In Vitro Starch Digestibility of Tortillas Elaborated by Different Masa Preparation Procedures

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ABSTRACT

Starch digestibility was evaluated in freshly prepared tortillas elaborated from masa obtained from different procedures (laboratory-made masa, commercial masa, and nixtamalized corn flour) and from laboratory-made masa with added commercial hydrocolloid, and stored for 24, 48, and 74 hr. Tortillas prepared with commercial masa had the highest available starch (AS) content and the commercial tortillas had the lowest, showing a decrease in AS content when storage time increased. Tortilla of commercial masa showed the lowest resistant starch (RS) content that agrees with the AS measured. However, tortilla of laboratory-made masa presented the highest AS and RS contents. RS increased with storage time, a pattern that is related to the starch retrogradation phenomenon observed when retrograded resistant starch (RRS) was quantified. Commercial tortillas showed predicted glycemic index (pGI) values of 62–75% using a chewing/dialysis procedure (semi in vitro method). Index values were lower than those determined in vitro. The pGI of tortillas decreased, and the values were different depending on the method used to prepare the masa and tortilla. Commercial tortilla and tortilla of NCF had the lowest pGI. Therefore, the procedure to obtain masa and thereafter obtain tortillas influenced the starch digestibility of the product.

The term corn means "what sustains the life"; its fruits or grains meant currency, religion, and food for diverse cultures of the world, and it is believed that domestication decisively influenced the development of the American cultures (Reyes 1990). Nixtamalization (corn grain treated with lime) is an ancient process developed by the Aztecs; it is still utilized to produce tortillas (Robles 1986). Tortillas represent an important source of calories, proteins, and calcium for diverse countries of Latin America such as Mexico and Guatemala, and the Mexican people living in the United States (Campas-Baypoli et al 1999; Billeb and Bressani 2001). Due to the expansion of the tortilla market, tortillas today are produced from nixtamalized corn flour (NCF) supplemented with hydrocolloids with the aim to yield products with longer textural shelf-life. In Mexico, the tortilla is part of the diet of all socioeconomic classes, with consumption per capita of 120 kg/year. To date, tortilla production in Mexico is ≈11 million tons, of which 22.8% is from dry corn flour; the rest is from commercial fresh masa nixtamalization or traditional self-preparation in rural areas (Serna-Saldivar et al 1990; Paredes-López et al 2000). Carbohydrates are the main fraction of tortillas (60–75%, db), where starch is the major constituent. Current knowledge of nutritional features of starch indicates that the bioavailability of polysaccharides in foods may vary widely (Tovar 2001). Hence, a nutritional classification of dietary starch has been proposed that takes into account both the kinetic degradation and the completeness of its digestibility, thus comprising rapidly digestible, slowly digestible, and indigestible (or resistant) fractions (Englyst et al 1992). Resistant starch (RS) is defined as the sum of starch plus the products of starch degradation not absorbed in the small intestine of healthy individuals (Asp 1992). RS intake has been associated with health benefits (Champ et al 2003). Therefore, agencies and health organizations recommend the intake of foods that contain significant amounts of RS. Starch is the major component of the tortilla. Its consumption is associated with the liberation of a high amount of glucose toward the blood and an increase in corporal weight. However, the quantity of digestible starch can be low in comparison with other foods from cereals such as bread. Tortillas in Mexico grow stale within hours, an effect associated with starch retrogradation and therefore with a decrease of starch digestibility.

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The objective of the present study was to evaluate the effect of the type of tortilla processing in determining the effect of storage time on in vitro digestibility of the starch and the glycemic index.

MATERIALS AND METHODS

Sample Preparation

Experimental tortillas were prepared from laboratory-nixtamalized maize using standardized conditions throughout the process. Batches of 5 kg of maize (commercial grain distributed for Industriales de la Masa y Tortilla de México) were cooked in 15 L of lime solution. Lime was added at 1% (grain weight basis). Maize was cooked for 1 hr at boiling temperature and then steeped in the same cooking vessel over 16 hr. The cooking solution (or "nejayote") was discarded and the resulting nixtamal was washed three or four times with tap water to remove bran and excess lime. Nixtamal was ground into a masa using a commercial stone grinder (Nixtamex, México, D.F.) with stones 6.5 cm wide and 12.5 cm in diameter. Water was added during grinding at the rate of 90 mL/kg. Laboratory-made masa was hand-kneaded with commercial hydrocolloids TC-1 (0.5%) (Gum Technology Corporation, Tucson, AZ). On the other hand, masa and tortillas were purchased from one small factory called a tortilleria where the traditional method of nixtamal production was used. NCF was obtained from the largest tortilla company in Mexico (Maseca, León, Guanajuato, México). The NCF was hydrated (100 g of flour/120 g of water) to obtain masa. All masas (from laboratory, laboratory-made with hydrocolloids, tortilleria, and NCF) were molded by pressure and extruded (Tortilladoras González, Naucalpan, Estado de México) into thin circles to obtain tortillas 1 mm thick. Tortillas were baked on a hot griddle (Hotpoint, 6B4411LO, Leisser S.A. de C.V., San Luis Potosí, México) for 1 min per side at an approximate temperature of 250 ± 5°C. After cooling, tortillas (including the commercial tortilla) were packed into polyethylene bags (20 × 30 cm, Plásticos de México, S.A. de C.V., México) and stored for 1, 2, 3, 7, and 14 days at 4°C. Tortillas with hydrocolloids were stored for 7 and 14 days. The fresh (stored 0 hr) and the stored samples were frozen in liquid nitrogen and freeze-dried (25 SL, Virtis Company, Gardiner, NY). Stored tortilla samples were reheated in a home gas-fired oven for 30 sec on each side at an approximate temperature of 250 ± 5°C, cooled to 30°C, frozen in liquid nitrogen, and freeze-dried. Tortillas were ground using a commercial grinder (Mapisa Internacional S.A. de C.V., México, DF) to pass a US No. 50 sieve and stored at room temperature in sealed plastic containers.

In Vitro Digestibility Tests

Available starch content was assessed following the multienzymatic protocol of Holm et al (1986) using Termamyl (Novo A/S, Copenhagen) and amyloglucosidase (102 857 Roche Diagnostics, Indianapolis, IN). The method proposed by Goñi et al (1996) was employed to estimate the amount of indigestible starch (comprising part of RS1 plus RS2 and RS3 fractions) (Tovar 2001). Retrograded resistant starch (RS3) content was measured as starch remnants in dietary fiber residues according to the modified method by Saura-Calixto et al (1993). The in vitro rate of hydrolysis was measured using hog pancreatic amylase according to Holm et al (1985). Each assay was run with 500 mg of available starch. In all these measurements, the sample was weighed in a test tube or beaker and homogenized with the appropriate solution for each technique under controlled conditions: first step (speed level 2, 1 min) and second step (speed level 2.5, 1 min) using an homogenizer (Polytron PT 1200 Kinematica AG, Switzerland).

Starch Hydrolysis Index of Products "As Eaten" (Chewing/Dialysis Test)

The in vitro rate of starch hydrolysis was assessed with the protocol developed by Granfeldt et al (1992). Samples of tortilla containing 1 g of available starch were tested. Before the digestion assay, tortillas were warmed to 65–70°C on a hot plate, simulating the regular household procedure. Six healthy subjects participated in the chewing experiments, which consisted of 15 chews in ≈15 sec. The chewed material was carefully expectorated into a 20-mL beaker containing 0.05*M* phosphate buffer adjusted to pH 1.5 with HCl, and the mixture was incubated with bovine pepsin for 30 min (37°C), neutralized (pH 6.9), and incubated with porcine pancreatic α-amylase in a dialysis bag. The reducing amylolysis products appearing in the dialysate were measured colorimetrically at 530 nm (Genesys 5, Spectronic Instruments, Rochester, NY), and expressed as maltose equivalents. Data were plotted as degree of hydrolysis vs. time curves and the hydrolysis index (HI) was calculated as the area under the curve (0–180 min) for the test product expressed as a percentage of the corresponding area for commercial white bread chewed by the same person.

Statistical Analysis

A completely random design with three replicates was used to analyze tortilla changes during storage. Data from AS, RS, RRS, and hydrolysis rate were analyzed using one-way analysis of variance (ANOVA) procedures. When analysis showed significant differences ($P < 0.05$), means were compared using Tukey's tests. The average HI was calculated from six digestion replicates run for each sample, and means were compared by the Wilcoxon matched-pair signed-rank test, each person being his own control. The predicted glycemic index (pGI) was calculated from HI values using the empiric formula proposed by Granfeldt (1994): pGI = 0.862 HI + 8.198, for which the correlation coefficient (r) is 0.026 ($P < 0.00001$). In vitro estimated glycemic index was calculated from the percentage of available starch hydrolyzed within 90 min (H_{90}) in the α-amylolysis assay applying the equation: GI = 39.21 + 0.803 (H_{90}), $r = 0.91$, $P < 0.05$ (Goñi et al 1997). Statistical analyses were run using the computer software (v. 6.0, SPSS Institute).

RESULTS AND DISCUSSION

Available Starch

The freshly prepared tortilla (time 0) made with commercial masa contained the highest available starch (AS) content (Table I), although a significant statistical difference was shown with respect to the fresh tortilla prepared using laboratory-made masa. The slight variations in the masa making process, maize variety, lime concentration, and extent of cooking could explain the observed differences. Fresh NCF tortillas had lower AS value (70.9%) than counterparts manufactured from the former samples. This can be associated with the NCF-making process that involves more severe processing conditions with subsequent drying (Bello-Pérez et al 2003) that may affect the potentially available starch because, under these conditions, a reassociation of starch molecules (annealing) (Knutson 1990) might occur that retards or impedes hydrolysis by the digestive enzymes.

The freshly prepared commercial tortillas had the lowest AS value (65.3%), and the freshly elaborated tortilla amended with hydrocolloids had higher AS content (Table II); however, this value was lower that those of tortillas prepared by the other three procedures. The commercial tortilla-making process might affect the content of this potentially available carbohydrate. There is no available information about the relationship between AS and the type of tortilla manufacturing equipment. When the same tortilla type is compared at different storage times, a decrease in AS values was observed (Table I). This is associated with the retrogradation phenomenon that takes place when gelatinized (disorganization of the structure) starchy products are stored. During starch retrogradation, the chains of starch are reorganized into structures difficult to digest by gastrointestinal enzymes. In various products, this effect is increased by prolonging storage which produces lower AS values. Commercial tortillas stored for 72 hr had the lowest AS value. The tortillas with hydrocolloids did not have appreciable changes in AS values during storage (Table II). It has been reported that hydrocolloids retard bread starch retrogradation (Russell 1983; Krog et al 1989); therefore, the addition of hydrocolloids to tortillas can extend shelf-life and could enhance their flexibility and palatability. It has been reported that addition of hydrocolloids to tortillas enhances flexibility and

TABLE II
Available Starch (AS), Resistant Starch (RS), and Retrograded Resistant Starch (RRS) in Corn Tortillas with Commercial Hydrocolloid Stored for Different Times[a,b]

Storage Time (days)	AS	RS	RRS
0	68.0 ± 0.7ab	3.0 ± 0.1a	1.7 ± 0.1a
7	66.4 ± 0.7bc	3.2 ± 0.1ac	1.7 ± 0.2a
14	64.8 ± 0.9c	3.4 ± 0.1c	1.8 ± 0.1a

[a] Mean of three replicates ± standard error.
[b] Values followed by the same letter in the same column are not significantly different ($P > 0.05$).

TABLE I
Effect of Storage Time on Available Starch Content in Different Types of Corn Tortillas[a,b]

	Storage Time (hr)			
Sample	0	24	48	72
Laboratory-made tortilla	73.0 ± 0.4a	72.8 ± 0.7a	73.2 ± 0.1a	71.0 ± 0.9a
Tortilla of commercial masa	74.5 ± 0.6b	73.4 ± 0.5a	72.8 ± 0.4a	67.4 ± 0.4b
Tortilla of commercial flour	70.9 ± 0.4c	70.2 ± 0.5b	68.3 ± 0.4b	66.3 ± 0.6c
Commercial tortilla	65.3 ± 0.4d	64.5 ± 0.3c	61.0 ± 0.3c	59.7 ± 0.2d

[a] Mean of three replicates ± standard error.
[b] Values followed by the same letter in the same column are not significantly different ($P > 0.05$).

strength, reduces stickiness during processing and packing, increases postbake moisture levels, slows staling, and extends shelf-life (Friend et al 1993; Arámbula-Villa et al 1999; Gurkin 2002).

Resistant Starch

Tortillas made with commercial masa had the lowest resistant starch (RS) values and counterparts produced from laboratory-made masa had the highest (Table III). There were no significant differences ($P > 0.05$) between the tortillas produced from NCF and the commercial tortilla. The highest AS value found in commercially made tortillas agrees with the lowest RS value; however, this pattern was not found in laboratory-made tortillas because they showed a high AS value and the highest RS values. Tortillas elaborated with NCF and commercial masa had similar RS contents (Table III).

The RS values increased with storage time; however, the tortilla produced with laboratory-made masa showed a faster increase in the RS content in the first days compared with the rest of the tortilla samples produced with other procedures. Commercial tortillas had a higher development rate of RS throughout storage, if the initial value (1.4%) is compared with the 72 hr (2.7%) value, an increment of ≈100% occurred. A lower development rate of RS was found in NCF and commercial tortillas; both had similar values throughout storage, showing similar values after 72 hr of storage. These tortillas were also similar to counterparts produced in the laboratory. In freshly prepared tortillas, Campas-Baypoli et al (1999) reported a RS value of 2.5%, which was similar to those determined in NCF commercial tortillas. In other studies, the same authors reported that tortillas stored for 72 hr at room temperature and under refrigeration had similar RS values (3.0%) (Campas-Baypoli et al 2002).

The tortilla with hydrocolloids had a constant RS value from the beginning of the experiment throughout storage. An explanation for this might be that the hydrocolloids contributed to the decrease in starch digestibility due to possible hydrophilic interactions among hydrocolloid chains producing a three-dimensional network (Ferrero et al 1994; Wang et al 2001; Mali et al 2003), somehow reducing the enzyme-substrate interaction. Furthermore, the significant increase viscosity of the lumen contents might have decreased starch hydrolysis. In addition, there is no arrangement of the starch chains to produce the phenomenon of retrogradation, and therefore the RS content of the tortilla amended with hydrocolloids did not change.

Retrograded Resistant Starch (RRS)

Fresh NCF tortillas had a significantly ($P < 0.05$) higher RRS content than the rest of the tortilla treatments (Table IV). The higher value could be due to the severe conditions exposed during the manufacturing process of this flour, from cooking of corn until drying and grinding of the grain into flour to obtain a product with longer shelf-life. These heat treatments caused higher damage to the starch structure, produced short depolymerized starch chains that enhanced chemical interactions, yielding a reorganized or retrograded structure (Biliaderis 1991).

Tortillas contained higher RRS values throughout storage, except for laboratory-made tortillas because values did not further increase after 24 hr of storage, meaning that the maximum starch retrogradation was achieved during the first day storage. These results show that the type of process influences the starch retrogradation, without losing the fact that the botanic origin of the corn could also have an important effect on this phenomenon. Further studies in this sense should be carried out. The fresh tortillas with hydrocolloids had slightly higher RRS values (Table II) compared with fresh tortillas prepared in the laboratory, tortillas of commercial masa, and commercial tortillas. However, RRS values were similar to tortillas made with NCF. The RRS values in tortillas prepared with hydrocolloids did not change during storage, in accordance with the idea that the hydrocolloid impeded starch retrogradation.

Rate of Enzymatic Starch Hydrolysis

Fresh tortillas had significant differences ($P < 0.05$) in degree of starch hydrolysis after the first 15 min of the in vitro test (Fig. 1). Tortilla prepared with commercial flour presented the highest percent of hydrolysis, whereas the laboratory-made tortilla presented the lowest. Consequently, in the first step of the experiment, the masa and tortilla processes influenced the rate of starch hydrolysis. NCF and commercial masa tortillas did not have statistical differences ($P > 0.05$) in the percentage of starch hydrolysis after 30 min. Therefore, it is possible that the amount of maltose liberated from the prolonged enzymatic hydrolysis produced the same caloric response. The tortilla with hydrocolloids had the lowest percentage of hydrolysis that agrees with the higher RS content. It would be important to consider that the starch of the tortilla amended with hydrocolloids had a slow digestion rate. Percentage of hydrolysis of tortillas prepared with laboratory-made masa gradually increased over 60 min, a different pattern

TABLE III
Resistant Starch Content in Corn Tortillas Stored for Different Times[a,b]

Sample	Storage Time (hr) 0	24	48	72
Laboratory-made tortillas	3.1 ± 0.0a	3.3 ± 0.1a	3.5 ± 0.5a	3.9 ± 0.0a
Tortilla of commercial masa	1.4 ± 0.2b	1.8 ± 0.2b	2.2 ± 0.2b	2.7 ± 0.0b
Tortilla of commercial flour	2.3 ± 0.2c	2.4 ± 0.1c	3.4 ± 0.2a	3.8 ± 0.1a
Commercial tortilla	2.2 ± 0.1c	2.6 ± 0.1c	2.9 ± 0.1c	3.8 ± 0.0a

[a] Mean of three replicates ± standard error.
[b] Values followed by the same letter in the same column are not significantly different ($P > 0.05$).

TABLE IV
Retrograded Resistant Starch Content in Corn Tortillas Stored for Different Times[a,b]

Sample	Storage Time (hr) 0	24	48	72
Laboratory-made tortilla	1.1 ± 0.0a	1.8 ± 0.0a	1.8 ± 0.0a	1.8 ± 0.0ac
Tortilla of commercial masa	1.1 ± 0.1a	1.2 ± 0.1b	1.5 ± 0.1b	1.7 ± 0.1a
Tortilla of commercial flour	1.9 ± 0.1b	2.1 ± 0.1c	2.4 ± 0.1c	2.8 ± 0.2b
Commercial tortilla	1.1 ± 0.1a	1.5 ± 0.1d	1.6 ± 0.1d	1.9 ± 0.1ac

[a] Mean of three replicates ± standard error.
[b] Values followed by the same letter in the same column are not significantly different ($P > 0.05$).

than that observed in the rest of the tortilla samples. This suggests that the amount of maltose liberated is more constant after the product is ingested.

The course of in vitro α-amylolysis reaction of one tortilla at different storage times is shown in Fig. 2. In general, starch hydrolysis values decreased when storage time increased; our results also demonstrated that longer storage times increased RS contents (Table III) and produced a concomitant decrease in hydrolysis rates.

The pGI was calculated with data of hydrolysis rate of tortillas at different storage times (Goñi et al 1997). Laboratory-made masa tortillas had the highest pGI values and they were not affected by storage (Table V). The pGI of tortillas prepared with commercial masa decreased with increases in storage time and were higher in tortillas made from NCF. Tortillas with hydrocolloids showed the lowest pGI values, and they were not affected by storage, a pattern that agrees with the RS and RRS values.

Starch Hydrolysis Index of Tortilla "As Eaten"

Percentage of starch hydrolysis of commercial tortillas stored at different times is shown in Table VI, and the hydrolysis curves are depicted in Fig. 3. The white bread used as reference presented a digestion value of ≈50% after 180 min, which agrees with the values reported by Grandfeldt et al (1992). The stored tortillas had a slight decrease in degree of hydrolysis that agrees with the RS and RRS values determined in these samples.

The hydrolysis index (HI) calculated from the hydrolysis curves (Fig. 3), as well as the predicted glycemix indexes (pGI), are presented in Table VII. The HI of freshly prepared tortilla (77.57%) was lower than that reported for commercially packed tortilla (91%) (Tovar et al 2003). When tortillas were stored for 24 hr or more, the HI was not statistically different ($P < 0.05$), showing that storage did not have any effect on the starch hydrolysis rate. Thus, the maximum retrogradation (RSS value) was obtained after 24 hr of storage (Table IV). The pGI values suggest that tortillas are moderately digestible and that they might have beneficial health effects provided by the RS (Champ et al 2003). The lower pGI values of refrigerated stored tortillas are important because they can present a reduction in the metabolic responses following their ingestion. It is important to mention the high variability in our pGI results. The large variability could be due to differences among the human subjects that participated in these experiments. However, the methodology has shown a high correlation with in vivo studies (Champ et al 2003).

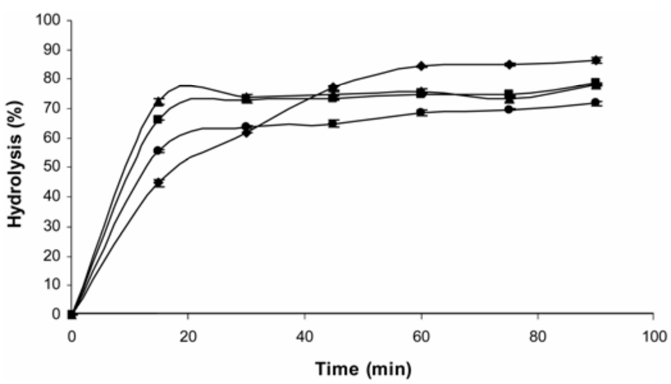

Fig. 1. In vitro starch hydrolysis of fresh tortillas from commercial masa (■), commercial flour(▲), laboratory-made masa (◆), and masa with hydrocolloid (●).

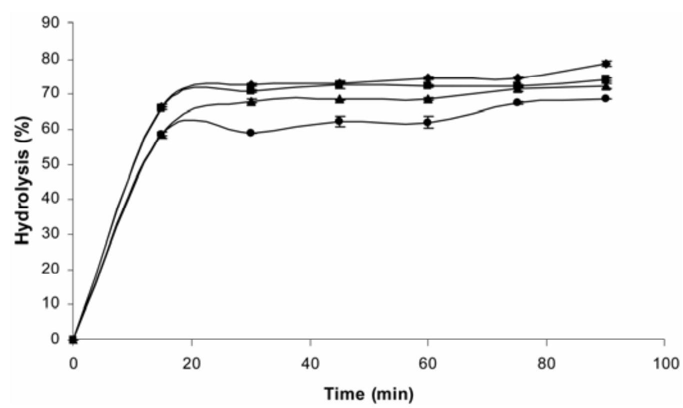

Fig. 2. In vitro starch hydrolysis of tortillas prepared with commercial flour stored for different times: 0 hr (◆), 24 hr (■), 48 hr (▲), 72 hr (●).

TABLE V
Effect of Storage Time on Glycemic Index of Corn Tortillas[a,b]

	Storage Time						
Sample	**0 hr**	**24 hr**	**48 hr**	**72 hr**	**0 days**	**7 days**	**14 days**
Laboratory-made tortilla	108.5a	108.4a	108.0a	107.7a			
Tortilla of commercial masa	102.6b	98.8b	97.4b	95.7b			
Tortilla of commercial flour	102.0b	101.0c	92.1c	86.6c			
Tortilla with hydrocolloids[c]					96.9a	96.8a	93.2b

[a] Calculated from the equation proposed by Goñi et al (1997).
[b] Values followed by the same letter in the same column for tortillas of laboratory, commercial and commercial flour are not significantly different ($P > 0.05$).
[c] Values followed by the same letter in the row for tortilla with hydrocolloid are not significantly different ($P > 0.05$).

TABLE VI
Degree of Starch Hydrolysis of Tortilla in a Chewing/Dialysis Digestion System[a,b]

	Degree of Hydrolysis (%)					
Storage time (hr)/Hydrolysis Time (min)	**30**	**60**	**90**	**120**	**150**	**180**
White bread (reference)	10.18 ± 0.72a	18.41 ± 0.78a	26.36 ± 0.83a	32.66 ± 1.42a	38.89 ± 1.40a	47.58 ± 1.5a
Tortilla						
0	5.45 ± 0.95b	13.31 ± 1.50b	19.98 ± 1.06b	25.59 ± 0.71b	32.08 ± 1.16b	38.86 ± 1.32b
24	4.28 ± 1.17b	10.73 ± 1.64c	17.33 ± 2.11bc	23.80 ± 2.66bc	29.51 ± 2.55bc	32.93 ± 2.93c
48	4.68 ± 0.84b	12.02 ± 0.90bc	16.91 ± 1.05bc	22.74 ± 1.11bd	27.17 ± 1.27cd	32.20 ± 1.20c
72	4.18 ± 0.72b	10.76 ± 1.04c	15.92 ± 1.36bc	21.42 ± 1.71de	25.70 ± 1.63d	30.01 ± 2.08c

[a] Mean of six replicates ± standard error.
[b] Values followed by the same letter in the same column are not significantly different ($P > 0.05$).

TABLE VII
Hydrolysis Index (HI) and Predicted Glycemic Index (pGI) of Tortilla[a,b]

Storage Time (hr)	HI (%)[c]	pGI (%)[d]
0	77.57 ± 1.76a	75
24	67.49 ± 5.34b	66
48	66.42 ± 2.60b	65
72	61.05 ± 3.65b	62
White bread (reference)	100c	94

[a] Data mean of six chewing and dialysis replicates ± standard deviation; $n = 6$.
[b] Means followed by different letters are significantly different ($P < 0.05$).
[c] Hydrolysis index (HI) was compared with white bread (Granfeldt et al 1992).
[d] Predicted glycemic index (pGI) = 0.862 HI + 8.198 (Granfeldt 1994).

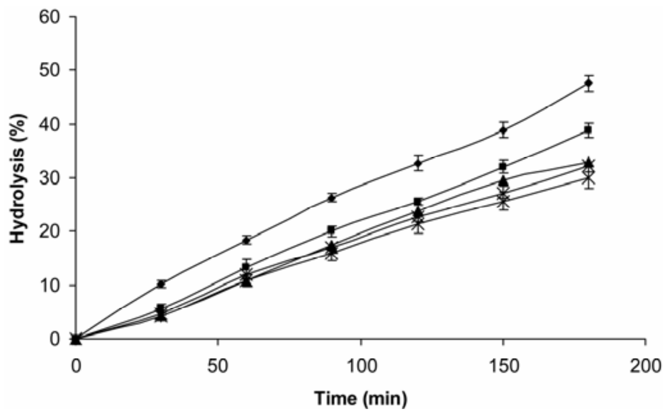

Fig. 3. Rate of starch hydrolysis after chewing, incubation with pepsin, and subsequent incubation with pancreatic α-amylase in fresh tortilla (■), 24 hr (▲), 48 hr (✕), and 72 hr (✱) of storage. White bread reference (◆).Values are means of six chewing and digestion experiments. Areas under curves were used for calculation of HI.

Comparison of pGI with Semi In Vitro and In Vitro Methods

The pGI values obtained with the Goñi et al (1997) equation (Table V) were higher than those obtained by the semi in vitro method of Grandfeldt et al (1992). The Goñi method was used to obtain a good prediction of GI of various foods; however, for tortilla, the GI value can be overestimated by this method. The difference might be due to the fact that Goñi's method uses data of percentage starch hydrolysis based on the available starch and, in Grandfeldt's technique, samples are weighed based on the total starch content. The advantage of the Goñi method is that it predicts GI faster than the Grandfeldt procedure.

CONCLUSIONS

Differences in available starch (AS) were found in tortillas prepared with masa by different procedures, decreasing when storage time increased. Addition of hydrocolloids decreased the AS content in higher levels without subsequent changes in the amount throughout storage. The abatement of AS values agrees with the increment in RS content due to the starch retrogradation phenomenon, assessed as retrograded resistant starch (RRS). Tortillas prepared with different masas and the commercial tortilla had different starch hydrolysis rates, with hydrolysis percentages that decreased when storage time increased. The chewing method (semi in vitro) showed pGI values lower than the in vitro procedure. The method for masa preparation, cooking of tortilla, and storage time affected the pGI value, therefore it is possible to control these parameters to obtain a tortilla with a given digestible caloric supply.

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