Fractionation and Composition of Commercial Corn Masa[1]

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ABSTRACT

Corn masa from five processes at two commercial plants was fractionated and analyzed for starch, nonstarch polysaccharides, protein, lipid, and calcium. Masa from tortilla chip, corn chip, and table tortilla processes was compared. Masa dry matter consisted of 26–53% particles (cell clumps > 63 μm), 41–65% cell fragments, and 5–9% dissolved solids and free lipid. Free starch granules constituted 90–97% of the smaller cell fragment fraction. Extensive gelatinization in free starch granules (47% loss of birefringence) was found only in corn chip masa made from soft corn given a severe heat treatment. Only 5 to 15% of the free starch granules in tortilla and tortilla chip masa lost birefringence. Calcium content of masa was affected by lime levels, cooking-steeping temperatures, and corn characteristics. Of total masa lipid, 25–50% was free and partially emulsified. Particle size distribution of masa was most influenced by grinding conditions. The proportion of free starch granules, dispersed lipid, and dissolved solid components in masa critically affects the properties of masa, tortillas, and fried masa products.

Corn masa is extensively produced in the United States and Mexico to make tortillas, Mexican food products, and corn snacks such as tortilla chips. Commercial processes for masa production generally utilize a modification of traditional nixtamalization, the alkaline-cooking method used for preparing corn tortillas. Both traditional and commercial methods for making tortillas and Mexican food products from corn have been reviewed (Katz et al 1974, Paredes-Lopez and Saharopulos-Paredes 1983, Rooney and Serna-Saldivar 1987).

In commercial operations, it is critical that masa produce a uniform sheet that is cohesive and slightly elastic, but not sticky. Various physical and chemical measurements that have been used to evaluate masa texture include nixtamal shear force (Bedolla 1980), Bingham viscosity of masa (Padua and Whitney 1982), masa particle size distribution (Khan et al 1982), amylograph viscosity of masa, and enzyme-susceptibility of masa starch (Vasquez-Moreno and D'Appolonia 1979). Calcium content of masa was determined by Trejo-Gonzalez and co-workers (1982). Additional chemical information is needed concerning the composition of the various fractions of masa and how they interact to form the desired product.

Dry matter losses in five commercial processes for masa production were reported (Pflugfelder et al 1988). Masa from these processes was examined in this study to characterize the properties of individual fractions that affect masa behavior. The complex, heterogeneous system of masa was fractionated into particulate and dissolved fractions, and their chemical properties were determined.

MATERIALS AND METHODS

Plant Samples and Data

Raw corn and masa samples from five commercial processes were taken at plants X and Z during three visits over eight months (Pflugfelder 1988). Production data recorded included corn variety and condition, amounts of corn, water, and lime per batch, and processing temperatures and times. Conditions at plant X were more severe than at plant Y. Corn at plant X was boiled in a steam-jacketed kettle with vigorous agitation, quenched with cold water, and pumped to steeping tanks through a small-diameter pipe. At plant Y, the corn and cooking water were heated to about 85° C directly by steam injection in combination cooking-steeping tanks. Compressed air agitation and pumping through large hoses reduced the shear stress to which the corn was subjected.

Nixtamal (cooked-steeped corn) was ground to masa with synthetic aluminum oxide stones at plant X and with traditional hand-carved lava rock stones at plant Z. The width of the gap between the grinder stones was not measured, but it was adjusted by experienced plant personnel to achieve the desired products.

An experimental production trial was conducted to evaluate the effects of corn cooking-steeping conditions using the same grinding conditions. Nixtamals from all the processes were ground under identical conditions in plant Z. In addition, yellow (Y) and white (W) corn nixtamals from the corn chip and tortilla chip blends were separated and ground.

Masa Fractionation

Production masa samples were gently slurried in an equal weight of water (200 g) immediately after sampling. The slurry was then sieved with a U.S. standard sieve no. 230 (63 μm) to separate larger particulate matter from smaller particulate matter and dissolved solids. This sieve was selected to separate free starch granules from the masa. An additional 200 ml of water was used in small aliquots to wash the larger particulate matter. The liquid fraction was combined and stabilized with 75 ppm of sodium azide. Both fractions were stored at 4° C.

Fractionation of commercial masa samples was completed in the laboratory. The particulate matter from each sample was resuspended and washed with water through U.S. standard sieves nos. 10 (2.0 mm), 16 (1.15 mm), 20 (850 μm), 30 (600 μm), 40 (425 μm), 60 (250 μm), 70 (212 μm), 100 (150 μm), and 230 (63 μm). Each sieve fraction was transferred to a tared weighing dish and dried 24 hr at 50–60° C. Dry matter yields were calculated for each fraction. All material retained on no. 40 or larger sieves was hammer-milled before chemical analysis.

The liquid portion from masa was centrifuged 5 min at 6,000 × g and the supernatant collected. The particulate matter was resuspended and centrifuged three times with deionized water and once with 30% ethanol. The washed solids, mostly starch, were vacuum filtered and dried 6 hr at 60° C and 12 hr at 110° C in a forced-air oven. Supernatants containing partially emulsified lipid and dissolved solids were combined, brought to 1,000 ml, stabilized with 75 ppm of sodium azide and refrigerated (4° C).

Corn and Whole Masa Sample Preparation

Whole corn and unfractionated masa were prepared for chemical analysis by drying to 5–10% moisture content in a 50–60° C oven. The dry material was hammer-milled through a 1-mm mesh screen.

Starch granules were isolated from each corn hybrid used in the five commercial processes (Pflugfelder et al 1988) by laboratory wet-milling. A 1-kg corn sample was steeped 48 hr (60° C initial temperature) in a solution containing 0.1% sulfur dioxide and 1.0% lactic acid. The solution was changed after 12 hr. A slurry was prepared by milling the steeped corn in a blender with dull blades. Starch collected by sieving the slurry through a no. 230 sieve was washed on a gravity table to remove protein and dried 6 hr at 60° C and 12 hr at 110° C.

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Chemical Analyses

Moisture content of masa and all ground samples was determined by drying in a forced-air oven at 110°C (method 44-15A, AACC 1983).

Corn, masa, and masa fractions were analyzed for total carbohydrate and total α-glucans (Pflugfelder et al 1988). The difference, termed nonstarch polysaccharide, represented total fiber and fiber hydrolysis products.

Crude protein, fat, and calcium contents were determined as described by Pflugfelder et al (1988). Lipid in the supernatant was extracted twice with 10 ml of chloroform per 25 g of liquid. The residual weight of lipid was determined after evaporation. Calcium was extracted from 0.15 g of the smaller particulate material with 5 ml of 0.5N HCl at 100°C for 20 min. The supernatant was also acidified before calcium analysis.

Loss of birefringence of raw corn starch and of the smaller particulate matter (mostly starch granules) was evaluated (Snyder 1984). The proportion of starch granules showing 50% or more loss of birefringence was calculated from examination of 12 microscopic fields.

Amylograph viscosity changes were determined on samples on an equal-starch basis (Shuey and Tipples 1980). Hold times at 95 and 50°C were 30 min.

Enzyme-susceptible starch (ESS) was measured using amyloglucosidase for 30 min at 60°C (Khan et al 1982). Liberated glucose was analyzed by the automated hexokinase method (Technicon 1978). ESS was expressed as milligrams of glucose per gram of starch. Total starch of autoclaved samples was determined using the same procedure.

RESULTS AND DISCUSSION

Masa Properties

Fresh masas from the five commercial processes were all moist, smooth, and slightly sticky. However, the physical properties of masa changed rapidly as the fresh masa cooled. The character of fresh masa was replaced by a drier, somewhat granular appearance. This staling of masa was unrelated to loss of moisture.

Fresh masa was slurried in water to prevent staling, retard starch retrogradation, and separate the solubles from the particulate material. The slurries were opaque yellow or white with suspended starch, and lipid material was visible at the surface. There was no indication that the slurrying and sieve washing operations caused additional particle size reduction.

TABLE I

Percent Yields of Particles, Free Starch Granules, and Dissolved Solids Fractions of Masa from Commercial Production and Experimental Trials[a]

Process[b]	Particle Fraction (>63 μm)	Free Starch Fraction (<63 μm)	Dissolved Solids Fraction
Commercial processes			
X-Ch	38.1	56.0	5.9
X-F	31.3	62.2	6.5
Z-Ch	53.4	41.6	5.1
Z-ChS	47.4	46.2	6.4
Z-Tl	26.0	64.9	9.1
Experimental trial			
EX-Ch	35.5	60.6	4.0
EX-F	29.5	65.7	4.8
EX-FY	37.7	59.0	3.3
EX-FW	42.3	53.2	4.5
EZ-Ch	32.9	63.0	4.2
EZ-ChY	36.7	58.9	4.5
EZ-ChW	36.8	59.3	4.0
EZ-Tl	31.8	64.0	4.3
SEM[c]	0.8	1.0	0.1

[a]Dry matter basis.

[b]Process codes: Plants X and Z, commercial production of tortilla chip (Ch), corn chip (F), and tortilla (Tl) masa; experimental trial (E); yellow corn (Y); white corn (W); short steep (S).

[c]Standard error of the mean (n = 3).

Centrifugation of the liquid fractions from masa produced five distinct layers. Above the large white starch layer were a thin brown layer of protein and pasted starch and a layer of white flocculent material, probably from cell walls. A layer of fatty material was above the cloudy supernatant. The lipid materials from masa prepared using high temperatures or with high lime content were most dispersible.

Fractionation of masa particulate matter revealed many differences in appearance. The largest particles (nos. 10 and 16 sieves; > 1.15 mm) were primarily germ and tip cap. Endosperm chunks constituted most of the intermediate sizes (nos. 20, 30, and 40 sieves; 425–1,150 μm); but the smaller particles (nos. 60, 70, 100, and 230 sieves; 63–425 μm) appeared to contain less endosperm. The smallest particles (through no. 230 sieve; < 63 μm) consisted of more than 90% free starch granules and will be called the masa free starch fraction in this paper.

Yields of Masa Fractions

Yields of particulate and dissolved solids fractions revealed differences between masas for the commercial production samples (Table I). The high-lime masa (Z-Tl) contained more smaller particles and dissolved solids than masas from the other processes. The tortilla chip masa at plant Z contained the largest particulate fraction, whereas the two processes at plant X yielded intermediate values. Yields of the free starch fraction were 41.6–64.9% in the production samples.

A more uniform distribution of particles was observed in the experimental trial where all the nixtamals from the different commercial processes were ground with lava stones at plant Z (Table I). For example, yields of free starch fraction were 60.6–65.7% using identical grinding conditions. Apparently, other processing conditions and raw material properties had less effect

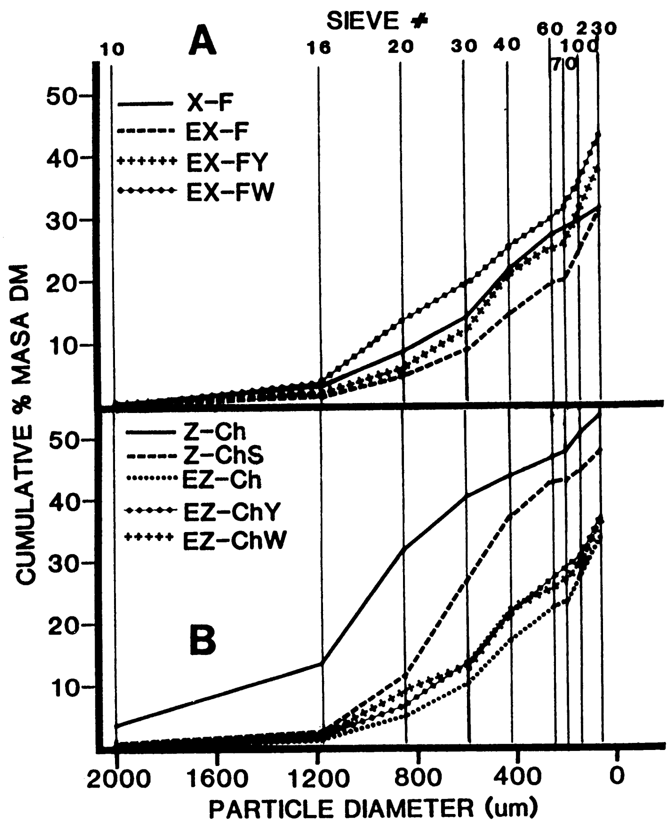

Fig. 1. Size distribution of masa particulate matter (> 63 μm) from processes X-F (**A**) and Z-Ch (**B**), expressed as cumulative percent (w/w) of masa dry matter in particles larger than indicated particle diameter. X-F, Z-Ch, and Z-ChS were commercial production masas made from yellow-white corn blends. EX-F and EZ-Ch were experimental trial masa samples corresponding to X-F and Z-Ch, respectively. Suffixes Y and W indicate the yellow and white corn components, respectively, of EX-F and EZ-Ch.

TABLE II
Percent Composition of Masa Fractions from Low-Lime (LL) and High-Lime (HL) Commercial Processes[a]

Masa Fraction	Masa LL	Masa HL	Starch LL	Starch HL	NSP[b] LL	NSP[b] HL	Protein[c] LL	Protein[c] HL
Whole masa	100.0	100.0	77.1	74.0	9.4	13.5	9.1	9.1
Particulates	42.8	26.1	60.2	37.9	16.9	26.5	17.5	30.0
U.S. Sieve no. (opening size [μm])								
10 (2,000)	1.2	...	33.4	...	36.8	...	20.1	...
16 (1,150)	5.0	...	52.1	...	25.4	...	15.6	...
20 (850)	10.2	...	65.4	...	15.3	...	14.5	...
30 (600)	9.6	1.8	63.5	31.2	16.1	33.9	16.1	30.0
40 (425)	7.7	6.4	62.1	32.3	13.9	32.8	18.9	30.2
60 (250)	...	6.3	...	36.3	...	28.6	...	30.2
70 (212)	5.5	...	59.5	...	14.6	...	21.0	...
230 (63)	3.6	6.0	54.2	44.1	14.8	15.7	23.8	31.6
SEM[d]	0.3	0.5	0.3	0.2	0.15	0.15	0.2	0.15
Free starch	51.5	64.9	94.2	90.3	2.9	7.2	0.8	0.8
Dissolved solids	5.7	9.1	27.3	6.2	15.6	27.3	3.0	4.6

[a]Dry matter basis. The means of low-lime processes (X-F, X-Ch, Z-Ch, and Z-ChS) are reported.
[b]Nonstarch polysaccharides.
[c]Protein = %N × 6.25.
[d]Standard error of the mean (n = 3).

TABLE III
Percent Composition of Free Starch Fractions in Masa[a]

Process	Percent of Masa	Starch	NSP[b]	Protein[c]
X-Ch	56.0	93.4 (67.7)	3.8 (24.8)	0.7 (5.4)
X-F	62.2	91.0 (72.2)	5.7 (39.0)	1.3 (12.0)
Z-Ch	41.6	96.8 (53.8)	0.5 (2.2)	0.7 (3.2)
Z-ChS	46.2	95.7 (60.5)	1.7 (7.0)	0.6 (3.2)
Z-Tl	64.9	90.3 (84.9)	7.2 (33.2)	0.8 (6.0)
SEM[d]	1.1	0.4 (0.4)	0.03 (1.6)	0.08 (0.5)

[a]Dry matter basis. Numbers in parenthesis reflect the percent of the component in the total masa.
[b]Nonstarch polysaccharides.
[c]Protein = %N × 6.25.
[d]Standard error of the mean (n = 3).

TABLE IV
Extent of Gelatinization in Masa Free Starch Fractions

Analysis/ Starch Sample	X-Ch	X-F	Z-Ch	Z-Chs	Z-Tl	SEM[a]
Loss of birefringence, %						
Native starch[b]	0	0	0	0	0	0
Masa free starch	16.0	46.4	16.9	8.7	5.4	3.2
Enzyme-susceptible starch (mg glucose/g starch)						
Native starch	83	84	80	80	73	5.8
Masa free starch	198	319	165	109	133	5.8

[a]Standard error of the mean (n = 3).
[b]Native starch isolated from corresponding raw corn or corn blend.

on masa particle size distribution than did the grinding conditions.

The particle size distribution of corn chip masa (X-F) ground with synthetic stones at minimum gap was coarser than when the same nixtamal (EX-F) was ground with traditional stones at a medium-fine setting (Table I, Fig. 1A). Yield of free starch was also 3.5% higher with the traditional stones.

Commercial nixtamal consists of intact kernels, broken kernels, and kernel fragments. This material, with exposed endosperm, may cause increased yields of the free starch fraction in masa. Coarser masa (smaller free starch fraction) was obtained with intact yellow (EX-FY) and white (EX-FW) kernels of nixtamal compared with the masa from corn chip process EX-F, which contained broken kernels (Fig. 1A). The white corn masa was also substantially coarser than the yellow corn masa, as expected, because the endosperm texture of the white hybrid (Asgrow 405W) is harder than the yellow hybrid (Pioneer 3186).

A comparison of masa free starch yields and cumulative distributions of masa particle fractions in the tortilla chip process (Z-Ch) also indicates the effects of processing and grinding conditions (Table I, Fig. 1B). Tortilla chip masa (Z-Ch, Z-ChS, and EZ-Ch) had coarse, intermediate and fine particles, respectively, depending upon conditions. Finer particle size of masa was achieved by decreasing the gap of the stone grinder. The yellow (EZ-ChY) and white corn (EZ-ChW) components of the experimental tortilla chip masa (EZ-Ch) were coarser than the blended masa, again reflecting the influence of broken kernels on masa properties.

Khan and co-workers (1982) reported a finer particle size distribution of masa was obtained using a pressure cooking procedure compared to commercial or traditional methods. Over-cooking of corn resulted in a finer particle size distribution. This was also observed in this study with the longer boiling (4 vs. 20 min) times of the X-Ch and X-F processes, respectively (Table I).

Composition of Masa Fractions

The four low-lime processes (X-F, X-Ch, Z-Ch, and Z-ChS) had very similar compositions for each masa fraction and were reported as average values (Table II). Their compositions, however, were substantially different than the high-lime process (Z-Tl). The large particles (nos. 10 and 16 sieves; > 1.15 mm) from the low-lime processes averaged 48.5% starch, 27.6% nonstarch polysaccharides (NSP), and 16.5% protein and appeared to be rich in germ and tip cap. In the medium particles (nos. 20, 30, and 40 sieves; 425–1,150 μm), starch content rose sharply (63.9%), whereas NSP and protein decreased to 15.4 and 15.9%, respectively. These particles appeared to be endosperm chunks; however, the protein and NSP contents were above those typical of corn endosperm. Smaller particles (nos. 60, 70, 100, and 230 sieves; 63–425 μm) contained less starch and NSP and considerably more protein (21.9%). The increased protein may indicate the presence of scutellum cell fragments from which much of the free lipid in the dissolved fraction was derived.

Large particles (nos. 10 and 16 sieves; > 1.15 mm) in masa from the high-lime process (Z-Tl) were absent (Table II). The largest particles (nos. 30 and 40 sieves; 425–800 μm) contained starch, NSP, and protein in approximately equal proportions. As the particle size decreased, starch increased, NSP decreased, and protein remained nearly constant in the masa fractions. The high pH and calcium content apparently promoted disintegration of cell walls and endosperm protein matrix. This resulted in smaller particles and a larger yield of the free starch fraction compared to masa from the low-lime processes.

Masa Free Starch Fractions

Starch and other cell fragments (through no. 230 sieve;

<63 μm) constituted 41.6–64.9% of masa dry matter and contained 90.3–96.8% starch granules (Table III). The highest yields of this fraction (64.9%) and of NSP (7.2%) were observed in the high-lime process for tortillas (Z-Tl). The kernel structure was apparently extensively degraded by the combination of high pH and fine grinding in that process. The free starch fraction from low-lime processes at plant X contained more NSP (4.8%) than similar samples from plant Z (1.1%). Higher cooking temperatures and increased physical stresses at plant X probably contributed to this result.

More than half of total starch was present as free granules in every masa sample studied (Table III). The average proportions of total starch separated in the smallest particulate fractions were 63.5 and 84.9% from low-lime and high-lime processes, respectively. Masa free starch fractions contained 2.2–39.0% of the total NSP and 3.3–12.0% of the total protein in masa.

Extent of gelatinization of starch granules was measured only in the masa free starch fraction, because gelatinization in particle-bound starch probably has little impact on masa texture or functionality. Only the severe heat treatment of corn chip process X-F, i.e., boiling for 20 min with 1% lime, caused extensive loss of birefringence (46.4%) of starch granules (Table IV). No other process resulted in more than 17% loss of birefringence. The lowest level of gelatinization was observed in the high-lime process for tortillas (Z-Tl). This suggests that the high pH of calcium hydroxide did not increase starch gelatinization in corn kernels during low temperature (< 85° C) processing. ESS of starch in this masa fraction for low-lime commercial processes was 36–140% greater than for native starch. ESS for process X-F was 280% greater than for native starch. The softer endosperm texture of Pioneer 3186 probably contributed to the increased starch gelatinization during the severe heat treatment of process X-F. However, calcium hydroxide concentration did not significantly increase starch gelatinization, as was suggested by Trejo-Gonzalez and co-workers (1982).

Amylograph peak viscosities of masa free starch fractions were also determined as an index of gelatinization (Fig. 2). Amylograph curves for the masa free starch fraction from processes X-Ch, Z-Ch, Z-ChS, and Z-Tl were similar to the corresponding raw starch curves (data not reported). Samples from processes X-F and EX-F had very similar curves showing lower viscosities than native starch (Fig. 2). Free starch fractions from the yellow (EX-FY) and white corn (EX-FW) components of process EX-F had higher peak viscosities than those from the commercial mixture of these corns. This suggests that broken and fragmented kernels significantly contributed to the extent of starch gelatinization in the masa free starch fraction. Samples from Pioneer 3186 (EX-FY) had higher viscosities than from the hard white hybrid, Asgrow 405W (EX-FW).

Masa Dissolved Solids

Dissolved solids fractions that were separated from masa by sieving and centrifugation constituted 5.1–9.1% of masa dry matter (Table V). The starch and lipid contents of this fraction were higher at plant X, and NSP and protein contents were higher at plant Z. The severe cooking treatment of process X-F (boiling 20 min with 1% lime) solubilized (gelatinized) starch but not protein, whereas the high-lime (< 85° C with 6% lime) process (Z-Tl) solubilized NSP and protein but not starch and lipid. This suggests that high pH is needed to solubilize cell wall materials and certain proteins.

The lipid that separated in the dissolved solids fraction constituted 23.2–41.1% of total masa lipid (Table V). The amount of free or dispersed lipid increased as the temperature and time of the cooking-steeping process increased. Less lipid was solubilized in the short tortilla chip process (Z-ChS), and the most severe process (X-F) yielded the most soluble lipid.

Calcium Distribution

Lime uptake during alkaline cooking of corn was affected by corn characteristics, processing conditions, and lime concentration. Alkalinity of corn kernels during processing was assumed to increase in proportion to calcium concentration. Calcium contents of whole masa and masa free starch fractions reveal that the longer cooking time in process X-F increased calcium uptake by 33 and 104%, respectively, compared to process X-Ch (Table VI). The softer endosperm texture of Pioneer 3186 used in process X-F probably contributed to increased calcium absorption.

Calcium concentrations in whole masa and masa free starch fractions from the short steep (5 hr) tortilla chip process (Z-ChS) were substantially higher than in the normal process (Z-Ch) (20–24 hr steep) (Table VI). The corn in the Z-ChS process was steeped at near 60° C without added water, i.e., no dilution of lime solution. The corn in the Z-Ch process was quenched following cooking, decreasing the temperature to 45–50° C and diluting the lime solution. Thus, high temperature and lime content appeared to increase calcium uptake in Z-ChS.

Calcium contents of masa and masa free starch fractions from the high-lime tortilla process (Z-Tl) were substantially higher than from the other processes (Table VI). This process used a fivefold higher lime concentration than the other processes. Absorption of calcium into masa and masa free starch fractions was approximately in proportion to lime levels.

TABLE V
Percent Composition of Masa Dissolved Solids Fractions[a]

Process	Masa	Starch	NSP[b]	Protein[c]	Lipid
X-Ch	5.9	25.1	14.3	3.0	30.8 (34.2)
X-F	6.5	41.2	9.5	1.9	23.3 (41.1)
Z-Ch	5.1	28.5	18.0	2.7	··· ···
Z-ChS	6.4	14.3	20.7	4.2	18.2 (23.2)
Z-Tl	9.1	6.2	27.3	4.6	16.9 (31.4)
SEM[d]	0.15	1.1	0.3	0.15	1.8 (1.6)

[a]Dry matter basis. Numbers in parenthesis reflect the percent of total masa lipid.
[b]Nonstarch polysaccharides.
[c]Protein = %N × 6.25.
[d]Standard error of the mean ($n = 3$).

TABLE VI
Calcium Contents (ppm) of Raw Corn, Whole Masa, and Masa Free Starch Fractions[a]

Process	Lime (%) (corn basis)	Raw Corn	Whole Masa	Masa Free Starch
X-Ch	1.0	225	1,805	588
X-F	1.0	150	2,400	1,198
Z-Ch	0.8	200	1,605	363
Z-ChS	1.0	180	2,210	582
Z-Tl	5.0	250	4,085	2,418
SEM[b]	···	18	104	69

[a]Dry matter basis.
[b]Standard error of the mean ($n = 3$).

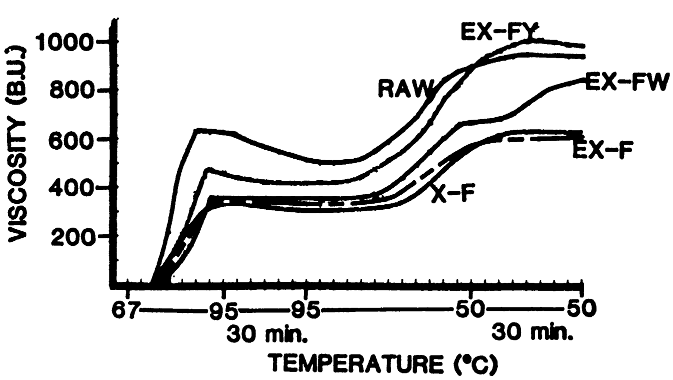

Fig. 2. Amylograph viscosity curves for masa free starch fractions from process X-F. Curve X-F is normal production masa from blended corn. Experimental production trial samples include EX-F, from blended corn, and its yellow (EX-FY) and white corn (EX-FW) components. The "raw" curve indicates native starch isolated from the corn blend (67% Pioneer 3186, 33% Asgrow 405W).

CONCLUSIONS

Commercial corn masa is comprised of larger particles of endosperm, germ, pericarp, and tip cap dispersed in a mass of small cell fragments and partially gelatinized free starch granules held together by dissolved solids and dispersed lipids. The free starch granules-cell fragment fraction (through no. 230 sieve, < 63 μm) contained at least 90% starch granules and made up about half of total masa dry matter. Larger particles (cell clumps; nos. 20, 30, and 40 sieves, 425–850 μm) constituted about 40% of masa dry matter and were mostly from the endosperm. Dissolved solids and dispersed lipids represented about 5% of masa dry matter. Soluble starch and fiber components were the major dissolved solids, with smaller amounts of protein and calcium. About one-third of the total masa lipid was extracellular and partially emulsified.

It is likely that masa free starch, dissolved solids, and free lipid are the primary determinants of the texture, flavor, and keeping quality of masa products. Gelatinization of free starch during baking and frying of masa provides the matrix in which particles are embedded. The flexibility of tortillas and the crispness of corn chips probably derive primarily from free starch gelatinization. Masa particles have a largely physical role in disrupting the dough to facilitate moisture escape and preventing excessive pillowing.

Dissolved solids in masa provide the substrates for browning reactions that are responsible for much of the flavor of masa products. They may also be important as binding agents. Free lipid may have a tenderizing effect on tortilla texture, as well as providing flavor volatiles though oxidative degradation.

Some earlier studies of masa and its products have treated masa as a homogeneous dough with uniform composition and physical properties. In fact, masa is a complex mixture of fractions whose reactions and interactions determine the behavior of the dough during baking and frying. There has been a tendency to overestimate the extent of gelatinization and the functional importance of particles in masa. Dissolved solids and free lipid components have rarely been considered in previous research. Further study of masa fractions is needed to improve masa quality and functionality and to optimize masa processes.

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