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Utilization of Korean Maizes in Production of Alkaline Processed Snack Foods

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Abstract

Alkaline cooking and processing properties of domestic maize varieties were evaluated by comparing to those of imported control maize(Asgrow 404). Domestric maize varieties were hydrated more rapidly and had lower dry matter losses during alkaline cooking than control maize due to softer endosperm texture and incomplete removal of pericarps. Domestic maize varieties produced masas with proper handling properties when nixtamals had the 50~52% moisture. However, masas produced from domestic maizes were puffed during baking and frying process due to the release of more free starch granules in the masa than control masa. Tortilla chips prepared from domestic maizes absorbed more oil during frying and had slightly higher water content with darker color than tortilla chips prepared from control maize. Among the domestic maize hybrids, KS42/Fla2BT113 had more acceptable kernel characteristics for processing of tortilla chips than other varieties.

Key words: alkaline cooking, maize, nixtamal, masa, tortilla chip

INTRODUCTION

Maize is used widely in food products including tortillas, tortilla chips and other snacks which are produced by cooking under alkaline conditions(lime cooking). These alkaline-cooked corn products are popular in many areas of the world due to their unique texture and flavor(1). Recently, tortilla chips are introduced in the domestic snack food market and their consumption is increased. Commercial procedures for tortilla chip production are reviewed in detail(2,3).

For production of tortilla chips, maize is boiled in lime solution, quenched and steeped overnight. The alkaline cooked and steeped maize(called nixtamal) is washed and ground into a cohesive plastic dough(called masa). Then the dough is flattened, cut into a thin triangular piece and baked for a short period of time(tortillas). These tortillas are equilibrated and deep fat fried.

To produce high quality tortilla chips, cooking conditions are critically important. Properly cooked nixtamal had optimum extent of water uptake, starch gelatinization and ease of pericarp removal. The cooking time of maize differs significantly between maize varieties and influenced by characteristics of kernel, temperature, lime concentration and the cooking methods(4).

Grinding process disrupts swollen gelatinized starch granules in the nixtamal and distributes the hydrated starches and proteins around the ungelatinized portions of the maize endosperm, forming a smooth cohesive masa. Generally, undercooked nixtamal is difficult to grind while overcooked nixtamal forms sticky masa with poor handling properties. Masa properties are also affected by types of maize endosperm, drying and storage conditions of the maize, as well as the amount of water uptake and extent of starch gelatinization during the alkaline cooking(5).

Although consumption of the maize-based snack foods increased rapidly, most of the domestic maizes are utilized directly as a vegetable and/or partial feed source. Most of the maizes processed in domestic food industries are imported foreign maizes. The selection of adequate domestic maize variety for the snack food industry, as well as continuing maize development program is essential to replace or reduce the import of foreign maizes. However, no information is available on the processing characteristics of domestic maize varieties in snack foods production.

The objectives of this study were to evaluate the alkaline cooking properties and the processing characteristics of domestic maize varieties in production of tortillia chips.

MATERIALS AND METHODS

Maize samples

Thirty five Korean yellow maize hybrids were produced from Crops Experiment Station, Suwon, Korea. Physical characteristics of these domestic maizes were evaluated to screen and select the proper maize variety for tortilla chip processing. Based on the kernel characteristics of domestic maize samples, four maize varieties(G4743, KS7rhm/DB544, KSrhm/Tzi3, KS42/Fla2 BT113) were selected and used for alkaline cooking and processing of tortilla chips. Commercial food grade yellow dent maize imported from U.S.(Asgrow 404) was used as a standard control maize.

Physical properties of maize samples

One hundred kernel weight was measured by counting and weighing 100 whole, clean sound kernels. Endosperm hardness of maize was measured using a tangential abrasive dehulling device(TADD, Model 4E, Saskatoon, Canada). Maize kernel(20g) were abrasively milled for 5min. The weight of material remaining was expressed as a percent of original sample weight. The higher values indicated a harder endosperm texture(6). Kernel color was visually rated on a scale in which 1 represented pale yellow, 2 represented bright yellow, and 3 represented deep orange and other undesirable color. Kernel type was measured by subjective rating based on the extent of the denting and the relative portions of hard versus soft kernels. Ease of pericarp removal was evaluated subjectively after staining the lime cooked kernels with eosine Y and methylene blue solution(3).

Alkaline cooking properties

Moisture uptake and dry matter loss of the maize during alkaline cooking were determined using the methods described by Serna-Saldivar et al.(7). Samples (15g) were placed in perforated nylon bags and cooked in a kettle containing 9L of lime solution(1% lime, grain wt. basis) for appropriate time intervals. After cooking, samples were quenched to 68°C and steeped overnight (12~14hr). Then, the nixtamal was washed, drained, and weighed. The weighed nixtamal was dried in an oven at 105°C for 48 hr. Water uptake and dry matter loss of maize samples were calculated using the following formulas :

$$\text{Nixtamal moisture(\%)} = \frac{(\text{wt. of Wet nixtamal} - \text{wt. of Dried nixtamal}) \times 100}{\text{Nixtamal wt.}}$$

$$\text{Dry matter loss(\%)} = \frac{(\text{Dried grain wt.} - \text{Dry wt. of nixtamal}) \times 100}{\text{Dried grain wt.}}$$

Tortilla chip preparation

Experimental procedures for production of tortilla chips were illustrated in Fig. 1. Maize samples were lime-cooked for predetermined optimum cooking time and quenched to 68°C and steeped overnight(12~14hr). Nixtamals were washed with tap water and ground into a masa using a laboratory grinding mill(Model 4E Straub Co., U.S.A.). Masa(10g) was sheeted using a hand tortilla press and cut into triangular pieces and baked at 210°C on an electric griddle for 50 sec on each side to form tortillas. Tortillas were cooled for 10min at room temperature, then deep fat fried for 1min at 195°C. In order to maintain uniform frying oil temperature, tortillas were fried in batches of 50g. The fried chips were drained and cooled for 15min on paper towels and stored at -2°C in plastic bags.

Physico-chemical analysis

Moisture content was measured using a forced-air oven at 100°C(8). Oil content of tortilla chips was determined with a Goldfisch apparatus(8). Color of tortilla chips was measured by a Juki tristimulus colorimeter

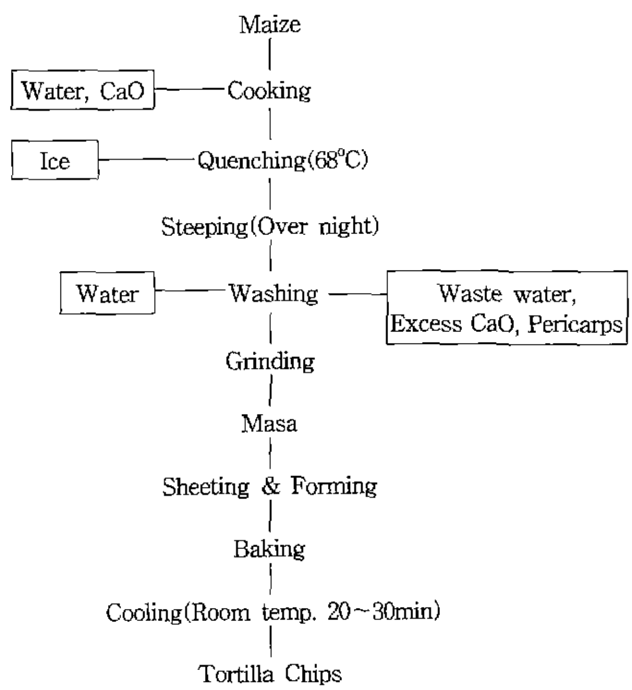

Fig. 1. Flow diagram for preparation of tortilla chips.

(JC-801S, Japan) and expressed using the Hunter Lab system. Pasting properties of samples were measured by heating and cooling at 50°C, 95°C, and 50°C for 2, 8, and 4min respectively using a Rapid Visco-Analyzer 3C(Newport Scientific Ltd., Sydney, Austalia)(9).

Statistical analysis

Data were analyzed using the analysis of varience (ANOVA) and Fisher's least significant difference(LSD) procedures as described by the SAS Institute(10).

RESULTS AND DISCUSSION

Kernel properties of domestic varieties

Physical characteristics of thirty five domestic maize samples were measured and compared to those of control maize(Asgrow 404) to select maize varieties suitable for alkaline processing. Four domestic maize varieties were finally screened and their physical characteristics were summerized in Table 1.

Domestic maize varieties had significant differences in 100 kernel weight, hardness and pericarp removal compared to those of control maize. All domestic varieties had softer endosperm texture with smaller kernel size. Pericarps of domestic maizes were difficult to remove during alkaline cooking compared to control maizes (Table 1). Among the domestic maize varieties, hybrid KS42/Fla2BT113 had the hardest endosperm texture with the easiest pericarp removal, meanwhile hybrid G4743 had the softest endosperm texture and KS7rhm/Tzi3 had the poorest pericarp removal. Kernel color of domestic varieties were similar to that of control maize (Table 1). These results indicated that hybrid KS42/Fla2BT113 had more acceptable kernel characteristics for alkaline processing than other varieties due to its harder endosperm texture and more easily removable pericarps with clean bright yellow color.

Table 1. Physical characteristics of control and selected domestic maize varieties

Maize varieties	100 Kernel Wt.(g)	Hardness (%)[1]	Kernel color[2]	Pericarp removal[3]	Kernel type[4]
Asgrow 404	34.4	53.8	2	1	SD
G4743	26.9	38.6	1.5	2.5	SD
KS7rhm/DB544	28.6	45.5	2	2.5	SD
KS7rhm/Tzi3	26.2	40.9	2.5	3	SD
KS42/Fla2BT113	27.6	48.3	2	2	SD
LSD(0.05)	0.8	1.8	·	·	·

[1]Percent material remained by abrasion. Kernels that are harder give higher values

[2]Rated on a scale in which 1 represents light yellow and 3 represents deep orange color

[3]Rated on a scale in which 1 represents complete removal and 5 represents no removal

[4]SD represents semi-dent kernel

Alkaline cooking properties

All domestic maize varieties absorbed water more rapidly and had lower dry matter losses during cooking and steeping than control maize(Figs. 2 and 3). Moisture content of KS42/Fla2B113 reached 36% by steeping overnight without cooking and gradually increased up to 58.7% after 60min cooking and steeping

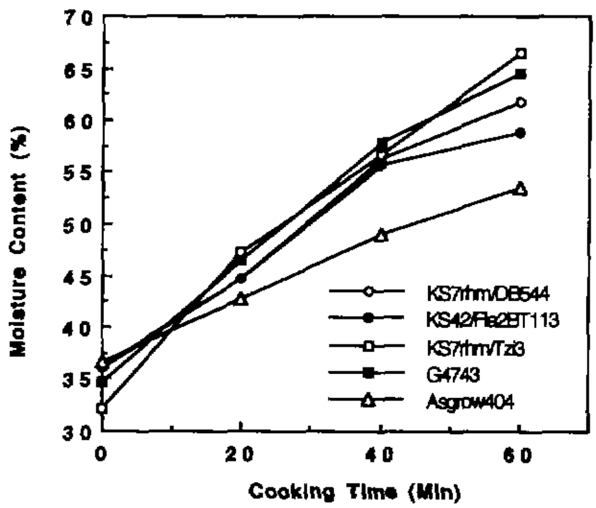

Fig. 2. Effects of lime cooking and steeping on moisture content of nixtamals.

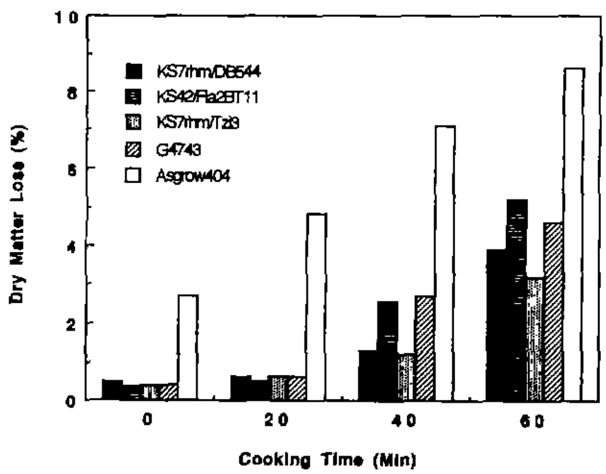

Fig. 3. Effect of lime cooking and steeping on dry matter losses of nixtamals.

(Figs. 2 and 3). However, hybrid KS7rhm/Tzi3 showed the fastest moisture absorption and the lowest dry matter lose during alkaline cooking.

Water uptake and dry matter losses during alkaline cooking were dependent on both kernel characteristics and alkaline processing conditions(4). Generally, most of absorbed water during alkaline processing was retained by gelatinized starches due to their swelling and hydration capacity(1). These results indicated that softer endosperm textures of domestic maize varieties caused higher water uptake and extent of starch gelatinization than control maize during alkaline cooking and steeping. Therefore, all domestic varieties should be cooked for shorter time than that of control maize to avoid excess water uptake and starch gelatinization during alkaline processing.

Pflugfelder et al.(11) reported that maize pericarps constituted most of the dry matter lost during alkaline processing and the amount of dry matter lost increased with the use of softer maize. Lower dry matter losses of domestic maize varieties than control maize was caused by incomplete removal of pericarp during alkaline cooking.

The hybrid KS42/Fla2BT11 was more suitable for production of tortilla chips than the other domestic varieties evaluated, since it had a harder endosperm texture and much lower water absorption and more pericarp removal during alkaline cooking.

Production of masa and tortilla

Preliminary studies showed that all domestic maize varieties were able to produce the masa with proper handling properties when the nixtamal had the moisture range of 49 to 51%. Therefore, maize samples were alkaline cooked and steeped until the moisture content of nixtamals reached to 50%. The cooking time of each maize variety was determined using a linear regression equation obtained from alkaline cooking trials. The calculated cooking time was 30.3, 33, 30.7, 35.6 and 49 min for hybrid G4743, KS7rhm/DB544, KS7rhm/Tzi3, KS42/Fla2BT113, and Asgrow 404, respectively.

Water was added to each nixtamals during grinding to prevent excess wear of grinder and to increase moisture content of masa up to 53~54% for better sheeting and forming ability. Properly cooked and ground masa made from domestic varieties showed similar or even better sheeting and forming ability than that of masa from control maize(Table 2). However, masas prepared from domestic varieties had much finer particles than that prepared from control maize, indicating more free starch granules released during grinding due to softer endosperm texture.

Table 2. Subjective evaluation of products and handling property during process of tortilla chips from domestic and control maize

Products	Asgrow 404	Domestic maize hybrids
Masa	-Cohesive plastic texture -Good formability	-More cohesive -Drier appearance -Excellent formability
Tortillas	-Elastic, rubbery texture -Dry appearance	-Elastic, rubbery texture -Wet appearance -Pillowing
Tortilla chips	-Complete dehydration -Crispy and crunchy	-Higher oil absorption -Higher moisture content -Friable tender texture -Darker color

Normally, steam generated during baking escapes rapidly though pores provided by the large particulates in the masa(12). However, masas prepared from domestic maize varieties were puffed during baking. Puffing of tortillas produced tortilla chips with poor organoleptic properties, as well as excessive breakage during packaging and handling(1). These results were probably caused by free starch granules released during grinding, since free starch granules underwent gelatinization more readily during baking than starches within the endosperm cells due to lack of physical restriction. Paste of gelatinized starches glued particulates together in masa, forming a starch gel matrix during baking by covering the pores on the surfaces of tortillas, resulting in the puffed tortillas(13,14).

Pasting properties of masa

The Rapid Visco-Analyzer(RVA) viscograms of masas revealed the cooking and processing on characteristics of starches in maize varieties. The viscograms of masa samples showed that pasting and setback viscosities decreased as cooking time increased (Fig. 4). The viscograms of masas prepared from domestic maizes had higher pasting and setback viscosity with faster viscosity breakdown during pasting than that of control masa. This suggested that free starch granules released in domestic masas were swelled and gelatinized during pasting fragmented more readily during cooking(shear thinning), resulting in faster vis-

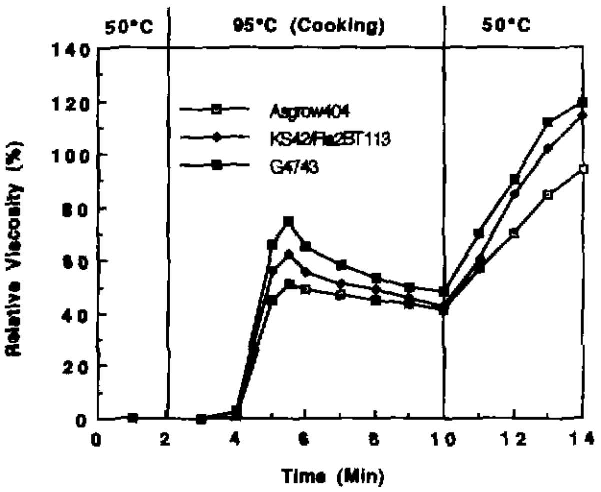

Fig. 4. Pasting properties of masa prepared from control and domestic maizes.

cosity breakdown than that of control masa. The viscogram of masa prepared from G4743 had the highest peak viscosity during cooking with the fastest viscosity breakdown and the highest setback viscosity.

Properties of tortilla chips

Tortilla chips produced from domestic maizes contained about 3~8% higher oil content than chips prepared from control maize(Table 3). Tortillas prepared from domestic varieties puffed during the early stage of frying due to the sealed surfaces which prevented steam from escaping. Higher moisture contents of tortilla chips is an another indication of sealed structures of tortilla chips produced from domestic varieties (Table 3). Puffing of tortilla chips during frying not only increased surface areas but hindered draining of absorbed frying oil, thus resulting the higher oil content of tortilla chips.

Tortilla chips prepared from hybrid G4743 and KS 7rhm/Tzi3 had the highest oil content than chips from other varieties. Among the domestic maize varieties, hybid KS42/Fla2BT113 produced tortilla chips with the lowest oil absorption and water content, implying as a potential domestic maize hybrid for production of tortilla chips.

The texture of tortilla chips made from domestic varieties were more tender and friable with less crunchness than tortilla chips from control maize(Table 2). This was presumably caused by slightly puffed structure during frying. The softer starch gel matrix present in tortillas stretched and expanded by vapor pressure generated during frying, resulting in more friable and tender texture.

All domestic maize hybrids produced darker tortilla chips compared to control chips(Table 3). Two factors may account for the dark color of tortilla chips; pigments and phenolic compounds in the pericarps. Khan et al.(4) reported that non-tannin polyphenols and condensed tannins in pericarps resulted in unacceptable dark tortillas. Therefore, dark tortilla chips prepared from domestic maize hybrids were presumably caused by incomplete removal of pericarps and by darkening of polyphenol compounds in the pericarps during alkaline conditions.

Table 3. Characteristics of tortilla chips made from control(Asgrow 404) and domestic maize hybrids[1)]

Maize varieties	Moisture content(%)	Oil content(%)	Color values		
			L	a	b
Asgrow 404	1.2	23.2	62.0	2.0	28.1
G4743	2.8	31.5	55.4	5.0	23.7
KS7rhm/DB544	2.0	27.7	59.0	6.7	29.1
KS7rhm/Tzi3	1.8	29.8	59.1	5.3	26.7
KS42/Fla2BT113	1.6	26.4	56.2	7.1	27.4
LSD(0.05)	0.3	0.8	0.5	0.2	0.3

[1)]Values are means of three observations.

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