NOTE

Effects of Endoxylanase Addition on Pasta Processing with Short Mixing Time

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Common pasta making involves the following steps: hydrating semolina (to 25–35% moisture content), mixing, kneading, sheeting or extruding through a die to obtain the desired shape, and then drying to a moisture content of ≈12% (Abécassis et al 1994). Conventional mixing in this process takes 10–20 min (Dalbon et al 1996). One of the latest technological advancements in pasta technology is the use of the Polymatik press. This hygienic system uses a twin-screw mixer combined with polygon kneading elements that mix and develop pasta doughs in <30 sec (Seiler 1996; Dexter and Marchylo 2000). This requires finer semolina granulation (<250 μm), which has the advantage that more homogeneous doughs are formed with quicker and better water absorption (Seiler 1996). However, due to this fine granulation, the level of starch damage is higher, resulting in higher cooking losses and sticky pasta when low temperature drying is applied and, hence, the use of high temperatures during drying (Dexter and Marchylo 2000). Under these conditions, cooking losses are comparable to those of pastas produced with conventional extrusion techniques (Seiler 1996).

The present study is part of ongoing research to gain insight into the factors affecting endoxylanase activities during pasta processing and the influence of these enzymes on the (drying) process and resulting pasta quality. Previous work showed that endoxylanases have an impact on the rheological properties of pasta doughs (Ingelbrecht et al 2000). The maximal consistency (Ingelbrecht et al 2000) and the extrusion pressure measured at the die (Ingelbrecht et al 2001) are significantly reduced when endoxylanases are added during dough mixing. A reduction of the total water content of the dough recovers the maximal consistency of the Control doughs prepared without endoxylanases (Ingelbrecht et al 2000). The combined use of endoxylanases and lower water levels may, therefore, result in extruding pasta doughs with lower moisture levels and probably shorter drying times. This is relevant because the drying process is the most time-consuming stage of pasta production.

The aim of this study was to investigate whether the effect of endoxylanases in conventional pasta processing also appear with Polymatik technology, which is characterized by very short mixing times. To that end, pasta was produced at a semi-industrial scale with the Polymatik press developed at the Canadian International Grains Institute (CIGI, Winnipeg, Canada).

MATERIALS AND METHODS

Durum wheat AC Avonlea semolina (harvest 2000; <150 μm) was obtained from CIGI and the moisture content was 13.8% (db) (Approved Method 44-15A, AACC 2000), ash content was 0.8% (Approved Method 08-01), and protein content was 12.7% (Approved Method 46-11A).

Endoxylanases (0.4 Somogyi units/g of semolina, further expressed as units) from *Bacillus subtilis* (Puratos NV, Groot-Bijgaarden, Belgium) were added by premixing semolina and endoxylanase powder before water addition.

Pasta was produced from AC Avonlea semolina with a Polymatik press (Bühler Ltd, Uzwil, Switzerland) at 45°C and subsequently dried at 85°C (Fig. 1) in a Turbothermatik batch dryer (Bühler Ltd.). This dryer was equipped with an internal balance making an easy monitoring of the weight of the pasta samples possible. All samples were produced with 50 kg of semolina as starting material. A Control sample (Control) and a sample with endoxylanase addition (Control+endoxylanase) were produced with flows of 100.0 kg of semolina/hr and 25.0 L of water/hr. Another sample with endoxylanase addition was produced with reduced moisture (RM+endoxylanase) so that the resulting pasta dough yielded the same extrusion pressure as the Control sample. Samples were stored at 22°C for at least two days before analysis.

Dried pastas (20.0 g) were boiled in ethanol (95%, under reflux) for 2 hr. After cooling, the ethanol was removed by vacuum rotary evaporation (45°C) and the material was air-dried. It was then crushed with mortar and pestle until it passed a 250-μm sieve and is hereafter referred to as inactivated pasta.

For the determination of the water-extractable and total carbohydrates in inactivated pasta as well as cooking losses, we used procedures of K. Brijs et al (*unpublished*). The optimal cooking time (T) was defined as that needed to gelatinize starch at the center of the pasta strands (Abécassis et al 1994).

International colorimetric indices L^*, a^*, and b^* were determined on the dry, uncooked pasta with a colorimeter (CM-525i, Minolta, Mississauga, ON, Canada) as in Abécassis et al (1994). Brightness was expressed as L^*, red index as a^*, and the yellow index as b^*. Indices were determined at least in triplicate.

Pasta (15 strands of 15 cm) was cooked to optimal cooking time (T) and (T+11) in 2.0 L of deionized water containing 1.0 g of NaCl. After 5 min of cooling, elastic moduli (g/mm) and maximal breaking strengths (g) and distances (mm) were determined with a texture analyzer (TA-XT2i, Stable Micro Systems, Surrey, UK) using the spaghetti-noodle tensile rig A/SPR. The initial distance between the probes (0.5 mm) was gradually increased to 100 mm

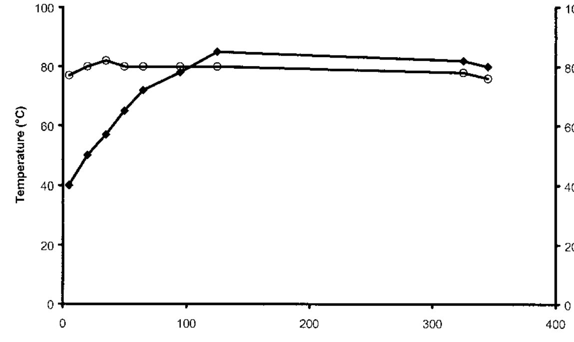

Fig. 1. Drying cycle used for pasta production: relative humidity (%) (○) and temperature (◆) as a function of process time.

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with a speed of 3 mm/sec. The elastic modulus (Hookean modulus) was recorded as the gradient (g/mm) in the linear region between trigger forces of 5 and 10 g. Analysis of the 15 strands was performed in duplicate.

Statistical Analysis

Data were analyzed using the ANOVA procedure of SAS system for Windows 8.1 (SAS Institute, Cary NC). Tukey's Studentized range test was used to determine significant differences.

RESULTS AND DISCUSSION

Pasta Production and Evolution of Moisture Contents During Drying

The extrusion pressures of the Control and Control+endoxylanase sample doughs during pasta production were 8.5 and 7.5 MPa, respectively. A water flow of 22.5 L/hr in the presence of endoxylanase (RM+endoxylanase) yielded an extrusion pressure of 8.4 MPa which was comparable to that of the Control. Similar results were obtained producing pasta doughs in a conventional experimental process (Ingelbrecht et al 2001; Brijs et al 2002), indicating that endoxylanases indeed have an impact in the Polymatik presses, although the mixing time is extremely short (30 sec).

During the initial stages of pasta drying (Fig. 2), important differences in drying behavior were detected. Pasta drying is a dynamic process involving heat and water transfer. Drying rates of both the Control+endoxylanase and the RM+endoxylanase pastas were very similar during the first period of drying (0–75 min), whereas the drying rate of the Control sample was much higher during this stage. It can be reasoned that water transfer during drying is not favored by increased viscosity of the inner part of the extruded pasta due to the transformation of the water-unextractable AX (WU-AX) to solubilized AX (S-AX). This is especially true for the endoxylanase used in this work (Courtin and Delcour 2001).

Quality Characteristics of Pasta Samples

Stress reactions inside the pasta strand due to poor water transfer and drying behavior could cause checking (i.e., formation of hairline cracks in the product). Checking was only observed when drying the Control+endoxylanase pasta and not with the RM+endoxylanase and the Control pasta samples. The use of less water for pastas produced with the same level of endoxylanase has a serious effect on the level of checking after drying. The initial lower water level of the RM+endoxylanase sample compared with the Control+endoxylanase sample was possibly under the critical level to cause checking.

A small negative influence was noted in the *a** value for Control +endoxylanase and RM+endoxylanase pasta samples (Table I). This is logically explained by the occurrence of Maillard reactions. The other colorimetric indices (*L** and *b**) remained relatively constant for all samples.

Carbohydrate Contents and Cooking Losses

Addition of endoxylanases during pasta production transformed WU-AX into S-AX, increasing the level of WE-AX (Table II). Of total AX (WE-AX and WU-AX), 29 and 82% were water-extractable for the Control pasta and for both pastas produced with endoxylanases, respectively, yielding a solubilization degree of 53%. These values are in accordance with those found in conventional pasta production with similar endoxylanase dosages, indicating that mixing and extruding with the Polymatik system (taking into account that smaller semolina granulations are necessary and other drying schemes were used) does not hinder endoxylanase activity.

Cooking quality in terms of elastic moduli (*E*), maximal forces (*F*) exerted and maximal distances obtained just before breakage of the cooked pasta strands remained relatively constant. However, for the sample RM+endoxylanase, a significantly higher value for *F* was noted (Table I). All pastas samples yielded an optimal cooking time of 11 min.

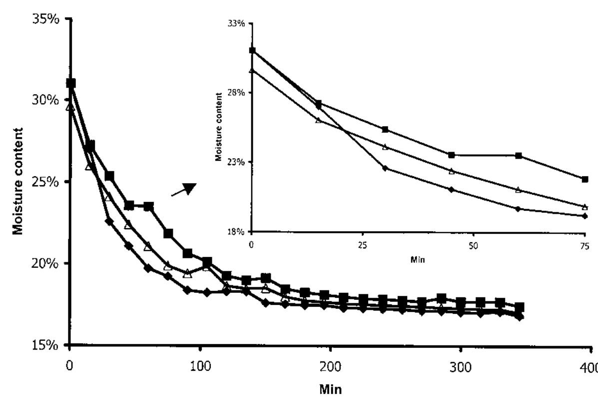

Fig. 2. Evolution of moisture contents of pasta during pasta production (Control ◆, Control+endoxylanase ■, RM+endoxylanase Δ). RM = reduced moisture.

TABLE I
Colorimetric Indices and Cooking Quality Characteristics of Pasta Samples[a]

	Dry Pasta			Cooked Pasta		
	*L**	*a**	*b**	*E* (g/mm)	*F* (g)	*D* (mm)
Control	72.4a	1.9a	59.7a	5.5a	45.2a	22.8a
Control+endoxylanase	71.9a	3.0b	59.8a	4.9a	42.9a	29.6a
RM+endoxylanase	71.6a	3.2b	60.1a	5.0a	48.6b	30.2a

[a] *L** brightness, *a** red, and *b** yellow. Control and Control+endoxylanase samples produced with 25.0 L of water/hr, while RM+endoxylanase was produced with 22.5 L of water/hr. Elastic moduli (*E*, g/mm; slope of initial linear part), maximal forces (*F*, g) exerted, and maximal distances (*D*, mm) obtained just before breakage of pasta strands at optimal cooking time (11 min). RM = reduced moisture. Values followed by the same letter are not significantly different ($P < 0.05$).

TABLE II
Composition and Cooking Loss of Inactivated Pasta Samples

	Composition[a] (%, db)			Cooking Loss[b] (%, db)		
Sample	TOT-AX	WE-AX+S-AX	AG	TOT-AX	AG	DM
Control	1.77	0.51	0.30	0.5	29.9	8.6
Control+endoxylanase	1.77	1.44	0.30	6.1	49.9	15.9
RM+endoxylanase	1.77	1.45	0.29	3.3	31.6	8.2
Max. coefficient of variation	6%	5%	7%	8%	6%	9%

[a] Total arabinoxylans (TOT-AX); water-extractable arabinoxylans (WE-AX); solubilized arabinoxylans (S-AX), and arabinogalactans (AG); dry matter (DM); reduced moisture (RM).
[b] Leached out at optimal cooking time (11 min).

Similar cooking losses (at optimal cooking time) were recorded for the Control and RM+endoxylanase pasta (Table II). These losses were higher for the Control+endoxylanase pasta, which can be explained by the checking phenomena seen for this pasta. Similar observations were made for AG (Table II).

Although AX were relatively well retained during the cooking process (Table II), the losses of AX were influenced by the direct impact of the endoxylanase addition (drastic transformation of WU- AX to S-AX and decrease of molecular weights of WE-AX and S-AX [results not shown]) and by the indirect impact (checking phenomena).

CONCLUSIONS

It was clear from increased AX-solubilization and reduced extrusion pressure, that endoxylanase activity is not hindered by the use of the Polymatik technology, characterized by a short mixing time, for pasta dough production. Using endoxylanases, moisture content of the pasta doughs can be lowered and this seems to be critical for checking. Color and cooking quality were influenced by the use of endoxylanases.

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