

Functionality of Rice and Sorghum Flours in Baked Tortilla and Corn Chips

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ABSTRACT

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The effects of raw and gelatinized sorghum and rice flours on the structure and texture of baked corn and tortilla chips were evaluated. Dry masa flour was hydrated into masa, sheeted, and cut. Corn chips were baked in an air-impingement oven, and tortilla chips were baked first in a three-tier oven and then in an air-impingement oven. Baked tortilla chips required significantly greater force to break and were less susceptible to breakage during handling than baked corn chips. Raw and gelatinized, normal and waxy rice and sorghum flours significantly changed the texture and structure of baked chips. Waxy rice and sorghum flours reduced peak force and work, increased chip thickness, and improved overall acceptability (as assessed by a taste panel), but waxy rice and sorghum chips were more

fragile and had a greater number of large central air cells. Waxy rice was more beneficial than waxy sorghum flour. Gelatinization of waxy flours increased thickness of baked chips, whereas gelatinization of nonwaxy flours had no improvement over waxy flours alone. Gelatinization of sorghum flour significantly decreased the peak force and work values for baked tortilla chips when compared with the control chips. Gelatinized rice flour tortilla chips were not significantly different than the control chips but were significantly harder than the other baked tortilla chips. The complex interactions that occur in baked corn and baked tortilla chips suggest that each ingredient acts differently in the two products. Thus, each ingredient must be evaluated for specific products and processes.

Fat content and texture are important quality parameters of baked and fried products. Sales of baked, reduced-fat tortilla chips are leveling-off after increasing significantly during recent years (SFA 1998). Baked chips have different taste and texture properties than fried chips, and consumer reactions have been mixed (Lujan-Acosta and Moreira 1997). However, increasing consumer demands for quality, low-fat products requires gathering more information on the processing and formulation alternatives needed to produce baked tortilla chips with a more desirable texture and taste.

Air-impingement ovens can be used to achieve an efficient chip-baking process. An air-impingement oven dries and browns the surface of a product with high-velocity air jets directed at a perpendicular angle to the product (Walker 1987). Air-impingement ovens bake products faster than conventional ovens and are used to bake a large number of products, including ready-to-eat cereals, snacks, meats, and doughs (Midden 1995).

Modified starches from different cereals are used as functional ingredients to help achieve various textural attributes in baked snacks (Sheng 1995). Lee (1991) found that waxy, high-amylose, and other mutant corn cultivars can significantly affect fried tortilla chip quality. In expanded or puffed snacks, greater expansion is obtained by changing the amylose-to-amylopectin ratio, and combinations of high-amylose and high-amylopectin starches are manipulated to produce desired properties. High-amylose corn starch also can be used when increased crunchiness and strength is required. Adding waxy corn starch is an effective way to increase expansion (Huang 1995).

Pregelatinization of waxy corn starch is required for snacks that expand during baking because baking conditions for expanded snacks do not allow time for adequate gelatinization of regular waxy starch, and pregelatinization of waxy corn starch allows expansion to begin earlier (Huang 1995). The functionality of the dough used for baked snacks is affected by the availability of gelatinized starch and by amylopectin and amylose content. Increasing the free amylopectin content tends to result in dough that is soft and cohesive and has film formation, sheet extensibility, puffability when heated, and a crisp-textured and fragile baked product (Addesso et al 1995).

The objectives of our study were to determine the effects of flours with differing endosperm characteristics on the textural, structural, and sensory characteristics of corn and tortilla chips baked in an air-impingement oven.

MATERIALS AND METHODS

Raw Materials

Dry masa flour (DMF), normal rice flour from broken kernels, waxy rice flour from waxy kernels, sorghum flour from decorticated kernels, and waxy sorghum flour from decorticated kernels were used to prepare baked corn and tortilla chips. Flour compositions and sources are listed in Table I. Clean sorghum kernels were decorticated with an abrasive dehuller (PRL Mini-Dehuller, Nutana Machine Co., Saskatoon, Canada) until 10% of the pericarp had been removed. Bran was separated from decorticated kernels with a Carter Dockage Tester (XT1 207, Hart-Carter Co., Minneapolis, MN) equipped with a No. 2 screen.

Preparation of Gelatinized Flours and Masa

Aqueous suspensions (7%) were prepared and heated slowly while stirring in a water bath at 90°C for 10 min. The hot gelatinized suspension was blended with DMF immediately after processing.

TABLE I
Flour Composition (%) and Source

Flour Sample ^a	Moisture (wb)	Starch ^b (db)	Crude Protein ^c	Soluble Amylopectin ^d	Soluble Amylose ^e
Dry masa	15.0	77	8.75	69.1	25.5
Rice	15.3	82	7.74	69.8	29.7
Waxy rice	14.6	81	5.95	98.1	...
Sorghum	13.3	78	8.75	68.6	31.0
Waxy sorghum	12.4	78	7.50	97.1	...

^a Dry masa flour: tortilla chip 1 (MINSAs, Muleshoe, TX); normal and waxy rice flours: broken kernels and raw milled waxy kernels, respectively (Comet Rice, Freeport, TX); sorghum and waxy sorghum flours: decorticated hammer-milled whole grains (ATx631*Tx436 and ATx630*R3338, respectively, 1992, Halfway, TX).

^b Standard (total starch assay). Megazyme method (Approved Method 76-13 [AACC 1995]).

^c N × 6.25 for corn starch, dry masa, sorghum, and waxy sorghum flours; N × 5.95 for rice and waxy rice flours.

^d Extracted at 120°C (HPLC-SEC). Soluble amylopectin = soluble amylopectin/soluble carbohydrates.

^e Extracted at 120°C (HPLC-SEC). Soluble amylose = soluble amylose/soluble carbohydrates.

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Masa was prepared by mixing DMF (500 g) for 1 min in a 19-L mixer (Hobart Corp., Troy, NY) at speed 1, hydrating with 500 mL of distilled water, and mixing for 2 min at speed 1. Masa was allowed to rest in a plastic bag for 10 min, sheeted, and cut into 20-g pieces with a sheeter-former (CH4-STM, Superior Food Machinery, Pico Rivera, CA).

Chip Preparation

Baked corn chips. Each of the raw rice and sorghum flours (100 g of each) were blended with DMF (400 g) for 1 min at speed 1 in a 19-L Hobart mixer. The mix was hydrated with 500 mL of distilled water and mixed at speed 1 for 2 min to produce masa. Hot gelatinized rice and sorghum flour aqueous suspensions were blended with DMF immediately after processing. Mixes were hydrated (1:1 ratio of water to dry ingredients) with distilled water and mixed at speed 1 for 2 min to produce masa. Masa was allowed to rest for 10 min, sheeted, and cut into 20-g pieces.

The masa pieces were placed on plastic trays and cut manually with an equilateral triangle-shaped cookie cutter (6 cm sides). The triangle-shaped pieces were placed on a round metal screen, and a second screen was placed over the first and fastened to it with three metal clips to produce flat baked chips.

Chips were baked in an air-impingement oven (model 2, Patent Smith Corp., Dallas, TX) at 191°C for 2 min with an airflow speed of 900 m/min. Baked corn chips were dried for 12 hr at 60°C in a forced-air oven to reduce moisture content from 4 to 3% (wb).

Baked tortilla chips. Three-tier and air-impingement ovens were used to produce baked tortilla chips. Masa pieces, sheeted (as described above) with the roller gap adjusted to produce 20-g pieces, were baked in a three-tier oven at 345°C for 40 sec to produce tortillas. Tortillas were placed on plastic trays and cut with an equilateral triangle-shaped cookie cutter (6 cm sides).

Chips were baked in an air-impingement oven by the procedure used for baked corn chips. Baked tortilla chips were dried for 12 hr at 60°C in a forced-air oven to reduce moisture content from 4 to 2% (wb); moisture content was determined with an infrared moisture balance (ICSC Scientific Company, Fairfax, VA) with 3-g samples and 75% lamp intensity).

Texture Measurement

Chip texture was evaluated with a texture analyzer (TA.XT2, Texture Technologies Corp., Scarsdale, NY). A metal clamp was used to attach a metal sheet (4 × 4 cm, 1 mm thick) to the analyzer as a guillotine. A second clamp was attached to the base. The analyzer arm was set 15 cm from the base, and a chip was placed on the base of the clamp smooth surface up (one side of the chip had to be in contact with the back of the clamp), and the clamp was closed gently without cracking the chip. The base clamp was set at 3.3 mm from the guillotine (Quintero-Fuentes 1997).

Chips were submitted to a compression test. Pretest, test, and post-test speeds were set at 7 mm/sec. Penetration distance was 3 mm. Maximum force and area under the force versus distance curve (work required to break the chip) were measured on six chips for each of

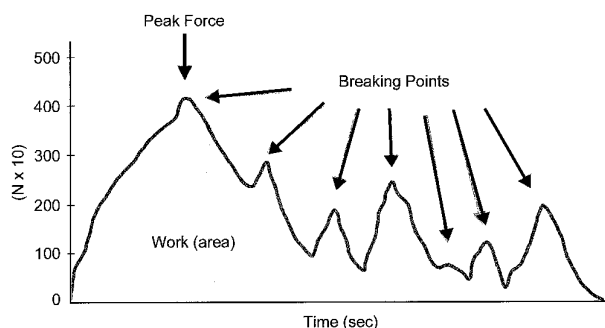


Fig. 1. Typical force curve for a dry masa flour (control) baked corn chip.

three baking trials. The number of peaks in each force curve was counted and represented the number of breaking points in the chip.

Chip thickness was measured using image software (NIH Image, version 1.61, National Institutes of Health, Bethesda, MD); air cell size and thickness were estimated subjectively and spot checked with image software for accuracy. Values reported are averages of 13 measurements on three chips from each treatment.

Breakage Susceptibility

Breakage susceptibility of chips containing different added flours was evaluated by a tumbler technique. Ten unbroken chips were weighed and placed inside rigid plastic bottles containing one 3.8-cm-diameter rubber ball. Bottles were attached to a tumbler that rotated for 1 min at 37.4 rpm. The number and weight of broken pieces of different sizes (large = 100–95% of an unbroken chip; fine = <5% of an unbroken chip) were recorded.

Environmental Scanning Electron Microscopy

Selected baked corn chips were viewed with an environmental scanning electron microscope (model E-3, Electroscan Corp., Wilmingon, MD) at an accelerating voltage of 20 kV, a condenser setting of 44, and a working distance of ≈5 mm, using the method of McDonough et al (1993). Chip samples required no special preparation techniques before viewing.

Sensory Evaluation

Thirty untrained panelists evaluated the selected baked chips. The texture attributes of brittleness and friability were evaluated on a nine-point rating scale (1 = least, 9 = most). Brittleness refers to the toughness or force required to break the chip on the first bite. Chips with greater friability scores broke more easily into small pieces in the mouth during chewing.

Overall acceptability was evaluated on a nine-point hedonic scale (1 = dislike, 5 = neither like or dislike, 9 = like). Two chips from each category were sampled by panelists. All samples were evaluated for all attributes during the same session. The sensory evaluation session was performed at the Experimental Foods Lab at Texas A&M University.

Statistical Analysis

Statistical analyses were performed with SAS software (version 6.10, SAS Institute, Cary, NC). Significant mean differences were analyzed within the general linear means procedure by the least significance difference (LSD) test. Any difference between factors was considered significant at $P < 0.05$.

RESULTS AND DISCUSSION

Evaluation of Baked Corn Chips

Relationship between structure and texture in baked corn chips. A typical force curve measures the number of breaks in a chip as pressure is exerted on the surface (Fig. 1). The peaks in the force curve correspond to air cell walls snapping under pressure, so the breaking points on the force curve can be related to the internal structure of the chip: the more aerated and porous the interior, the greater the number of air cells and air cell walls, and the greater the number of peaks in the force curve (i.e., more breaking points). More air cells generally indicate increased chip puffiness or thickness. Cross sections of chips made from each type of flour are shown in Fig. 2. Peak force and work, number of breaking points, chip thickness, and breakage susceptibility for each type of chip are presented in Table II. Baked control (DMF) corn chips (Fig. 2I) had a smooth starchy continuous phase and air cells that were elongated near the center of the chips (interior air cells) and small and rounded near the surfaces (peripheral air cells). The structure was uniform in thickness, had thick air cell walls, and averaged approximately seven breaking points per chip.

Addition of nonwaxy sorghum flour (20%) to DMF produced minor changes in chip structure (Fig. 2A) and had no effect on chip thickness or number of breaking points in the force curve of baked corn chips. Central air cells were slightly larger, but thicker air cell walls reduced breakage susceptibility values. Larger peripheral air cells in chips resulted in a lower force to break (3.63 vs. 4.21 for control chips); the continuous phase appeared to be weaker, resulting in lower peak force and work values. Addition of nonwaxy rice flour (20%) (Fig. 2E) to DMF resulted in thin chips with large elongated central air cells that reduced chip strength (peak force = 3.81 and work = 2.93) when compared with control chips (Fig. 2I). Peripheral air cells were fewer, air cells throughout the chip had thinner air cell walls, and there was more continuous phase in the interior of the chip. Although there were a similar number of breaking points when compared with the control, thinner air cell walls increased breakage susceptibility; nonwaxy rice chips were as crispy as control chips but easier to break. Sheng (1995) reported that added rice flours increased crispiness in wheat- and corn-based snack chips.

Addition of waxy flours (20%) to DMF significantly increased the number of air cells within chips, thereby increasing the number of peaks in the force curves and breaking points. Addition of waxy sorghum flour (Fig. 2C) increased chip thickness more than nonwaxy sorghum flour (Fig. 2A); however, peak force and work were lower than for control chips. Lee (1991) reported that slow reassociation of amylopectin chains occurred in waxy flours, which created a softer gel matrix that was stretched by vapor pressure generated during frying, resulting in puffer tortilla chips. In our study, air cells decreased in size but increased in number, resulting in a larger number of breaking points. Air cell walls were thinner near the surfaces, resulting in a higher percentage of fines. Baked chips with waxy rice flour (Fig. 2G) were thicker than chips with nonwaxy rice flour (Fig. 2E), but the formation of large central air cells with thin walls made waxy rice chips much weaker (peak force = 2.87). However, breakage susceptibility values for chips containing waxy rice were significantly lower than for control chips and chips with raw sorghum flour, implying that waxy rice starch reassociates more firmly than does waxy sorghum starch. Sheng (1995) reported

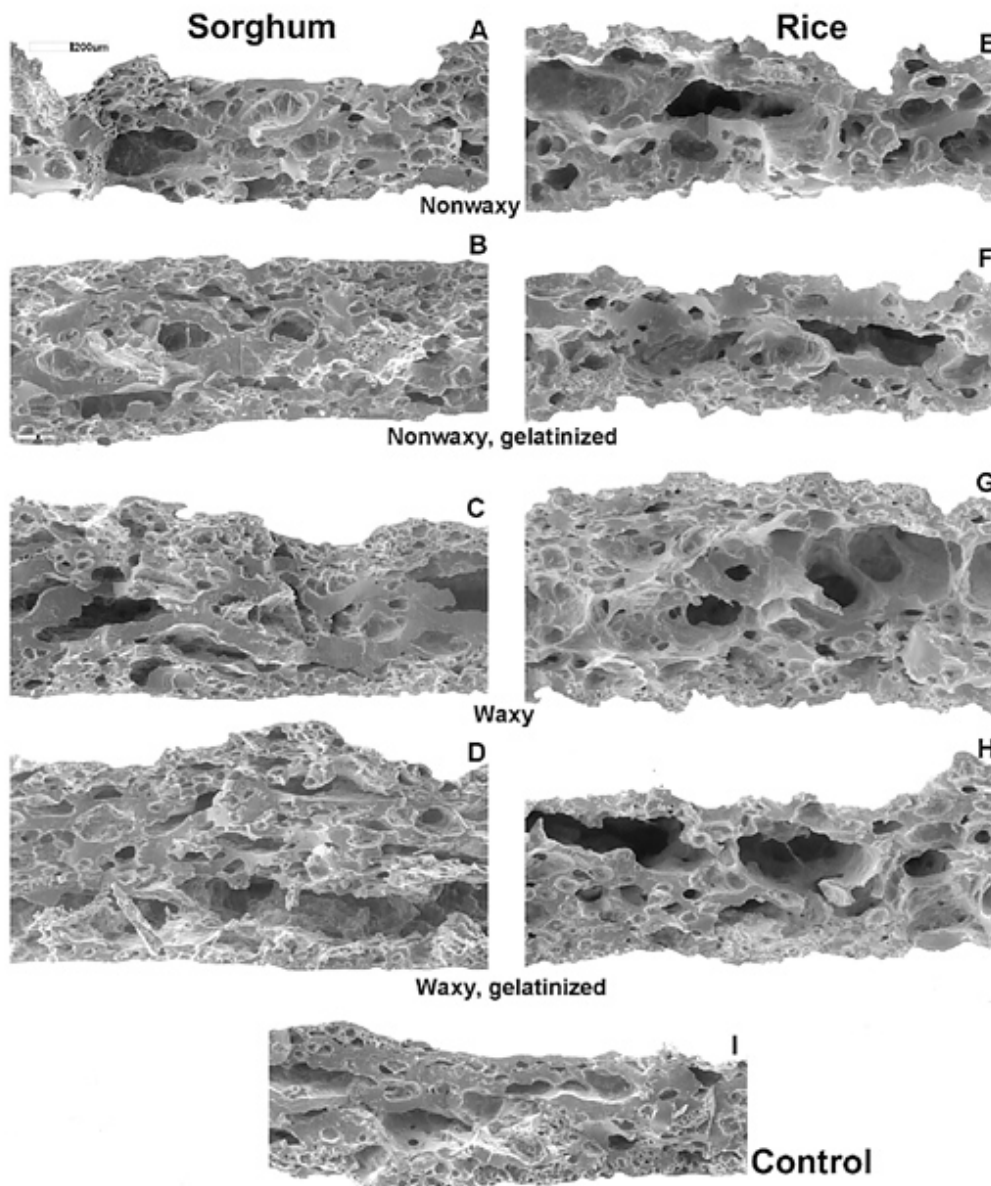


Fig. 2. Structure of baked corn chips with different flours added (20%) to dry masa flour: **A**, nonwaxy sorghum; **B**, nonwaxy gelatinized sorghum; **C**, waxy sorghum; **D**, waxy gelatinized sorghum; **E**, nonwaxy rice; **F**, nonwaxy gelatinized rice; **G**, waxy rice; **H**, waxy gelatinized rice; and **I**, 100% dry masa flour (control).

that the addition of waxy flours to chips reduced their hardness and made them crunchier. In our study, the number of breaking points in chips with waxy flours was higher than in control and nonwaxy chips due to a larger number of small peripheral air cells.

Addition of gelatinized nonwaxy flours resulted in slightly increased numbers of breaking points compared with addition of raw nonwaxy flours. In chips with gelatinized sorghum (Fig. 2C), more continuous phase was present during baking, which trapped more steam during expansion, resulting in thicker chips compared with chips with raw nonwaxy flours (Fig. 2A). Gelatinized sorghum chips were slightly weaker than raw sorghum chips, and breakage susceptibility values were higher due to more small thin air cell walls near the surfaces that developed in the extra continuous phase during baking. Huang (1995) reported that ingredients gelatinized before baking required no further cooking to contribute to texture development, because they allowed the expansion process to begin earlier. The addition of gelatinized rice flour (Fig. 2F) slightly decreased chip thickness but made chip thickness more regular than in raw nonwaxy rice chips. Gelatinized rice flour also increased air cell wall thickness, which helped maintain chip strength. The interiors of both gelatinized sorghum and rice chips expanded more and contained larger central air cells. Gomez et al (1992) reported that bigger air cells formed in fried chips when large particulates were glued together by gelatinized starch paste that formed a tight starch gel matrix.

Addition of gelatinized waxy flours to dry masa flour had no more effect on breaking points than addition of gelatinized nonwaxy flours. When gelatinized waxy sorghum flour was added to

the mix (Fig. 2D), chip thickness increased, and the force (4.14) and work to break (6.33) also increased dramatically over the raw sorghum flour chips (3.63 and 2.77, respectively; Fig. 2A). There was more continuous phase in gelatinized waxy sorghum chips, which produced large central air cells (described above), but because expansion in these chips was so high, the force to break was not diminished. However, breakage susceptibility increased dramatically due to large numbers of small air cells with thin walls that developed near the surfaces.

Addition of gelatinized waxy rice resulted in slightly thicker chips (Fig. 2H) when compared with raw rice chips (Fig. 2E), but expansion was not as great as in sorghum chips. Large central air cells formed and decreased the strength of gelatinized waxy rice chips (3.26) when compared with raw rice chips (3.81). There was an increased number of smaller air cells with thick walls, which kept the percentage of fines low. The continuous phase was not as thick in the outer areas of gelatinized waxy rice chips, which may have contributed to lower force to break value. More small air cells formed in rice than in sorghum chips, creating an almost foamy interior, which imparted some strength to rice chips and decreased breakage susceptibility, which was more in line with the reported advantages of adding rice flour to chip formulations (Sheng 1995). Even with large internal air cells, gelatinized waxy rice chips retained a level of strength similar to raw rice chips, probably because of the extra strength of the continuous phase.

Organoleptic properties. Selected baked corn chips were evaluated for brittleness, friability, and overall acceptability by a sensory panel (Fig. 3). Brittleness and friability values were related to chip microstructure. Rice flour chips had significantly lower brittleness and higher friability values than control chips, were irregular in thickness, and had large elongated central air cells that reduced the force required to break them during the first bite, making them more susceptible to breakage (friability). Adesso et al (1995) reported that rice flour made baked products crispier but more tender. Gelatinization of rice significantly increased brittleness and friability values when compared with those of raw rice. The additional expansion in gelatinized rice chips, as well as thinner air cell walls near the surfaces, may explain this finding. The greater number of air cells in gelatinized rice chips increased friability values when compared with raw rice chips and made chips crunchier.

Waxy rice flour chips also had lower brittleness values than control chips; however, there was a significant increase in friability. Waxy rice chips had large central air cells that allowed chips to collapse quickly when bitten but had more small peripheral air cells than control chips, which made waxy rice chips more friable. Small air cells have thin walls that collapse easily and fragment

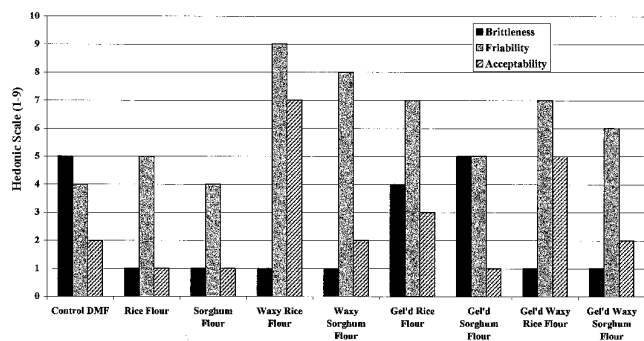


Fig. 3. Sensory panel results for baked corn chips prepared with dry masa flour and 20% added raw or gelatinized, waxy or nonwaxy flours. For brittleness, friability, and acceptability, least significant difference = 0.60, 0.71, and 0.83, respectively.

TABLE II
Physical and Textural Characteristics of Baked Corn and Tortilla Chips Prepared Using Dry Masa Flour with 20% Raw and Gelatinized Waxy (W) and Nonwaxy Flours^a

Sample	Nongelatinized Flour					Gelatinized Flour				LSD
	Control	Rice	Sorghum	W Rice	W Sorghum	Rice	Sorghum	W Rice	W Sorghum	
Baked corn chips ^b										
Peak force (N)	4.21	3.81	3.63	2.87	3.50	3.89	3.39	3.26	4.14	0.394
Work (area) ^c	4.63	2.93	2.77	4.55	3.23	4.53	3.82	4.76	6.33	0.492
No. of breaking points	7	7	7	13	11	8	9	9	9	1.5
Chip thickness (mm)	0.676	0.735	0.641	1.088	0.894	0.655	0.841	0.825	1.078	0.075
Breakage susceptibility										
(% fines)	7	10	5	4	9	10	12	4	18	2.3
Baked tortilla chips ^d										
Peak force (N)	6.19	4.37	2.05	2.95	2.16	5.79	2.23	3.38	2.40	0.269
Work (area)	3.09	2.62	1.57	3.17	1.45	5.54	2.31	2.16	1.59	0.413
No. of breaking points	1	1	2	4	3	3	3	2	2	1.3
Breakage susceptibility										
(% fines)	1	2	1	8	3	4	5	6	2	2.3

^a Values are means of three replicates and six duplicates.

^b Moisture content is 3.1 ± 1%.

^c Area = force × distance.

^d Moisture content is 2.1 ± 1%.

when bitten. Gelatinized waxy rice chips had lower friability and acceptability values than raw waxy rice chips because the chips were thinner and the air cell walls were thicker.

Addition of nonwaxy sorghum flour produced minor changes in the microstructure of chips, but the sensory panel detected a significant decrease in brittleness when compared with control chips that may have been caused by the slightly larger central air cells in nonwaxy sorghum chips or by the properties of the sorghum starch itself. Gelatinization of nonwaxy sorghum flour caused an increase in brittleness when compared with nonwaxy sorghum, due to the greater expansion of gelatinized sorghum chips and formation of additional air cells within the interior; a more starchy continuous phase also was present during baking that trapped steam during expansion, resulting in thicker chips.

Waxy and gelatinized waxy sorghum flours had the same effect on brittleness as waxy and gelatinized waxy rice flours. Gelatinized waxy sorghum chips were thicker than waxy sorghum chips but had large interior air cells, which made them break easily on the first bite.

Waxy rice chips had the highest overall acceptability values. Panelists liked the low force required to break the light crunchy chips on the first bite and the fact that the chips broke into many small pieces during mastication. Given that the values for brittleness and friability are similar for waxy rice and waxy sorghum flour chips, taste and appearance also may have influenced the panelists' opinions.

Evaluation of Baked Tortilla Chips

Texture properties. The peak force of baked control (DMF) tortilla chips was much higher than that of baked control corn chips (6.19 vs. 4.21, respectively). Except for gelatinized waxy flour chips, baked tortilla chips were less susceptible to breakage than their baked corn chip counterparts. This result was expected because tortilla chips were baked in a triple-pass oven and then baked again in an air-impingement oven. The loss of moisture and setting of the structure (formation of surface holes and interior tunnels by steam passage) reduced expansion of baked tortilla chips in the air-impingement oven. Similar results were reported by Gomez et al (1992) for baked tortillas. As observed with baked corn chips, a less expanded chip (fewer air cells within the structure) required higher force and work to break and was less susceptible to breakage due to lack of fracture points in the structure.

Tortilla chips containing 20% sorghum and rice flours had significantly reduced peak force and work values when compared with control chips. The most significant changes occurred when sorghum flour was used (peak force mean of 2.05 vs. 6.19), whereas the mean for rice flours was 4.37. This trend also was observed with baked corn chips, suggesting the continuous phase formed by sorghum and rice flours was weaker than the continuous phase formed by dry masa flour.

Gelatinized nonwaxy rice flour had no significant effect on the peak force values of tortilla chips. Nonwaxy, waxy, and gelatinized waxy rice flours significantly reduced the peak force to break the chips (i.e., the chips were more tender). In baked chip experiments, gelatinized starches produced chips with thicker air cell walls; a similar action here may explain why gelatinized nonwaxy rice chips were as hard as the control chips. Sheng (1995) reported that addition of waxy rice to chips made chips more tender, which would account for waxy chips having lower peak force values than control chips. The baked corn chip results suggest that waxy rice flour increased the number of air cells with thin walls within baked tortilla chips, making them more susceptible to breakage. This is probably the case for tortilla chips as well.

The effect of nonwaxy sorghum flour was no different than that of waxy sorghum, waxy sorghum flour may be more susceptible to differences in moisture content during baking. The effect of waxy sorghum flour was significant in baked corn chips when more steam was available during air-impingement baking to produce expansion

of the continuous phase. In a triple-pass oven, moisture evaporated quickly from baked masa (McDonough et al 1993); there was probably insufficient moisture available to permit further expansion during impingement baking. It may also be that waxy sorghum had no effect on expansion, but waxy rice may have had an effect because of differences in water retention related to starch granule size and shape.

CONCLUSIONS

Rice and sorghum flours and two different baking procedures produced baked chips with unique structures and textures. Thick air cell walls decreased breakage of chips and made them stronger. A foamy structure formed in chips with waxy rice flour and improved the textural qualities, but no similar foamy structure formed in sorghum chips, which tended to have thicker air cell walls than rice chips. When the number of larger air cells increased, chips broke more easily because the interiors collapsed faster under pressure. At the same time, the change in the force required also depended on the thickness of air cell walls. An increase in the strength of the continuous phase resulted in a decrease in breakage and an increase in force to break; this strength most likely depended on the particular characteristics of the starches contained in each formulation. Gelatinized flours allowed chips to expand earlier in the baking process to produce a puffer chip. Waxy flours also increased the crunchiness and acceptability of chips by making them more porous (smaller air cells) and friable. Baked chip structure determines texture characteristics; therefore, understanding the factors that affect structure development during processing, such as gelatinization and amylose-amylopectin content, is a key to modifying baked chips for greater consumer acceptance.

It is difficult to interpret what happens during baking of corn and tortilla chips when rice or sorghum flours of various kinds are added. Apparently, there are many interactions that affect texture. In general, waxy rice and sorghum produced more friable, breakable baked corn and tortilla chips. However, waxy sorghum flour did not provide any advantage over nonwaxy sorghum flour for enhancing the texture of baked tortilla chips. Waxy sorghum flour did provide an advantage in baked corn chips. The effect of pregelatinization of flours depended on the type of flour. In rice flours, gelatinization generally increased chip strength; however, this was not true for sorghum tortilla chips where gelatinization did not affect peak force values. The flours appeared to behave differently based on the system into which they were incorporated. Based on our experiments, we cannot answer the question as to which flour is best for improving the overall acceptability of tortilla and corn chips. More research is required to sort out what the effects of flour are and what really happens when other flours are added to dry masa flour in baked snacks.

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