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Improving the Nutritional and Textural Properties of Wheat Flour Tortillas

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Wheat flour tortillas are the fastest growing segment of the North American baking industry. As this market grows, the search for healthier alternatives to traditional foods also increases. Nutritionally, flour tortillas are rich in carbohydrates that generate a high glycemic index subsequent to ingestion, demonstrating a behaviour similar to white bread. Hence, the formulation of more nutritious tortillas, with higher levels of protein, dietary fiber and antioxidants, appears to be promising. Although the number of publications concerning the nutritional improvement of flour tortillas is limited, attempts utilizing soybean, whole wheat, and triticale flours have been reported. Additionally, as different ingredients are added to traditional formulations, the texture is very likely to be affected, as are the shelf-life and other sensory properties. Among other additives, hydrocolloids have been reported to improve the textural qualities of bakery goods and flour tortillas. They comprise a number of water-soluble polysaccharides with varied chemical structures providing a range of functional properties that make them suitable to this application. This paper discusses the tortilla market, reviews research attempting to develop novel and nutritious products, and discusses the application of hydrocolloids as texture improvers.

Keywords: tortillas, nutrition, texture, hydrocolloids

Introduction

Flour tortillas are a unique baked product that has been produced in Mexico for centuries. Ethnic foods are increasingly conspicuous as symbolic transnational cuisine experiences that both constitute and convey broad processes of eco-

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nomic and cultural globalization (Lind and Barham 2004). Tortillas are now more popular in United States than bagels, croissants, English muffin, pitas or any other type of ethnic bread. In 2005, the baking industry in United States showed a consistent increase in the flour tortilla market. While the consumption of fresh bread was up 0.3%, the increase in tortilla sales was of 3.5% in comparison to the previous year (Kuk 2006). In the "State of the Tortilla Industry Survey: 2000", it was reported that U.S. sales at wholesale prices for tortillas totaled more than US$ 4 billion in 2000, representing a growth rate of 57% over the past four years (Tortilla Industry Association 2007).

The major ingredient for production of flour tortillas is wheat flour, while corn tortillas are produced from lime-cooked, stone-ground corn. Although flour tortillas are produced with many of the same ingredients as bread, processing technologies and product characteristics are quite different (Dally and Navarro 1999). A flour tortilla can be defined as a flat, circular, light-colored bread. Usually they have an average thickness of 1/16 in and diameters ranging from 6 to 13 in. They are generally eaten with beans, meats, cheese, avocados, spreads, and other ingredients (Waniska 1999).

Historically, the beginning of the tortilla is difficult to date precisely, but its social life is intimately woven into the Mesoamerican culture of maize, where its history can be traced through that of maize (Lind and Barham 2004). Tortillas originated as a corn product in Mexico, however the introduction of wheat to the New World by the Spaniards in 1525 eventually led to the preparation of tortillas made from wheat flour. In this time, tortillas were homemade and generally prepared on a daily basis. Wheat flour was mixed with water, lard, and salt to form a dough. The resulting dough was divided and hand-shaped or rolled into tortilla disks which were baked on a hot griddle (Serna-Saldivar et al. 1988). Today, most flour tortillas are industrially manufactured following the same principles, however using different technologies.

As tortilla is the fastest growing segment of the North American baking industry (Cornell 1998; Kuk 2006; Tortilla Industry Association 2007), reconstructing the tortilla with new nutritional attributes and in new formats has been part of this growth as have changes in the tortilla industry itself. On the other hand, the increasingly popular market for functional foods and the search for healthier alternatives to conventional foods, with the consumer desire for convenience and practicability, also increased (Berne 2005).

Nutritionally, flour tortillas are rich in carbohydrates that generate a high glycemic response after ingestion, similar to white bread (Saldana and Brown 1984). Hence, formulating more nutritious tortillas, with more protein, dietary fiber and antioxidants, would be well received by consumers. Additionally, food scientists should also focus on increasing the shelf-life of tortillas. While consumers typically reject bread after one week on the grocery shelf, they expect tortillas to be edible over weeks and even months at a time (Friend et al. 1995). Various tortilla formulations include hydrocolloids to extend shelf-life and retain freshness. Hydrocolloids are water-soluble polysaccharides with varied chemical structures providing a range of functional properties that make them suitable for shelf-life extension. This review describes modern flour tortilla production, as well as strategies to develop new and more nutritious products, also discussing the application of hydrocolloids as texture improvers.

Processing and end uses

Tortillas are produced by three basic methods: hot pressing, die cutting, and hand stretching. Since the 1970s, when Mexican fast food chains started to operate in large scale in Canada and United States, tortilla production has increased about tenfold (Lind and Barham 2004). More than 90% of the increase is represented by tortillas made by the hot-press method (Waniska 1999).

In the hot-press method, rested and relaxed dough pieces are transferred onto a heated conveyor plate where a hydraulic press device is typically used to form discs from dough balls. During pressing a thin skin is formed, which helps to seal the tortilla and limits the release of steam and carbon dioxide generated during baking. This contributes the typical puffed characteristic of the tortilla. In general, hot-pressing is not very efficient, but results in tortillas with the desired soft texture and more flexibility retention during storage. These tortillas are well suited for fajitas, soft tacos, burritos and wraps (Dally and Navarro 1999; Waniska 1999).

The die-cut method is more efficient, yielding a lower cost product. However, the quality of the resulting tortillas is inferior to the hot-press counter-parts. They are less soft, more pasty, and lose flexibility more quickly. Most die-cut tortillas are used to prepare processed foods, such as burritos, chimichangas, or enchiladas. Few are merchandised as tortillas on the retail market (Waniska 1999). They are produced by dough extrusion and gradual multi-step sheeting to the desired thickness. Dough sheets are then passed under a die-cut cylinder and to produce uniformly shaped products (Dally and Navarro 1999).

The hand-stretch method usually produces tortillas that are larger, thinner, and stronger than pressed or die-cut approaches. The relaxed dough pieces are passed through a pair of sheeting rolls to form an elongated shape and passed again through another pair of rolls at a 90º angle to shape them into round, flat discs. They are then hand-stretched to the final shape and diameter (Dally and

Navarro 1999). Although the characteristics of the final product are acceptable, the increased labor and the slower rate of production discourages most manufacturers from utilizing this method (Serna-Saldivar et al. 1988).

After the raw tortilla discs are produced by any of the three methods, they are baked in a three-level tortilla oven. Oven temperatures and baking times are adjusted according to the desired characteristics of the end-product. Fresh baked tortillas are cooled on multilevel conveyors before packaging (Dally and Navarro 1999).

Improvements in equipment and operating software have facilitated an increasingly rapid production of hot-press tortillas, imposing increased quality, uniformity, and shelf-stability requirements on tortilla manufacturers (Waniska 1999).

Traditional and novel ingredients: improving the nutritional properties

Flour tortillas contain four major ingredients: flour, water, shortening/oil, and salt. In Mexico, flour tortillas contain only these ingredients, resulting in products with short shelf-life (2–4 days). However, in North America, where a far longer shelf-life is required (10–20 days), formulations contain preservatives, chemical leavening agents, emulsifiers, hydrocolloids and other ingredients to improve softness and shelf life as well as tortilla flavor and functionality (Cornell 1998).

Generally, enriched, bleached, hard-wheat flour is utilized, but all purpose and soft-wheat flours are also applied in some operations. Usually bleached flour is preferred due to its impact on the color of the end-product, generating whiter tortillas (Serna-Saldivar et al. 1988). Different manufacturing methods require different flour characteristics and varied levels of water. Die-cut formulations require 25% of high gluten-flour and lower addition of water in comparison to hot-press and hand-stretch tortillas, which require only regular flour (Dally and Navarro 1999). Moreover, the impact of flour quality appears to be quite significant, as are the water and fat levels (Dally and Navarro 1999; Friend et al. 1995; Serna-Saldivar et al. 1988; Wang and Flores 1999; Waniska 1999).

Oilseed flours have been traditionally used to fortify staple foods such as corn tortillas and table bread (Cardenas et al. 2005; Dhingra and Jood 2001). Among the different types of oilseeds, soybean has been preferred due to its favourable amino acid composition which complements the amino acid profile of cereals. Besides, soybeans are widely available and accepted in numerous food products. The utilization of isolated soy protein is based on its acceptable sensory qualities, favourable amino acid composition, high protein content, relatively low caloric value, acceptable storage stability and a relatively light color (Dhingra and Jood 2001).

Besides traditional ingredients, efforts to increase the nutritional value of corn and flour tortillas by incorporating alternative flours date back to at least 25 years. The protein quality of corn tortillas, wheat flour tortillas, and corn-soy tortillas (90% corn: 10% soy; 80% corn: 20% soy) has been evaluated (Valencia et al. 1979). Based on parameters such as protein efficiency ratio, net protein ratio, nitrogen utilization and relative nitrogen utilization, the corn-soy mixtures (e.g. 80:20 and 90:10) had the highest protein quality. The protein quality of corn and flour tortillas were similar.

Utilizing defatted and undefatted soybean isolate, Gonzalez-Agramon and Serna-Saldivar (1988) verified the effect of incorporating such ingredients on the nutritional, physical, chemical and sensory properties of flour tortillas. Tortillas were produced in a hot-press following the procedures of a commercial tortilla factory. It was observed that tortillas fortified with 11.1% defatted soybeans or 5.6% undefatted soybean isolate contained twice as much lysine and similar sensory properties as the control.

Since the dietary fiber content of flour tortillas is similar to white bread (Saldana and Brown 1984), attempts to increase their fiber content by adding mixtures of whole and refined red or white wheat flours have been performed (Friend et al. 1992). In this study, tortillas were prepared by hot-press from mixtures of whole and refined red or white wheat flours (0, 25, 50, 75, 100% whole wheat) and were evaluated for some physical, chemical and organoleptic properties. Whole wheat flour significantly influenced the dough water absorption (increased), color (darker) and storage stability (decreased). Furthermore, fiber content of tortillas was increased by adding either 10% oat bran or 10% rice bran; but both significantly affected dough machinability and the mixing process. The authors concluded that acceptable tortillas can be prepared from both whole red and white wheat flours, however tortillas prepared using 50% whole wheat flour were more acceptable than were tortillas prepared with 100% whole wheat flour. Additionally, it was observed that tortillas containing whole white wheat flour had higher acceptability than those with whole red wheat flour, which may be explained on the basis that the latter causes darker color.

Conversely, Seetharaman et al. (1994) investigated the application of fibers isolated from corn, oat, pea, soy, and sugar beet in the processing of flour tortillas. It was observed that as added fiber increased from 0 to 4, 8, 12, 16, or 20%, regardless of source, dough machinability was significantly decreased along with significant increases in mixing and resting times. Apart from changes in physical parameters such as color and diameter, the authors stated that dietary fiber content increased more than sevenfold at the highest level of fiber incorporation (20%), however shelf-stability had important negative changes in high-fiber tortillas. Based on a consumer acceptability test, the investigators detailed that tortillas containing 8% soy or oat fibers were as acceptable as the control, concluding that tortillas with a good shelf-stability and high consumer acceptability could be made by adding up to 12% of some fibers.

Recently, the potential of triticale as a substitute for wheat in flour tortilla production has been reported (Serna-Saldivar et al. 2004). Triticale (*Triticosecale* Wittmack) is the first man-made cereal produced by crossing wheat (*Triticum* spp.) and rye (*Secale cereale* L.). Besides being environmentally more flexible than other cereals, triticale has better nutritional qualities than wheat and better baking qualities than rye (Tsen et al. 1973). Its inferior baking quality to wheat is due to its weaker dough structure, which develops faster, absorbs less water, and has less stability than wheat flour dough (Unrau and Jenkins 1964). In this study, Serna-Saldivar et al. (2004) investigated different mixtures of triticale and wheat flours in a typical hot-press formulation. The authors confirmed the inferior baking quality of triticale flour through reduced optimum water absorption and reduced yield of triticale tortillas due to lower moisture content and water absorption. However, the composite flour containing 50% of triticale has produced dough with acceptable rheological properties and good quality tortillas. Additionally, sensory evaluation tests indicated that triticale could substitute for 50% of wheat flour without affecting texture, color, flavor, and overall acceptability of tortillas. The authors also pointed out that for the production of 100% triticale flour tortillas, at least 2% vital gluten had to be added to the formulation as improver.

As shown, alternative ingredients that can improve the nutritional profile of wheat flour tortillas have been successfully applied. However, as different raw materials are added to a traditional formulation the texture is significantly affected, as are the shelf-life and other sensory properties. Soluble and insoluble fibers have been employed in wheat flour tortillas showing different plausible mechanisms which lead to poorer final product quality (Seetharaman et al. 1997). Addition of soluble fiber at 8% indicated poor gluten development and extensive starch gelatinization during baking, resulting in tortillas with denser crumbs. Insoluble fibers, however, showed to physically disrupt the gluten network, causing the collapse of air bubbles and tortillas with decreased shelf-stability (Seetharaman et al. 1997). Hence, lengthening the time traditional and novel tortillas retain freshness characteristics is an actual and challenging issue to food scientists involved in research and development.

Improving the textural properties with the application of hydrocolloids

Considered a convenient bakery good, tortillas are now expected to last for several days. Moreover, they are frequently frozen and are then expected to have the same quality characteristics as the fresh product after thawing (Cornell 1998). In this context, the use of additional ingredients that can improve the textural characteristics of the traditional and novel flour tortillas appears very promising.

Changes to formulations including the addition of anti-microbial agents, acidulants, leavening agents, yeast, nonfat dry milk, emulsifiers and hydrocolloids have been reported (Friend et al. 1992; 1993; 1995). These additives were aimed to improve production efficiency, product uniformity, shelf-stability and texture.

The texture of bakery goods is often improved with the addition of hydrocolloids. They comprise a number of water-soluble polysaccharides with different chemical structures providing a range of functional properties that make them widely used in the food industry. Hydrocolloids are able to modify starch gelatinization (Rojas et al. 1999), and to extend the overall quality of the product during time. In addition, some studies have reported the use of hydrocolloids as fat replacers (Lucca and Trepper 1994). In bakery goods, they act by improving shelf-life stability and texture by retaining more moisture and retarding staling. There is an increasing demand for hydrocolloids in bakery, where they have been utilized with diverse purposes. Guar gum has been employed for improving the volume and texture of frozen dough bread (Ribotta et al. 2004), while the employment of hydroxypropylmethylcellulose (HPMC) has resulted in soft bread-crumb loaves with higher specific bread volume, improved sensory characteristics and extended shelf-life (Bárcenas and Rosell 2005; Collar et al. 1998). Similar behaviour has been reported for HPMC when it was studied in the performance of bread stored in sub-zero temperatures (Bárcenas and Rosell 2006). Xanthan gum, HPMC and other hydrocolloids have been tested for their potential as bread improvers and antistaling agents (Guarda et al. 2004). In this investigation, all of them were able to decrease the loss of moisture content during storage and to reduce the dehydration rate, consequently retarding the crumb hardening.

Regarding the effects of hydrocolloids on processing and qualities of hot-press wheat tortillas, Friend et al. (1993) studied the addition of natural (Arabic, guar, and xantham), modified cellulose (carboxymethylcellulose [CMC], HPMC and methylcellulose) and commercial blends (mixtures of natural and modified cellulose gums). The authors found that hot-press tortillas containing natural gums, modified cellulose gums, or commercial blends were consistently round, puffed, slightly browned, and of good quality. The texture was verified through the determination of rollability over time, performed using an empirical technique where the extent of cracking and breaking was evaluated. It was observed that the rollability of tortillas was retained longer with CMC and cellulose-based commercial blends. During freezing and thawing, rollability of all tortillas decreased, however those containing CMC were significantly more rollable than control after five freeze-thaw cycles.

The beneficial effects of hydrocolloids in tortilla processing have been discussed by Gurkin (2002). The major functions of hydrocolloids and their interactions were reviewed, and the author concluded that water-binding is the main feature of gums in tortillas. The ability of the large molecules to hold moisture, as much as 100 times their weight, was reported to help prevent staling. Moreover, the interactions between different structures were emphasized. In this regard, it cited the beneficial combination of guar gum with CMC as water-binding agents, confirming their potential as textural improvers.

Recently, the influence of hydrocolloids on rheological characteristics of whole-wheat dough and quality of Chapatti has been reported (Shalini and Laxmi 2007). Chapatti is a flat unleavened Indian bread made of whole-wheat flour that is similar to flour tortillas. This bread is usually prepared in households by hand sheeting of dough followed by baking on hot griddle, being consumed fresh. In this study, guar gum, CMC, HPMC, and k-carrageenan were added to the dough and the textural characteristics were evaluated on fresh and stored chapattis. Hydrocolloids were incorporated at various levels ranging between 0.25% and 1.0% w/w of whole wheat flour. Amongst the hydrocolloids studied, they observed that guar gum gave the highest extensibility for fresh and stored chapatti. The force required to tear the fresh chapatti decreased with hydrocolloid addition, however guar gum addition at 0.75% w/w of whole wheat flour gave the softest chapatti. Extensibility of stored chapatti significantly decreased with storage both at room as well as refrigeration temperature, although refrigerated chapatti containing guar gum showed less loss in extensibility up to a period of 2 days. It was concluded that there was no significant effect on color of chapattis due to addition of hydrocolloids, and sensory acceptability was found to be higher than that of control chapatti.

Conclusion and future perspectives

Wheat flour tortillas can have their nutritional and textural attributes improved through the incorporation and application of the right ingredients and additives. To date, few studies report the application of novel ingredients in the formulation of traditional flour tortillas. Since the fortification of bread with nutritious ingredients has been reported (Dalgetty and Baik 2006; Dhingra and Jood

2001; Doxastakis et al. 2002) it is suggested that similar attempts can be done in flour tortillas. In fact, the impact of alternative ingredients on the textural quality parameters is expected to be much lower in tortillas than in breads. While breads are expected to have a regular, raised and expanded structure, tortillas are denser, therefore the addition of non-gluten flours would have a less critical impact. Nonetheless, it is evident that any dilution of the wheat flour by alternative flours would give a corresponding decrease in gluten functionality, impacting texture and shelf-stability.

Considering the nutritional and economical aspects of legumes (Tharanathan and Mahadevamma 2003), it is then suggested that flours made from pulses such as peas, beans, lentils and chickpeas are added to traditional recipes. The incorporation of pulses in flour tortillas is suggested in levels that could range from 15% to 35%. Conversely, ingredients such as barley flour for beta-glucan, flaxseed for omega-3, and other food materials with demonstrated high antioxidant activity, should also be studied. However, these attempts would surely affect the processing quality of an established flour tortilla recipe, an issue that could be minimized by the addition of individual or combined hydrocolloids.

According to the literature, modified cellulose (CMC and HPMC) and guar gum seem the most promising. Additionally, dietary fiber isolated from pulse legumes could possibly bring a new perspective in the production of such products.

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