Vivas et al. (1987) indicated that solubility of corn and sorghum proteins was affected by cooking in alkali, steeping, grinding, and baking into tortillas. Solubility of sorghum proteins was more affected than that of corn proteins. Alkaline processing also affected the molecular weight of both corn and sorghum proteins. The *in-vitro* protein digestibility values dropped after nixtamalization. Apparently, the formation of complex compounds which reduced the solubility also made the protein inaccessible for pepsin degradation, and thus, less digestible. However, the nutritional value of sorghum related lime-cooked products, predicted by *in-vivo* analyses, is quite comparable to similar corn products (Serna-Saldivar, 1984).

Amylograph peak viscosity and enzyme-susceptible starch ratio are two methods which have been used to measure starch gelatinization in masas. The peak pasting viscosity of masa slurries in a Brabender Viscoamylograph was found to decrease with increasing cooking times, cooking temperature, lime concentration and steeping time. The enzyme-susceptible starch ratio was found to increase with cooking time and temperature (Vasquez-Moreno and D'Appolonia, 1979).

Various physicochemical measurements have been used to evaluate texture including nixtamal shear force (Bedolla 1980), Bingham viscosity of masa (Padua and Whitney, 1982) and masa particle size distribution (Khan et al., 1982).