MedCrave
Step into the World of Research

MOJ Food Processing & Technology

Research Article

Open Access

CrossMark

Effect of two hydrocolloids (carob and guar gums) on physicochemical and textural properties of tortillas, fresch and subjected to refrigeration and freezing

Abstract

Tortilla, an important Mexican food item, is consumed normally in fresh stage in which both, softness and flexibility are important attributes. To know the effect of two gums on characteristics of tortilla, this food was prepared by standardization of the elaboration process by using nixtamalized corn flour. Several systems or tortilla types were prepared, the control and added with gums at different concentration. Physicochemical properties (color, moisture, and pH), as well as texture characteristics (puncture, firmness, and extensibility) were measured in fresh form, and also after six day of storage in refrigeration, and three weeks in freezing conditions. Color and pH were stable, whereas moisture increased with gum addition. Low temperatures generated a higher loss of water and rigidity in the control system than those determined with gum incorporation. Based on overall texture of tortillas, the guar gum had a better effect on it than carob gum, and consequently the effect of gum blends was better. In general, puncture, firmness, and rigidity forces augmented lightly through storage at low temperatures, and the conclusion is that the effect of gum blends on tortilla texture is positive and better that the effect of simple gums, without affecting other physicochemical properties of tortillas.

Volume 13 Issue 1 - 2025

Victoria Salinas G,[1] Vélez Ruiz JF[2]

[1]Departamento de Ingeniería Química e Ingeniería en Alimentos, Universidad de las Américas Puebla, Mexico

[2]Independent Consultant, Mexico

Correspondence: Vélez-Ruiz JF, Independent Consultant, 19 Oriente 1015, Col El Angel, Puebla, Pue. Mexico, Tel +2222 370117

Received: December 12, 2024 | Published: February 4, 2025

Introduction

Corn tortilla is an important food in México and Central America, it has good nutritional value and may be elaborated with different flours besides corn, different flour mixes, exhibiting different characteristics of diameter, thickness and other properties. It is a food item that has been successfully introduced in markets of United States, Asia, and Europe.[1] Early technology for elaboration of tortillas was developed by Mesoamerican civilizations; however the original processing stages have changed in years of evolution; in our days the next stages are involved: selection of corn, nixtamalization, water immersion of corn, grinding of the nixtamalized corn, formation of the round shape, cooking, packaging, and distribution. Is estimated that about 80% or more of Mexican population consumes this food product, and in average the consumption per capita is around 75 kg per year.[2] For this food item, texture is very important, whether it is consumed immediately or some days later. Because of these textural properties, such as punction, firmness and extensibility, among others, are very important. On the other side, gums as polysaccharides of different level of complexity are used to improve functional properties of foods, such as texture.[3]

Thus, with the objectives of study and analyze several properties of tortillas, this important food item was elaborated without and with gums, in fresh and in preserved at low temperatures forms. The research was divided into two main parts, initially the elaboration of tortillas was standardized, characterizing their physicochemical and textural properties in a) fresh form, b) with and c) without gums addition. Secondly, the same tortillas (control and with gums) were stored throughout six days, at low temperature (15°C), measuring their characteristics every two days. And through of three weeks, at freezing conditions (-18°C), in which their properties were determined every week, determining a variety of texture forces.

Materials and methods

The used flour was a commercial one, MASECA brand (GRUMA Company). Whereas both gums, carob and guar (Mexican brand, TIA Foods) were taken from laboratories (Chemical and Food Engineering, Universidad de las Américas, Puebla). The research was divided into two main stages, firstly the elaboration of tortillas was standardized, characterizing their physicochemical and textural properties in fresh form, without and with gums addition. Secondly, the same tortillas (control and with gums) were stored throughout six days, at low temperature (15°C), measuring their characteristics every two days. And through of three weeks, at freezing conditions (-18°C), in which their properties were determined every week, determining a variety of texture forces.

Batches of tortillas, the control and added with gums were prepared similarly, the difference was the incorporation of gums (carob, guar, and combinations in 0.10, 0.25, and 0.50% w/w). Preparing 4 kg of flour without and with the correspondent concentrations of gums, and 5.5 L of water; mixing manually these ingredients during 5 min, then kneading it. The elaboration was completed with a Mechanical Kneader ("Máquinas Tortilladoras", Celorio Company, Monterrey, N.L., MEX.) for 5 min more, in a local dedicated to sale of tortillas, in a locality near to Cholula, Puebla.

The correspondent quantity of flour dough (4 kg) was taken, pressed in a manual machine, cooked in a hot surface, with its characteristic roundness and weight (Figure 1a). Then the manufactured tortillas were stacked in fresh form (Figure 1b) or packed into individual plastic bags (Figure 1c), as it may be observed in Figure 1. Physicochemical Analysis

The applied physicochemical determinations were based on accepted methodologies, these are next.

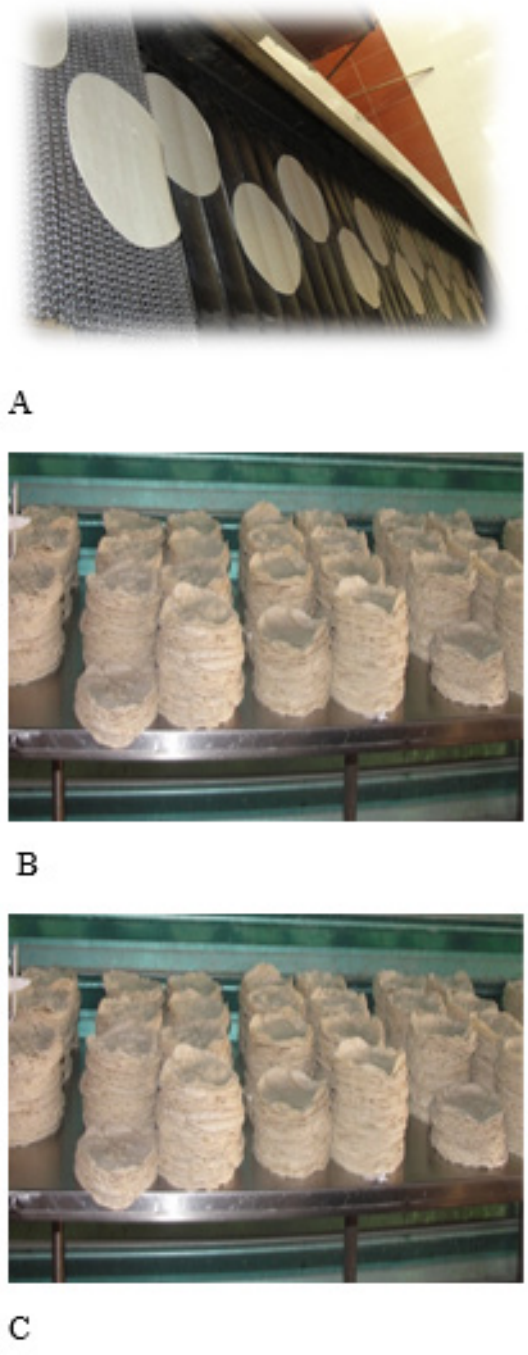

Figure 1 Details of tortillas elaboration, a) kneading, forming, and cooking in a Celorio Machine, b) stacking of fresh samples, c) packaging of individual samples for storage.

Color was measured with a Gardner Color System 05 colorimeter (Hunter Labs, Reston VA, USA), previously calibrated with white and black plates, as the references with standardized reflectance, and using a tristimulus scale

Moisture was measured by weight loss through water evaporation, introducing the samples into an oven at 130°C for 1 hour, according to the method 925.10 of AACC.[4] pH was measured with 10 g of sample, that was homogenized with 90 mL of distilled water, and by immersion of the electrode of the instrument (Spectro photometer Jenway, model 3319, UK) in the liquid, taking the lecture 25 (+5) s after the immersion, at room temperature. Texture Analysis Complementary, the textural properties for this type of food were completed, such as punction and extensibility with a Texture Analyzer, and firmness with a Kramer cell, that determined in the next way.

For the punction test, the sample (circle of 2 cm diameter, 1 cm thickness) was placed between two plastic plates, in which an orifice of 4 cm diameter was the support, thus the stem crossed the tortilla at a velocity of 1 mm/s (Figure 2a), then the applied force was recorded. For firmness determination a Kramer Cell connected to a Texture meter (Texture Analyzer XT2, USA) was utilized, following the procedure described by Ramírez-Wong et al.,[6] measuring the maximum force needed to break the sample of 5 cm^2, in which the Kramer cell simulates the chewing action from humans.

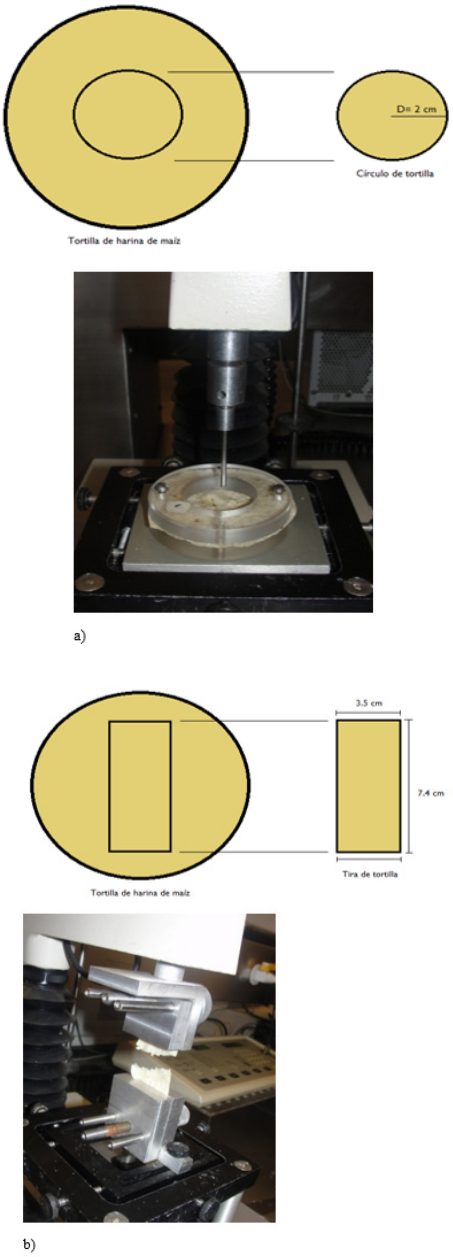

Figure 2 Pictures of samples preparation and devices for: a) Punction test, b) Extensibility test.

Citation: Victoria SG, Vélez RJF. Effect of two hydrocolloids (carob and guar gums) on physicochemical and textural properties of tortillas, fresch and subjected to refrigeration and freezing. *MOJ Food Process Technols.* 2025;13(1):1–6. DOI: 10.15406/mojfpt.2025.13.00317

And for the extensibility two retaining clips were subjected to the Texture meter, thus the prepared sample (rectangle pieces of 7.4 cm x 3.5 cm), taken from the center, was placed between the clips that were displaced at 1 mm/s (Figure 2b), recording the applied force (Figure 2).[7] All of them, both properties of tortilla were determined by triplicate and subjected to statistical analysis with the MINITAB software v.16® (Minitab Inc., State College, PA, USA), and applying a 95% of significance.

Results and discussion

Physicochemical characterization of tortillas

Fresh tortillas: All the elaborated tortillas exhibited a range of 18.4 to 20.6 g in weight, a range of 12.0 to 13.0 cm in diameter, and a range of 1.10 to 1.25 cm in thickness, that are typical dimensions for this food item. Similar results were reported by Ramírez-Wong et al.[5] although they used artisanal dough, whereas Bressani,[9] mentioned wider ranges for these dimensions, as a function of family customs. Measured physicochemical characteristics for the ten different systems of studied tortillas, in fresh form (recently elaborated), are included in Table 1.

Table 1 Physicochemical Properties (*) of Studied Fresh Tortillas

Tortilla System	Color parameters			Moisture (%)	pH
	L	A	b		
Control (S1)	71.24	- 1.70^{D}	13.03	47.69±0.12^{B}	6.74±0.04^{A}
Guar 0.10 (S2)	69.07	- 1.05^{B}	12.89	45.33±0.41^{C}	6.36±0.19^{BC}
Guar 0.25 (S3)	68.51	- 1.06^{BC}	12.89	47.53±0.71^{BC}	6.01±0.01^{E}
Guar 0.50 (S4)	71.99	- 0.84^{AB}	12.80	49.06±0.38^{AB}	6.09± 0.01^{DE}
Carob 0.10 (S5)	71.2	- 0.80^{AB}	12.67	45.68±0.96^{C}	6.13±0.00^{D}
Carob 0.25 (S6)	70.97	- 0.91^{AB}	13.45	48.24±0.10^{AB}	6.08±0.01^{DE}
Carob 0.50 (S7)	73.15	- 0.64^{A}	13.58	44.77±0.62^{C}	6.07±0.01^{DE}
Gums 0.10 (S8)	73.5	- 1.49^{D}	12.68	49.94±0.60^{A}	6.51±0.01^{B}
Gums 0.25 (S9)	73.73	- 1.43^{CD}	13.76	48.34±0.33^{AB}	6.48±0.03^{B}
Gums 0.50 (S10)	73.04	- 1.63^{D}	13.19	48.42±0.41^{AB}	6.51±0.01^{B}

* Means and standard deviations (of three replicates). Only means for luminosity.

Color parameters exhibited samples with high luminosity (68 to 74), light yellow color (12.67 to 13.58) and a red trend (- 0.64 to – 1.70). Luminosity and yellow tone of tortillas did not show significant differences, in contrast to red color, in which four groups were observed (super index A to D, in Table 1). Therefore, the luminosity was not influenced by gums presence, although the mix of gums generated a light increasing in this parameter. The red color of tortillas exhibited a decrease influenced by the gums, more notable in simple gums that in their combinations. Two of these parameters are comparable with those values for tortillas prepared from a variety of doughs or "masas",[7] who reported 65.8-82.7 for *L*, 15.17-36.12 for *b*, and -1.96-6.14 for *a*; they analyzed the quality of tortillas. In general, the color of tortillas is influenced by several factors, such as the corn type, freshness of corn, and nixtamalization process, among others. Moisture showed small differences, it was in a range of 45.3 to 49.9%, in which there was significant effect of gums, without a trend, in which three groups were observed. A light augment of moisture was noted with the incorporation of gum mixes, that it may attributed to a synergistic effect, these macromolecules favored water entrapment. Measured moisture content was similar to those, reported by Acosta-Estrada et al.[7] with 31.54-51.12%; by Suhendro et al.[6] with 47.9 - 48.2%; and higher to the reported by NNI of Mexico of 44.8% (Hernández et al., 1974). The water content is influenced by flour composition and mainly, by the elaboration process, particularly the cooking-drying stage, among others.

With respect to pH, as an important and characteristic physicochemical property, our tortilla systems showed a range of 6.36 to 6.74. It was a significant effect of gums, detecting five groups, the control system was the highest, whereas tortillas with carob and guar gums decreased more this parameter than the combinations of gums. As concentration of both gums augmented, the pH of tortillas was lower, with exception of guar 0.25%. This parameter is strong influenced by calcium components in the nixtamalization process. With respect to other work, a pH of 8.36-8.70, was reported.[8] the pH of our ten tortilla systems was notably lower, attributed to a lower calcium concentration in our studied samples. Bressani,[9] reported that studied tortilla properties and others may present variation, as a function of the used flour, and people, who elaborate tortillas at familiar and artisanal levels

Effect of storage

Tortillas in refrigeration

To explore and to know the effect of tortillas stored at low temperatures (refrigeration and freezing), the same ten systems were studied. Similarly, to the analysis of fresh tortillas, ten systems were elaborated and stored at refrigeration atmosphere (15 + 2°C), to analyze the effect of this variable on their properties, with the desirable objective of improving the shelf life. Physicochemical characteristics (moisture and pH) were determined by triplicate on days 0, 2, 4 and 6, the results are included in Table 2.

Table 2 Water Content (*) of Studied Tortillas Through Refrigeration

Tortilla System	Day: 0	Moisture (%) and pH		
		2	4	6
control (S1)	47.69+0.12^{B} 6.75	45.09±0.31^{AB} 6.50	44.89±0.31^{BC} 6.45	44.58±0.02^{BC} 6.54
Guar 0.10(S2)	45.33±0.41^{B} 6.36	45.92±0.45^{B} 6.48	44.28±0.43^{B} 6.75	45.04±0.34^{B} 6.90
Guar 0.25(S3)	47.53±0.71^{B} 6.00	46.98±0.82^{B} 6.06	46.91±0.38^{B} 6.12	46.70±0.21^{B} 6.09
Guar 0.50(S4)	49.06+0.38^{AB} 6.00	49.32±0.31^{A} 6.30	46.17±0.19^{B} 6.30	45.77±0.13^{C} 6.78
carob 0.10(S5)	45.68±0.96^{B} 6.03	46.91±0.05^{B} 6.18	46.40±0.22^{BC} 5.94	45.28±0.01^{B} 6.24
carob 0.25(S6)	48.24±0.10^{AB} 6.15	46.00±0.37^{B} 6.27	44.81±0.01^{BC} 6.51	46.73±0.22^{B} 6.57
carob 0.50(S7)	44.77±0.62^{B} 6.30	45.78±0.26^{B} 6.24	46.48±0.30^{B} 6.12	44.81±0.23^{C} 6.21
Gums 0.10(S8)	49.94±0.60^{A} 6.51	50.10±0.72^{A} 6.39	49.34±0.71^{A} 6.15	48.08±0.70^{A} 6.36
Gums 0.25(S9)	48.34±0.33^{AB} 6.48	48.40±0.62^{B} 6.42	48.04±0.33^{A} 6.21	47.46±0.10^{A} 6.12
Gums 0.50(S10)	48.42±0.41^{AB} 6.51	47.38±0.77^{B} 6.42	47.37±0.08^{A} 6.45	46.53±0.88^{BC} 6.45

* Means and standard deviations (of three replicates).

As may be observed, higher contents of moisture corresponded to tortillas with gums (day 0). And the evolution through storage is not general, it could be mentioned that it was a light decreasing in water content. There was a significant effect of refrigeration on this parameter, as well as a significant influence of time. An although is a short difference, the control exhibited higher water decreasing during storage. Thus, the effect of water retention of tortillas with gums addition was reached. pH of tortillas was variable with not clear trend;

at day 0, the range was 6.0 – 6.8, whereas at day 2, was 6.1 - 6.5. At day 4 again the range was wide, 5.9 to 6.8, and at day 6, changed from 6.1 to 6.9. The influence of gums was significant, only on the first day (day 0), and after was variable, but without significant effect.

Freezing of tortillas

Again, and similarly to the analysis of fresh tortillas, ten systems were elaborated and stored in a freezer (-18 + 1°C), to analyze the effect of freezing process on tortilla properties, with the same objective, influence and improving on shelf life. Both physicochemical characteristics (moisture and pH) were determined by triplicate on days 0, and weeks 1, 2 and 3. Results of moisture determinations are included in Table 3, whereas the pH results are only mentioned and discussed below (Table 3).

Table 3 Physicochemical properties (*) of studied tortillas during freezing

Tortilla System	Moisture (%)			
	Day 0	First week	Second week	Third week
Control (S1)	47.69±0.12^{B}	45.81± 1.10^{C}	47.86±0.53^{A}	44.16±0.14^{C}
Guar 0.10(S2)	45.33 ±0.41^{C}	45.36 ±0.08^{C}	45.72±1.08^{C}	50.57 ±1.15^{C}
Guar 0.25(S3)	47.53±0.71^{BC}	44.79±0.24^{B}	43.69±0.24^{B}	ND
Guar 0.50(S4)	49.06 ±0.38^{AB}	46.89 ±0.09^{C}	47.02±0.84^{B}	50.21±0.01^{C}
Carob 0.10(S5)	45.68±0.96^{C}	46.26±0.14^{C}	48.89±1.20^{A}	47.67±0.66^{A}
Carob 0.25(S6)	48.24±0.10^{AB}	44.77 ±0.29^{B}	44.98±1.49^{C}	45.42±1.05^{B}
Carob 0.50(S7)	44.77 ±0.62^{C}	46.73 ±0.37^{C}	43.12 ±1.03^{B}	ND
Gums 0.10(S8)	49.94 ±0.60^{A}	48.67±0.76^{A}	51.73±1.47^{C}	46.31±0.31^{B}
Gums 0.25(S9)	48.34±0.33^{AB}	49.63±0.11^{A}	48.22±0.50^{A}	47.17±1.07^{A}
Gums 0.50(S10)	48.42±0.41^{AB}	49.37±0.54^{A}	48.80±0.32^{A}	47.12±0.62^{A}

* Means and standard deviations (of three replicates). ND: not determined.

There was not a general trend of this parameter, but it was observed a significant difference due to freezing storage. Part of the response may be attributed to the defrosting process, that was slow. It took two hours to reach the room temperature: one and half hour into refrigeration and half hour at room temperature, and even though was completed with too much care, there was heterogeneity in tortillas response. Some of them gained water content at first week (control, S5, S7, S9, and S10), others, at second week (control, S2, S4, S5, S6, and S8) and others at third week (S2, S4, and S6). In addition to storage, there was significant influence of gums concentration. pH showed a constant behavior (6.6 – 6.8) in four systems, tortillas control and with gums (S8, S9, and S10) at weeks one and two, to increase at the third (7.0 -7.1). The rest of systems with pH 6.0 - 6.4 at day 0, exhibited a decreasing trend at first week (5.9 – 6.0) that augmented for the second (6.1 - 6.8). At the third week the same four systems (control, S8, S9, S10) increased the pH to 7.1-7.2, and the other four systems (S2, S4, S5, S6) exhibited a decreasing in pH (6.1 – 6.4). The control was the system with highest pH (> 6.8). In general, and in comparison with the control, it was a significant effect of gums at first week, whereas at second it was significative influence of gums and concentrations. In general, and in comparison, with the control tortilla, the pH was influenced by the studied three factors, gums and concentrations, as well as storage.

Textural determinations of tortillas systems

Fresh tortillas

Textural characteristics of fresh tortillas were measured, as firmness, punction and elasticity, at two temperatures, room temperature (24-27°C), and high temperature (80 + 10°C), in which they are placed and lately heated, before its consumption, just to have the data. These objective determinations represent the tortilla resistance to mechanical actions carried out by human consumers, when they take the item to be consumed, as a reference. Texture measurements are summarized in Table 4 at both temperatures.

Table 4 Textural Measures (*) of Studied Fresh Tortillas at Two Temperatures

Tortilla System	Firmness		Punction		Extensibility forces (N)	
	Room	High	Room	High	Room	High
Control (S1)	19.25	13.15	0.84	0.7	1.92	1.41
Guar 0.10 (S2)	8.3	9.89	0.84	0.46	1.5	1.35
Guar 0.25 (S3)	8.46	14.33	0.5	0.78	1.89	1.5
Guar 0.50 (S4)	8.94	8.89	0.64	0.53	3.33	2.5
Carob 0.10 (S5)	8.66	11.81	0.52	0.9	4.2	3.51
Carob 0.25 (S6)	11.15	14.27	0.72	0.84	3.24	2.34
Carob 0.50 (S7)	13.25	20.87	1.3	1.17	4.14	3.45
Gums 0.10 (S8)	6.88	12.99	0.57	0.43	2.35	2.35
Gums 0.25 (S9)	9.01	11.95	0.6	0.54	2.13	2.13
Gums 0.50 (S10)	7.69	13.34	0.6	0.57	1.8	1.8

* Means of three replicates.

Results display the texture of tortillas freshly elaborated at two conditions that is the response and modification in texture when the tortilla is prepared before their consumption. Control tortilla showed the highest forces in firmness, and punction forces (with one exception), whereas the extensibility was not the highest one; there was six systems that showed higher tension force than control. In general, with only few exceptions, the gums decreased the firmness, and punction (except S7), and increased the extensibility (except S2, S3, and S10).The punction of tortillas exhibited a range of 0.5 – 1.30 N, was lower than a determined range of 2.18 -5.06 N for tortilla enriched with soybean,[8] that was reported as firmness, being a penetration test similar to the measured in our work. Whereas the extensibility force with a range of 1.50-4.20 N is lower than the range reported by Acosta-Estrada et al. (2023),[7] who determined a range of 2.3-11.2 N for breaking force. This information may be very useful for manufacturers that could incorporate these gums in tortilla elaboration and improve texture characteristics of this food item.

With respect to high temperature, eight of ten samples exhibited higher firmness (except control and S4) with respect to room temperature determination that could be a desirable change in texture. In contrast, the punction at 80°C was lower in seven samples (except S3, S5 and S6). Whereas for extensibility, all systems showed lower tension at high temperature than at room, in which the three tortillas formulated with gums combination were more extendable, being a good modification. In the three measured forces, the interaction of gums with carbohydrates of tortilla was inconstant. There were significant differences in the determined forces between room and high temperatures.

Effect of refrigerated storage

Fresh tortillas required a lower punction force that those forces applied to refrigerated items, in which the difference was attributed to the retrogradation phenomenon in the starch of the flour used for tortillas elaboration.[10] Situation that may be observed in the punction force of Table 5.

Table 5 Textural determinations (punction, *) of studied tortillas through refrigeration

Tortilla System	Room temperature Extensibility (N)					Heated at 80°C (+ 10) -30 s				
	Day:	0	2	4	6	Day:	0	2	4	6
Control (S1)		0.84	1.23	1.5	2.16		0.6	0.42	0.48	0.73
Guar 0.10(S2)		0.84	1.15	1.44	2.22		0.48	0.6	0.78	0.71
Guar 0.25(S3)		0.53	0.72	0.75	0.81		0.62	0.76	0.9	0.72
Guar 0.50(S4)		0.72	0.9	1.17	1.08		0.35	0.6	1.08	0.57
Carob 0.10(S5)		0.54	0.78	1.23	1.08		0.9	0.57	0.99	0.54
Carob 0.25(S6)		0.78	0.93	1.32	1.92		0.63	0.55	0.87	0.81
Carob 0.50(S7)		1.29	1.17	0.96	1.23		1.1	1.24	0.85	1.2
Gums 0.10(S8)		0.6	0.75	1.17	1.2		0.63	0.42	0.48	0.45
Gums 0.25(S9)		0.63	0.81	1.08	1.23		0.6	0.51	0.9	0.57
Gums 0.50(S10)		0.66	0.87	1.24	0.77		0.63	0.54	0.36	0.6

Means of three replicates.

In general, an increasing trend was observed with days of refrigeration at room temperature, although there was not significant difference between these results, at different days of storage. Similar results were reported by Besojano et al.[11] for the force in wheat tortillas, in fresh form 1.07 N, and wheat tortillas, stored 5 days at refrigeration, 1.57 N. And, as was expected, when the same tortillas were tested after heating, the punction force was lower, as it may be observed in Table 5. The range for punction force in tortillas at room temperature was 0.53 to 1.29 N at day 0 and 0.77 to 2.22 N at day 6, whereas heated tortillas exhibited a range of 0.35 to 1.10 N at day 0, and 0.45 to 1.2 N at last day; in this last determination, tortilla with carob 0.50 (S7) was the highest in days 0, 2 and 6. With respect to the other two forces, firmness, and extensibility, similar results were obtained. They are included in Tables 6 and 7. At room temperature, tortilla without gums showed highest values of firmness force and a generalized increasing trend was determined through storage for tortillas with gums, attributed to a more compact structure favored by changes in starch and water loss. This response for firmness by triplicate, was different at high temperature, observing that the first measure was lower than the other two determinations (Table 6).

Table 6 Textural determinations (firmness, *) of studied tortillas through refrigeration

Tortilla System	Room temperature extensibility (N)					Heated at 80°C (+ 10) -30 s				
	Day:	0	2	4	6	Day:	0	2	4	6
Control (S1)		19.5	21	25.8	21.9		13.2	12.3	21	17.7
Guar 0.10(S2)		8.4	11.7	15	17.4		9.6	21	20.7	12.6
Guar 0.25(S3)		9	10.5	14.7	14.1		14.1	9	24.9	12.6
Guar 0.50(S4)		9.9	13.8	17.5	19.2		9	10.2	21.6	11.1
Carob 0.10(S5)		8.7	11.1	17.4	17.5		12	12.6	22.2	9.9
Carob 0.25(S6)		11.7	12.6	17.4	19.2		14.4	12.7	21.9	15.3
Carob 0.50(S7)		13.2	15.6	17.4	18.3		21	11.4	20.1	15.3
Gums 0.10(S8)		7.2	10.8	15	13.2		13.2	11.7	16.2	15.9
Gums 0.25(S9)		8.4	10.9	13.8	16.8		11.7	11.4	20.1	15
Gums 0.50(S10)		7.8	10.2	14.1	15.9		13.2	12	17.1	16.8

Means of three replicates.

It is notable the difference between determinations at day 0 and 2, with respect to higher values at days 4 and 6, mostly at day 4. Influence of gums on tortilla response in firmness test was variable, and even though days 4 and 6 were highs, those values measured at day 4, were the highest. Similarly, that in punction test, biochemical changes in starch,[10] and water reduction are considered as responsible of textural changes, firmness in this case.

Extensibility of tortillas, may be considered as one of the most important textural characteristics by the consumer. Table 7 includes the results obtained for the ten systems at room and high temperatures (Table 7).

* Means of three replicates.

Determinations of extensibility tests at room temperature at day 0, were the lowest in general. They increased for the rest of the days of refrigeration, with only one exception, in which the tortilla control showed the highest value at day 6. This trend is very interesting because it is showing an improving of extensibility with storage time, favored by starch changes and lower water loss, as well as favored by the presence of gums, with the mentioned exception; exhibiting thus, significant difference from both factors, storage time and gums presence, and not for the concentration of gums. The extensibility force at day 0, showed a range of 1.50 - 4.38 N, with a mean value of 2.94 N, that was similar to that of 2.82 N reported by Suhendro et al.[6] On the other hand, the measures of extensibility at high temperature, did not show an observable trend.

Table 7 Textural determinations (extensibility, *) of studied tortillas through refrigeration

Tortilla System	Room temperature extensibility (N)				Heated at 80°C (+ 10) -30 s				
	Day:	0	2	4	6	Day:	0	2	4	6
Control (S1)		1.95	1.92	5.88	9		1.38	1.23	4.08	3.33
Guar 0.10(S2)		1.5	2.25	3.87	5.49		1.2	2.7	5.16	3.27
Guar 0.25(S3)		1.8	4.02	5.85	6.18		1.35	1.53	2.43	3.6
Guar 0.50(S4)		3.33	5.82	5.82	5.7		2.37	2.22	2.67	1.32
Carob 0.10(S5)		4.38	4.38	5.25	6.39		3.6	1.53	2.43	2.43
Carob 0.25(S6)		3.42	5.04	6.99	7.32		2.28	1.71	3.09	2.13
Carob 0.50(S7)		4.38	5.13	7.26	7.59		3.48	1.47	2.19	3.18
Gums 0.10(S8)		1.32	3.33	4.77	6.33		2.22	1.77	2.46	1.89
Gums 0.25(S9)		1.92	3.39	3.99	5.7		2.16	2.04	2.91	2.16
Gums 0.50(S10)		1.29	4.23	4.83	5.76		1.62	1.62	1.89	2.28

Effect of freezing storage

The same textural properties for tortilla systems were determined after freezing storage completing 1, 2 and 3 weeks were completed, but texture was only measured at room temperature. The punction measures presented a similar response through storage, without influence of storage time, being the tortilla control the item with highest punction values. The range of values, in three weeks of storage was 0.666 – 1.56 N, being lightly lower than for refrigeration storage (0.52 – 2.22 N) and a significant effect of gums, decreasing the punction resistance, was determined. For firmness measuring, the range of 10.8 – 20.7 N, was comparable to those values determined for refrigerated tortillas (7.2 – 25.8 N). No significant effect was quantified from gums, concentration, and storage time factors. It may be noted that the low value for tortillas subjected to freezing (10.8) was higher than for the determination for refrigerated items (7.2), and the high determination (20.7 N) is lower than for refrigerated samples (25.8 N). And finally, for extensibility forces of frozen tortillas, the range of 2.22 - 8.19 N was also comparable to those determinations completed for refrigerated systems (1.29 – 9.00 N). It this case, the recorded measures showed similar situation, being the low value for tortillas subjected to freezing, higher (2.22), than for those determinations completed for refrigerated items (1.29), and the high determination (8.19 N) is lower than for refrigerated samples (9.00 N). Texture of frozen tortillas was probably influenced by physical and biochemical changes, such water retention and starch retrogradation,[7] the last was not determined in this research.

Conclusion

Although tortillas are normally food items for immediate consumption, this research studied the effect of two gums and two preservation process on physicochemical (color, moisture, and pH) and textural (punction, firmness, extensibility) properties of this food item. Although there are differences, all analyzed tortilla systems corresponded to standard characteristics for this food. There were not generalized trends in tortilla properties influenced by the studied factors, however some interesting and important observations were completed. Tortillas with gums exhibited higher water content, and both processes (refrigeration and freezing) contributed to a lower water loss of tortillas with gums that control. Tortillas with added gums showed a lower pH,that was not influenced during the storage at low temperatures. Refrigeration through six days and freezing through three weeks in tortillas with gums, contributed to a decreasing in firmness and an increasing in extensibility. Information of this research contributes to the knowledge of the nature and response of tortillas subjected to the studied factors and also, to improve the characteristics and storage of a very important Mexican food product.

Acknowledgements

None.

Conflicts of interest

The authors declare that there is no conflict of interest.

References

1. Cortés-Gómez A, San Martín-Martínez E, Martínez-Bustos F, et al. Tortillas of blue maize (*Zea mays L.*) prepared by a fractional process of nixtamalization: analysis using response surface methodology. *J Food Eng*. 2005;66(3):273–281.
2. Escobedo-Garrido JS, Jaramillo-Villanueva L. Consumer preferences for corn tortillas. *CIAD J Contemp Food Reg Dev*. 2019;29(53):1–25.
3. Platt-Lucero LC, Ramírez-Wong B, Torres-Chávez PI, et al. Effect of the addition of gums on the texture of extruded nixtamalized corn flour tortilla. Proceedings of the International Symposium on Conventional and Alternative Technologies in Corn Processing. Chihuahua, Mexico. 2011.
4. American Association of Cereal Chemists (AACC). Approved Methods of the American Association of Cereal Chemists. 10th ed. 2000.
5. Ramírez-Wong B, Sweat VE, Torres PI, et al. Development of two instrumental methods for corn masa texture evaluation. *Cereal Chem*. 1994;70:286–290.
6. Suhendro EL, Almeida DH, Rooney LW, et al. Objective rollability method for corn tortilla texture measurement. *Cereal Chem*. 1999;75(3):320–324.
7. Acosta-Estrada BA, Serna-Saldívar SO, Chuck-Hernández C. Quality assessment of maize tortillas produced from landraces and high-yield hybrids and varieties. *Front Nutr*. 2023;10:1–17.
8. Hassan SM, Forsido SF, Tola YB, et al. Physicochemical, nutritional, and sensory properties of tortillas prepared from nixtamalized quality protein maize enriched with soybean. *Appl Food Res*. 2024;4(1):100383.
9. Bressani R. Chemistry, technology and nutritive value of maize tortillas. *Food Rev Int*. 1990;6(2):225–264.
10. Arik Kibar AE, Gönenc I, Us F. Modeling of retrogradation of waxy and normal corn starches. *Int J Food Prop.* 2011;14(5):954–967.
11. Besojano FP, Joseph S, Miranda-López R, et al. Rheological and sensory evaluation of wheat flour tortillas during storage. *Cereal Chem*. 2005;82(3):256–263.