Drying corn for specialty milling

Latin American specialty foods offer opportunities for maize, but quality requirements must dictate the drying techniques used

by Alvaro Castillo-Niño

In Latin America, specialty flours are used to produce different types of "masas," used mostly in ethnic foods, such as the Mexican and Central American tortillas and the Venezuelan and Colombian "arepas." The export of corn (maize) for these prime corn milling markets has attracted strong attention in North America in recent years, especially for the Mexican market, where, under the terms of NAFTA, corn import duties will drop precipitously after about 2005.

However, grain drying practices greatly affect the quality of these end-use products, and appropriate drying methods for corn destined to reach such end-use markets must be taken into account by exporters. Processors and grain handlers also must recognize that drying methods used in North America can't be applied in all regions, primarily due to weather factors.

Arepas

Arepas are consumed in Venezuela, Colombia and, to some extent, Panama. Venezuelans consume annually more than 35 kg per capita, most of it coming from industrial precooked flour. Colombian per capita consumption of industrial (commercial) precooked corn flour averages about 8 kg per year, and that figure could double, or triple, if traditional at-home preparation is included.

The word "arepa" probably comes from the Cumana Indian word for corn, "erepa." Arepas are usually baked, and sometimes fried, and have a firm texture. Tortillas are baked and the final texture is flexible and can be wrapped to form "tacos."

CORN PROCESSING FOR AREPAS

A Venezuelan-European industrial process for precooked corn flour to prepare arepas was developed in the mid-1950s. For arepas, corn is mechanically dry peeled without the use of calcium derivatives, and the germ is fully removed. Older conical degerminators have generally been replaced by friction type units, borrowed from the rice milling industry, that have increased endosperm yields from an average of 68% of the dry raw corn, to 72% or higher. Endosperm is what remains of the corn kernel after removal of hulls and germ.

Photo by Scott Bauer, ARS.

After peeling and germ removal, the corn receives moisture conditioning and direct steam treatment for controlled gelatinization.

CONTROLLING FISSURES IS QUALITY KEY

To get good flour yields for arepas, corn should be of a hard variety, relatively free of fissures or mechanical damage; starch should be good quality and must be easily separated from the peel and germ. Heat damaged grains should be restricted, as for any high-quality food, since they may cause germ oil diffusion on the endosperm. To get good quality flour, fat must be limited to 1% of weight.

Corn fissures (or crystallization, as it is called in Venezuela) are key to good flour quality. Fissures are single or multiple internal breaking lines that do not extend to the surface of the grain; their presence above a level of 15% generally has a strong impact on market price. Field drying of corn may produce some internal fissures, usually limited to 3% of grains, but post-harvest drying increases internal fissures significantly.

The Venezuelan quality standard for corn for commercial milling for "arepas" and other food uses divides grain into three classes, limiting grain fissures to 5%, 10% and 15% and heat-damaged grain to 1%, 2% and 3%, respectively, for each class.

U.S. white corn, processed either in the U.S. or in Latin America, for masas is setting new quality standards; corn is being separated into four categories, according to fissuring levels: a) grain without fissures; b) grains with single fissures;

c) grains with double fissures and d) grains with multiple fissures. White corn generally has a harder endosperm than yellow corn, and thus is more susceptible to stress cracking.

Most corn fissuring is produced by rapid drying, induced by high temperatures and followed by rapid cooling. Fast drying also may harden the grain's outer shell preventing internal moisture removal while the shell becomes over-dried.

Kernels with a large number of stress cracks are more susceptible to breakage, yield smaller grits during dry milling, absorb water too rapidly during wet milling and are more susceptible to insect and mold damage during storage.

Industrial yields of corn flour are affected by fissures in two ways. Firstly germ removal and peeling are affected because part of the endosperm adheres to germ and peels, and secondly, high temperatures may develop uncontrolled gelatinization of the endosperm that may affect the flour final quality. High temperatures (over 284°F/140°C) also produce protein and proteolytic denaturation that may affect final product quality.

Dirk Maier and Adam Watkins of Purdue University's Agricultural and Biological Engineering Department, proposed a Stress Crack Index (SCI) in their paper "Drying of White Food Corn for Quality." By counting the number of kernels in each stress crack category within a sample, the Stress Crack Index [SCI = (#single) + (#double*3) + (#multiple*5)] can be calculated and used as a measure of the severity of damage in the corn.

"It is clear that as the kernel temperature increased during drying, the level of stress crack damage increased as well," the paper says. "Between 100°F (37°C) and 130°F (54°C) there was a large step increase in the amount of stress crack damage that occurred. In other words, once kernel temperatures exceed 100-110°F (37-43°C), stress crack damage was so severe that increasing the temperature from 130°F to 160°F (54°C) or 200°F (93°C) did not make a significant difference. Thus, in order to minimize the amount of stress cracking damage,

kernel temperatures should be kept below 100-110°F (37-43°C).

"Dryer operators must realize that the kernel temperature is not the same as the drying air temperature. The drying air temperature is the temperature set at the burner. The maximum kernel temperature is the highest allowable temperature the kernels should reach during the drying process." It is recommended that operators establish relationships between air temperature and grain temperatures.

It can easily be deduced that the less heat and the slower the drying (and cooling) process, the higher the final white corn quality will be, the report concludes.

As a guideline, it has been established from testing in Venezuela and Colombia that corn drying air temperatures should be lower than 158°F (70ºC). A maximum moisture removal rate of 3% points per hour is also recommended.

LOCAL REQUIREMENTS DICTATE DRYING METHODS

United States and European experience in drying corn is mostly limited to grain destined for feed and wet-milling. Several problems have arisen in recent years in arepas-consuming countries when manufacturers have tried to use the so called "dryeration" slow cooling process to compensate for initial high-drying temperatures that induce rapid moisture removal.

Dryeration is a well known process to improve heat efficiency and reduce fissures in feed corn. This procedure yields good results for feed, where corn drying temperatures may be close to 100ºC, and 30% or more fissures and uncontrolled gelatinization are not key problems.

Dryeration does reduce fissuring compared with common fast cooling, but that the fissure level obtained is still generally not acceptable for flour milling and end-use products.

The dryeration process uses low air temperatures prevalent during harvesting months in temperate zones. In tropical zones, where many tortillas and arepas consumers are located, low air temperatures are not available and the cooling efficiency of dryeration will be reduced. The resulting design failures have been quite dramatic — one installation intended for drying 4,000 tonnes of corn per day (at moisture reduction of 24% to 13%), when adjusted to get arepa-quality corn, was able to dry only 800 tonnes per day.

Experience, supported by testing, permits the recommendation of the following drying and tempering temperatures to dry high moisture corn destined for food flours. WG

Drying recommendations of corn for food flours.
(It has been assumed that initial moisture is 22%, and final moisture to be around 13%)

	Initial Moisture	Final Moisture Moisture	Drying Air temp. ºC	Average Retention time, minutes	Moisture percentage points removed per hour
First drying pass	22%	17%	70 (158°F)	75	4.0
Tempering				300 (5 hours)	
Second drying pass	17%	13.25%	70 (158°F)	85	2.8
Cooling	Slow, preferably on final storage silos				

Alvaro Castillo Niño is manager of Ediagro Ltda., an agro-industry consultancy based in Bogotá, Colombia. He may be contacted at: ediagro@colomsat.net.co.

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