Effects of High Pressure and Glycerol on the Physico-chemical Properties of Corn Tortillas

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ABSTRACT

Corn tortillas were produced by mixing dry masa and water (2:3 w/w) with and without glycerol (4% d.b.) and salt (1% d.b.), and cooked on a 325 °C griddle for 30 seconds. The samples were allowed to cool at ambient conditions (25 °C and 50% RH) prior to being individually vacuum packaged in high-barrier flexible pouches and pressurized at 500MPa and 800 MPa for 1 and 10 minutes.

Control and pressurized corn tortillas were analyzed for macroscopic (moisture content, water activity) structural ("freezable" water, FW, by differential scanning calorimetry, DSC and weight loss by thermo-gravimetric analysis, TGA) and molecular (^{1}H cross relaxation, ^{1}H T_1 and ^{1}H T_2 nuclear magnetic resonance, NMR) properties.

All samples were found to have similar moisture contents of 50-52 % (total basis) and water activity. Addition of glycerol to the formulation caused a significant reduction in the amount of FW from 41% (g "freezable" water/ 100 g sample control samples) to 31%, (10% reduction). High pressure induced a slight decrease in "freezable" water content of both control and glycerol added samples. Weight (moisture) loss by TGA was found to be bimodal ("lower" and "higher" temperature domains) in all samples. High pressure treatment caused an increase in the "lower temperature". At a molecular level, ^{1}H Cross relaxation NMR indicated that the majority of the protons were liquid-like. Both ^{1}H T_1 and ^{1}H T_2 NMR relaxation were found to follow a single exponential decay with T_1 relaxation times equal to about 900 milliseconds and T_2 relaxation times in the order of 15 milliseconds for control samples. High Pressure treatment caused a reduction in both ^{1}H T_1 and T_2 relaxation times.

INTRODUCTION

Tortillas represent one of the fastest growing segments in the baking industry (Suhendro et al 1998). Fresh, homemade corn tortillas become stale after only a few hours and are subject to mold, yeast, and bacterial growth because of the high moisture content. The food industry would like to extend the shelf life of corn tortillas to ease product distribution (from refrigerated to room temperature) and to respond to consumer demand.

In commercial applications, microbial contamination is reduced by using carboxy-methyl-cellulose, proprionates and sorbates. A cheaper alternative may be found in glycerol, a polyol that acts as a humectant and is known to lower the water activity of the product while maintaining flexibility and pliability.

High pressure processing (HP) might be an alternative to the use of additives in extending corn tortillas shelf life. High pressure has been proven effective in extending the shelf life of high moisture content products (e.g. orange juice, tomatoes, and meat) by enzymes and yeast and molds inactivation (Nienaber and Shellhammer 2001, Shook et al 2001, Lucore et al 2000). The high moisture content and the flat nature of corn tortillas make them a good candidate for a successful application of this stabilization technique.

MATERIALS & METHODS

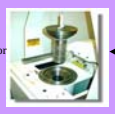
Mixing

Dividing and rounding
(30 g dough rounded to sphere)

Pressing

Cooking
(300-350 C for 30 sec)

Packaging



Control: 40%masa, 60% water
Glycerol: 40%masa, 60% water, 4%glycerol, 1%salt

High Pressure treatment
Press: ABB Flow Quintus Food Processor QFP-6 ColdIsostaticpress (Sweden).
Conditions: 500 MPa and 800MPa for 1 and 10 minutes room T (end T = 45C)

TORTILLAS ANALYSIS

Macroscopic Level
Moisture content vacuum oven, AOAC 1991, Method 925.90
Water activity 25 C, Decagon Aqualabmeter TE8255

Structural Level
Thermogravimetric Anlayzer (TGA)
TGA 2960 (TA Instruments, New Castle, DE, USA), 15 20mg, scan rate at 20C/min, T range 25200 C
Differencial Scanning calorimeter (DSC): DSC 2920 (TA Instruments, New Castle, DE, USA), 81 mg, scan rate 5C/min, T range-50C to 200C.

Molecular Level
300 MHz Bruker Ins. Inc., Billerica, MA, USA)
^{1}H Cross relaxation (Wu and Eads, 1993; Vodovotzet al. 2001)
Relaxation time T_1- Inversion recovery T_2- CPMG pulse sequence

OBJECTIVE

The objective to this study was to investigate the effect of high pressure treatment and glycerol on the macroscopic, structural, and molecular properties of corn tortillas.

RESULTS and DISCUSSION

Macroscopic properties

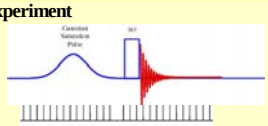
	CONTROL		GLYCEROL	
	m.c. (%)	a_w	m.c. (%)	a_w
No pressure	52.3 ± 1.2	0.99	49.7 ± 0.7	0.98
500MPa 1min	53.2 ± 1.1	0.99	50.4 ± 0.8	0.98
500MPa 10min	52.0 ± 0.7	0.99	51.6 ± 1.1	0.98
800MPa 1min	52.3 ± 0.8	0.99	51.9 ± 1.5	0.98
800MPa 10min	50.7 ± 2.0	0.99	50.9 ± 1.2	0.98

NO significant differences in moisture content or water activity among samples

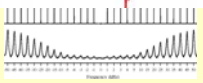
Molecular properties

^{1}H cross relaxation

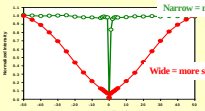
Experiment



Pulse sequence



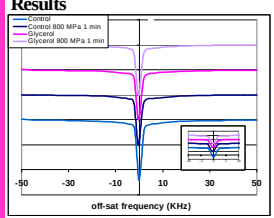
liquid signal observed at various offset frequencies



The resulting Z-spectra reflects the solid-like protons

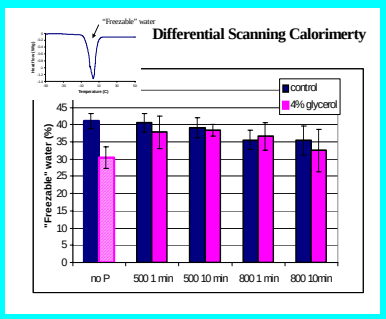
(Wu and Eads, 1993; Vodovotz et al. 2001)

Results

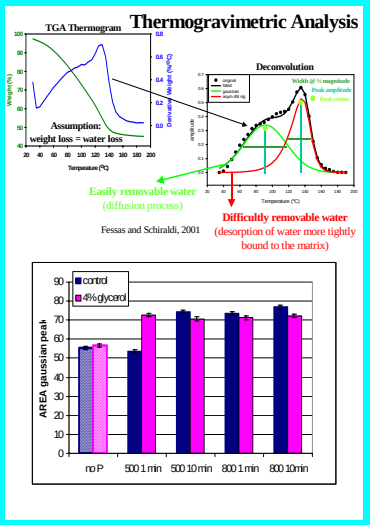


- Z-spectra for corn tortillas showed a single narrow component indicating the presence of highly mobile protons in this product.
- High pressure treatment and addition of glycerol did not change the spectra.

Structural properties



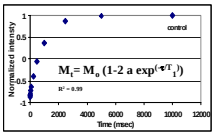
- High pressure (HP) treatment slightly reduced FW in corn tortillas in proportion to the strength and duration of HP treatment.
- Addition of 4% glycerol significantly reduced the FW in the no HP treated sample but not significantly in the HP treated sample. It is hypothesized that the HP treatment may cause a phase separation of glycerol in the tortilla matrix.

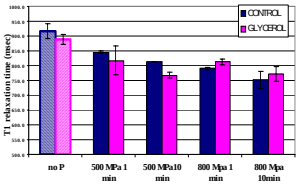


- No significant change in peak amplitude, peak center and peak width at half magnitude was found in all samples for both gaussian and asymmetric double sigmoidal peaks
- The area of the gaussian and asymmetric double sigmoidal peaks (ADS) were found to, respectively, increase and decrease as consequence of HP treatment. The only exception was the control HP treated at 500 MPa for 1 min where the HP treatment may not have been long enough to induce a change in water properties measurable by TGA. The same HP conditions induced a significant change in the gaussian perk area for the glycerol sample that might indicate that glycerol facilitated water redistribution in the sample.
- HP treatment induced a change in water properties making it more easily removable.

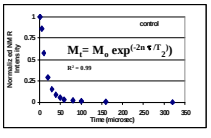
^{1}H relaxation time

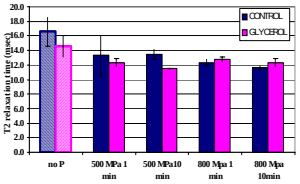
T_1





T_2





M_t = peak height
M_o = equilibrium magnetization
τ = interpulse spacing
a = correction factor
N = number of echoes

- T_1 and T_2 were best fitted using a single-exponential model.
- Only one ^{1}H population was detected in all samples.
- High pressure treatment caused a slight reduction in T_1 and T_2 relaxation times in corn tortillas.
- Glycerol caused a reduction in T_1 and T_2 relaxation times when associated to HP treatments at 500 MPa. At 800 MPa glycerol containing samples had T_1 and T_2 slightly higher than the corresponding controls. These higher pressure treatments might have induced a redistribution of the water soluble phase (glycerol/water) that altered the ^{1}H relaxation process.

CONCLUSIONS

MACROSCOPIC PROPERTIES: HP and glycerol did not cause any change in macroscopic properties (moisture content and a_w)
STRUCTURAL PROPERTIES: HP slightly reduced "freezable" content. Glycerol significantly reduced "freezable" water content in the no-HP treated samples; HP caused phase separation of glycerol.
MOLECULAR PROPERTIES: HP did not affect nor alter solid ^{1}H distribution. T_1 and T_2 measurements were sensitive to both glycerol and strength of HP treatment

The effects of HP treatment and glycerol addition could not be followed by traditional water analysis techniques (Macroscopic Properties). Molecular and structural techniques were necessary to detect changes incurred by such formulation and processing. Future work is necessary to understand the changes in molecular/structural properties as related to storage stability.

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