The use of xylanase to improve physicochemical characteristics of nixtamalized corn flour and tortilla texture obtained by extrusion


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ABSTRACT

Whole white corn was ground, and lime, water, and xylanase enzyme (0.05%, 0.075% or 0.1% w/w) were added. Blends were extruded, dried and ground to obtain nixtamalized corn flour (ENCF), which was used to make tortillas. Water absorption index and water absorption capacity (WAC) were determined in the obtained flour. Moisture content and viscoelastic characteristics ($G'$, $G''$, and $\tan \delta$) were determined in corn masa. Tortillas were made, and moisture content, texture (cutting force and rollability) during storage (2 h, 24 h, 48 h) were carried out. Tortillas of the best treatment were evaluated by sensory evaluation. The extruded flours with xylanase showed significantly ($P < 0.05$) WAC higher than the extruded flour control without xylanase. The viscoelastic parameters were increased by adding xylanase enzyme. There were no statistically significant differences between 0.075 and 0.1% added xylanase ($P > 0.05$). The addition of xylanase decreased tortilla firmness and increased its flexibility during storage. The effect was more significant at concentrations of 0.075% and 0.1% xylanase. Corn tortillas with these xylanase concentrations showed no differences ($P > 0.05$), and they were 15% less firm (softer) than the control. Viscoelastic parameters correlated negatively with tortilla firmness ($r = -0.99$). Additionally, corn tortillas made with ENCF containing xylanase enzyme had acceptable organoleptic characteristics.

Keywords Corn tortilla • Extrusion • Xylanase • Viscoelastic Characteristics • Texture

INTRODUCTION

The softening of most corn pericarp layers is essential to form masa with acceptable sheeting characteristics [13]. The use of the enzyme xylanase is a novel way to improve the production of corn tortillas from extruded nixtamalized corn flour. Xylanase hydrolyzes the β-1,4-glycosidic bonds of xylose on the backbone of arabinoxylans. The cleavage produces arabinoxylans of lower molecular weight that affect the physicochemical and rheological characteristics of masa [4]. The objective of this study was to evaluate the effect of xylanase on the water absorption index and water absorption capacity of ENCF. Moreover, the viscoelastic characteristics of masa, texture of resultant tortillas and an assessment of tortilla quality via a sensory panel were investigated.
MATERIALS & METHODS

Commercial white corn, commercial hydrated lime powder and Grindamyl Powerbake 7500, an uninhibited component of xylanase preparation from Bacillus subtilis, with an activity of 163 000 U/g were used. Corn samples (3 kg each) were ground in a mill (Pulvex, Model 200) with a 0.8-mm mesh. The ground corn was placed into polyethylene bags to avoid moisture loss and stored at 5 °C until use. Samples of ground corn were blended in a mixer (Hobart Corporation, Model AS200) for five minutes with 0.3% (w/w) lime. Xylanase, previously diluted in deionized water, was immediately added to the mixture to reach a final moisture content of 30% (w/w) [9]. Xylanase concentrations used were 0 (control), 0.05, 0.075 or 0.1% (w/w). Each mix was placed in a polyethylene bag and stored for 12 h at 5 °C. Before extrusion, each mix was tempered at 25 °C for 4 h. Extrusion was performed in a single-screw laboratory extruder (Brabender, Model E 19/25 D) with a screw diameter of 19 mm, a length-to-diameter ratio of 25:1, a nominal compression ratio of 2:1, a die opening of 3 mm, and four zones of heating / cooling (1300 W each). Extruder operating and milling conditions recommended by Platt et al. [10] were used. The conditioned sample was fed through the extruder feed hopper at 45 rpm. The screw speed was 112 rpm and the extrusion temperatures were 60 °C, 70 °C, 80 °C and 90 °C. Extrudates were dried in a constructed tunnel dryer at 65 °C for 1 h. Then, the extrudates were ground with a 0.8-mm mesh up to 61-63% of the accumulated material had passed through the 80 mesh to obtain the extruded nixtamalized corn flour (ENCF). Tortillas were prepared with ENCF and distilled water in accordance with the water absorption capacity (WAC). The water absorption index (WAI) and water absorption capacity (WAC) were determined on each ENCF. The WAI was measured using a procedure reported by Anderson et al. [2]. WAI was expressed as g gel/g dry sample. The WAC was measured using the procedure reported by Flores-Farias et al. [6] and the WAC of each flour was recorded in ml water / 100 g flour. ENCF was rehydrated with enough water to provide fresh masa, which provides the proper consistency to make tortillas and avoid masa stickiness. The water absorption index (WAI) and WAC were determined on each ENCF. Moisture content and viscoelastic characteristics (G', G'' and Tan δ) were determined in the corn masa. Moisture content, firmness and rollability were measured at 2, 24 or 48 h after the tortillas were made. The moisture content of masas and tortillas were assessed using the 44-15 method [1]. Firmness was measured using the Kramer’s Cell attached to a texture analyzer (Instron Co., Model 4465), according to the procedure reported by Ramirez-Wong et al. [11]. Rollability was evaluated by the Wansiska procedure [14]. Tortillas with the best treatment (firmness) were evaluated by a sensory panel. Tortillas made in a commercial tortilleria were cooled and placed in polyethylene bags, and they were brought to the laboratory for sensory evaluation. A panel of 50 people with no previous training carried out the tortilla sensory evaluation. The panel evaluated five attributes (aroma, flavor, color, texture and acceptability) using the following hedonic scale: 7 = like extremely, 6 = like, 5 = like slightly, 4 = neither like nor dislike, 3 = dislike slightly, 2 = dislike, and 1 = dislike extremely [3]. A completely randomized design was used. An analysis of variance was performed for all data gathered. The Tukey test (P < 0.05) was used to compare specific treatments.

RESULTS & DISCUSSION

Table 1 presents the water absorption index (WAI) and water absorption capacity (WAC) of the extruded nixtamalized corn flour (ENCF). In this study, the WAI of extruded flour without xylanase (control) was similar to that reported by Platt et al. [10]. However, the WAI was greater than the value reported by Gutierrez-Dorado et al. [8], who obtained WAI value of
2.51g gel/g. The ENCF treated with xylanase showed significantly (P < 0.05) higher WAI than the ENCF control. Similarly, the WAC of the ENCF treated with xylanase was significantly (P < 0.05) higher than the WAC of the extruded flour without the enzyme (control). This may be attributed to the effect of xylanase on the arabinoxylans in the extruded corn flour. Due to their high molecular weight, arabinoxylans from corn pericarp are not extractable by water. After molecular weight reduction by xylanase, the arabinoxylans may become water extractable, which has been reported to provide a higher water absorption capacity [7, 12]. Regarding to the WAC of extruded flour without xylanase, similar values were recently reported by Platt et al. [10] in extruded flour without hydrocolloids.

**Table 1** Extruded nixtamalized corn flour (ENCF) quality evaluation with xylanase

<table>
<thead>
<tr>
<th>Flour</th>
<th>WAI (g gel/g dry matter)</th>
<th>WAC (ml water/100 g flour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENCF</td>
<td>3.21 ± 0.03b</td>
<td>90.5 ± 0.86b</td>
</tr>
<tr>
<td>ENCF with xylanase (0.05%)</td>
<td>3.39 ± 0.03a</td>
<td>92.2 ± 0.28a</td>
</tr>
<tr>
<td>ENCF with xylanase (0.075%)</td>
<td>3.40 ± 0.04a</td>
<td>92.2 ± 0.28a</td>
</tr>
<tr>
<td>ENCF with xylanase (0.1%)</td>
<td>3.45 ± 0.03a</td>
<td>92.2 ± 0.28a</td>
</tr>
</tbody>
</table>

Values are means ± SD. Within a column, values with same letter are not statistically significant (P < 0.05)

WAI  water absorption index, WAC water absorption capacity

The masa moisture content (MMC) from each of the ENCF treatments is summarized in Table 2. Corn masas from ENCF with xylanase showed an increase in moisture content (P < 0.05) when compared to corn masa from ENCF without xylanase. This is reflected in the higher water absorption capacity of the xylanase-treated ENCF. The MMC of the extruded flour was similar to the extruded flour without hydrocolloids reported by Platt et al. [10].

**Table 2** Moisture content in masa and tortilla from extruded nixtamalized corn flour (ENCF) with xylanase

<table>
<thead>
<tr>
<th>Flour</th>
<th>MMC (%)</th>
<th>TMC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENCF</td>
<td>50.57 ± 0.01b</td>
<td>38.66 ± 0.12b</td>
</tr>
<tr>
<td>ENCF with xylanase (0.05%)</td>
<td>51.34 ± 0.42a</td>
<td>39.47 ± 0.06a</td>
</tr>
<tr>
<td>ENCF with xylanase (0.075%)</td>
<td>51.20 ± 0.10a</td>
<td>39.61 ± 0.40a</td>
</tr>
<tr>
<td>ENCF with xylanase (0.1%)</td>
<td>51.70 ± 0.20a</td>
<td>39.68 ± 0.12a</td>
</tr>
</tbody>
</table>

Values are means ± SD. Within a column, values with same letter are not statistically significant (P < 0.05)

MMC  masa moisture content, TMC tortilla moisture content

The viscoelastic parameters were dependent on frequency. For any frequency and treatment, the storage moduli $G'$ were higher than the loss moduli $G''$. These parameters were affected by xylanase enzyme. The magnitude of $\tan \delta$ increased with increasing treatments of xylanase in comparison to the control without xylanase (Fig. 1). This could indicate that corn masas became more viscous in the presence of xylanase because it made the masa softer and changed the viscoelastic properties [5, 12]. $\tan \delta$ values of ENCF at 0.075 and 0.1% xylanase showed no statistical differences (P > 0.05). In this study, suitable levels of xylanase (0.075-0.1%) resulted in a desirable softening of corn masa, thereby improving its machinability.
In Fig. 2 is presented tortilla texture (measured as firmness) evaluated from all ENCF treatments at 2, 24 and 48 h after the tortillas were made and stored at 25 °C. For any ENCF treatment, tortilla firmness increased with storage time. The addition of xylanase decreased the rupture force value in tortillas as xylanase concentration increased. The effect was more significant at 0.075 and 0.1% (w/w) xylanase. Tortillas with these two levels of xylanase showed no statistical differences (P > 0.05), and they were 15% less firm (softer) than the tortillas made from ENCF without the enzyme. Rubio et al. (2003) obtained tortillas from commercial corn flour with less firmness using commercial 0.01% (w/w) xylanase with an activity of 109,000 U/g. Extruded corn flour has a higher fiber content than commercial corn flour (Gutierrez-Dorado et al. 2008). Therefore, the amount of xylanase for enzymatic hydrolysis of corn pericarp in extruded corn flour must be higher than in commercial corn flour. Tortillas made with the extruded flour containing xylanase were more flexible, and they maintained high rollability scores during storage. The addition of xylanase retarded the loss of flexibility. Tortillas made with extruded flour without xylanase showed a significantly (P < 0.05) lower value of rollability at 24 and 48 h compared with tortillas containing xylanase.

A sensory evaluation test was performed on tortillas from the treatment of extruded flour with 0.075% (w/w) xylanase. This treatment was selected because the tortillas showed a lower firmness with less enzyme concentration. The attributes evaluated were aroma, color, flavor, texture and acceptability. Attributes of corn tortillas made with flour containing xylanase were compared to corn tortillas without xylanase (control) (Table 3). Corn tortillas with xylanase were softer than tortillas made with the extruded flour without xylanase (P < 0.05). This difference comes from xylanase hydrolyzing the arabinoxylans and lowering their molecular weight. Tortillas containing the enzyme was acceptable.
Figure 2. Firmness of tortillas produced from extruded nixtamalized corn flours (ENCF) during storage.

Correlation analysis was carried out among flour quality parameters, masa viscoelastic properties and tortilla texture determinations from all the treatments. The IAA of flour had correlations with WAC ($r = 0.97$), masa moisture content ($r = 0.96$) and tortilla moisture content ($r = 0.98$). The viscoelastic parameters ($G', G''$, Tan $\delta$) correlated ($r = -0.99$) with tortilla firmness during storage. The relationships among viscoelastic properties of masa and tortilla firmness confirm that an oscillatory dynamic sweep test can predict the extruded flour quality with xylanase enzyme.

**CONCLUSION**

Water absorption index and water absorption capacity of nixtamalized corn flour (ENCF) were improved by adding xylanase during extrusion. When compared, the corn masa produced from ENCF with xylanase had higher viscoelastic parameters ($G', G''$, and Tan $\delta$) than the ENCF without the enzyme. Furthermore, tortillas made from extruded flour with xylanase had a softer texture than tortillas made without the enzyme. The viscoelastic parameters correlated with tortilla firmness, which confirms that the dynamic method is capable of differentiating masas from extruded flours with xylanase enzyme. Extruded nixtamalized flours performed very well in a commercial plant, and tortillas with good quality were obtained. Tortillas made of extruded flour with 0.075\% (w/w) xylanase were evaluated acceptable by the sensory panel, and they were considered softer than tortillas prepared without the enzyme.

<table>
<thead>
<tr>
<th>Sensory Attributes*</th>
<th>Aroma</th>
<th>Color</th>
<th>Texture</th>
<th>Flavor</th>
<th>Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENCF</td>
<td>5.60 ± 0.96a</td>
<td>5.33 ± 0.98a</td>
<td>4.66 ± 1.51b</td>
<td>5.66 ± 0.95a</td>
<td>5.51 ± 1.09a</td>
</tr>
<tr>
<td>ENCF with xylanase (0.075%)</td>
<td>5.72 ± 0.72a</td>
<td>5.18 ± 0.98a</td>
<td>5.39 ± 1.29a</td>
<td>5.42 ± 1.11a</td>
<td>5.66 ± 0.88a</td>
</tr>
</tbody>
</table>

Values are means ± SD. Within a column, values with same letter are not statistically significant ($P < 0.05$)

*Hedonic scale: 7 like extremely, 6 like, 5 like slightly, 4 neither like nor dislike, 3 dislike slightly, 2 dislike, 1 dislike extremely

**Table 3** Sensory Evaluation Scores of Tortillas from Extruded Nixtamalized Corn Flour (ENCF)
REFERENCES


