LWT - Food Science and Technology 77 (2017) 1–7

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Quality attributes of whole-wheat flour tortillas with sprouted whole-wheat flour substitution

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ARTICLE INFO

Article history:
Received 31 August 2016
Received in revised form
29 October 2016
Accepted 8 November 2016
Available online 11 November 2016

Keywords:
Sprouting
Whole-wheat flour
Tortilla quality
Sensory

ABSTRACT

Sprouted whole-grain foods are an emerging trend in the food market due to consumers' desire for health-promoting foods. The objectives of this study were to examine the rheological properties of whole-wheat flour (WWF) with sprouted WWF substitution (0, 25, 50, 75 and 100 g/100 g) and tortilla products made from it. Flour samples were analyzed for gluten index, color, solvent retention capacity, and Mixolab parameters, while tortillas were analyzed for weight, diameter, color, opacity, texture, rollability, and sensory attributes. Mixolab data showed that water absorption, dough development, and stability times decreased with an increase of sprouted WWF substitution. In terms of tortilla baking performance, tortillas made with higher amounts of sprouted WWF were larger in diameter and specific volume, brighter, and more opaque, and received higher sensory scores in color, flavor, and overall acceptability. For texture parameters, tortillas made with a higher percent of sprouted WWF required less force to break, which indicated that tortillas were less firm. After 16 d of storage, tortillas made with higher amounts of sprouted WWF were more rollable and shelf-stable. The results demonstrated that sprouted WWF could bring benefits to WWF tortilla's baking performance, i.e. better appearance, higher consumer acceptability, and longer shelf life.

1. Introduction

Consumers, especially health-conscious consumers, are looking for more whole-grain choices in the market. One innovative choice is sprouted grains, which are becoming more mainstream. According to AACC International, "Malted or sprouted grains containing all of the original bran, germ, and endosperm shall be considered whole grains as long as sprout growth does not exceed kernel length and nutrient values have not diminished. These grains should be labeled as malted or sprouted whole grain" (AACC International, 2008). The production of sprouted grains consists of three major steps: steeping, germination, and kilning (Hübner & Arendt, 2013; Richter, Christiansen, & Guo, 2014). Carefully selected wheat grains are soaked in water under precise and controlled conditions of time and temperature. The wheat grain germinates, or sprouts, via circulating humid air to control growth. In the kilning step, warm air is circulated through the wheat grain to dry and develop flavor and color. The sprouted wheat can then be milled into whole-wheat flour (WWF). Controlled sprouting is a less expensive and more efficient method to improve nutrient profiles of grains. Studies have reported that sprouting not only significantly increased antioxidant activity (Hung, Hatcher, & Barker, 2011), vitamin C, E, β-carotene, minerals (i.e. Cu, Fe, K, and Zn), and folate content (Koehler, Hartmann, Wieser, & Rychlik, 2007; Plaza, De Ancos, & Cano, 2003; Yang, Basu, & Ooraikul, 2001) but also reduced antinutrients, such as phytic acid, which might result in greater bioavailability of nutrients (Azeke, Egielewa, Eigbogbo, & Ihimire, 2011). Therefore, incorporating sprouted WWF into grain products meets the desires of health conscious consumers for more whole grain options, along with the added nutritional benefits.

As to baking performance, several studies have shown that less controlled sprouting, such as pre-harvest sprouting or over sprouting, adversely affected wheat product baking and yielded bread with sticky dough and inferior texture (Ariyama & Khan, 1990; Every & Ross, 1996). However, a recent study demonstrated that whole-wheat bread made from 100 g/100 g controlled sprouted WWF had an increased loaf volume, decreased proof time,

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http://dx.doi.org/10.1016/j.lwt.2016.11.017
0023-6438/

and less bitterness compared to bread made with non-sprouted control flour (Richter et al., 2014). In the case of producing WWF pasta, sprouting lowered water absorption capacity and cooking water free starch but increased plasticity and elasticity of cooked pasta (Shneider, Moiseeva, & Moiseev, 2009).

Tortillas are more popular than other types of ethnic breads in the US, and this segment of the market continues to grow (Perez-Carrillo, Chew-Guevara, Heredia-Olea, Chuck-Hernández, & Serna-Saldivar, 2015). As whole-wheat bread becomes more acceptable to consumers, other whole-wheat products, such as tortillas, require additional efforts to maintain and/or improve consumer acceptance and repeat purchase. To the best of our knowledge, the impact of sprouted WWF on tortilla baking performance has not been reported elsewhere. The objectives of this study were to examine the rheological properties of WWF blends with sprouted WWF substitution at 0 g/100 g, 25 g/100 g, 50 g/100 g, 75 g/100 g, and 100 g/100 g, and baking performance of tortillas made from them.

2. Materials and methods

2.1. Materials

Commercial sprouted hard white spring WWF and regular hard white spring WWF were kindly provided by an American milling company. The median particle sizes of the original sprouted WWF and regular WWF were 136.56 and 98.94 μm, respectively. In order to minimize the particle size impact on dough properties and tortilla baking performance, the original sprouted WWF was sifted to pass through a 95-μm screen. The fractions above the 95-μm screen were further ground 2 times using a Perten 3100 laboratory mill (Perten Instruments, Hägersten, Sweden) equipped with a 0.6-mm metal mesh screen and blended with other fractions to obtain a similar median particle size to regular WWF (Table 1). Sodium bicarbonate (powder ACS) was purchased from ChemProducts (Portland, OR), and sodium aluminum phosphate (SALP) was provided by ICL Food Specialties (St. Louis, MO). Salt, Crisco vegetable shortening, and sugar were purchased from a local supermarket (Portland, OR). Sodium stearoyl lactylate (SSL) was available through Corbion (Kansas City, KS). Potassium sorbate and calcium propionate were obtained from Muhlenchemie GmbH & Co KG (Ahrensburg, Germany).

2.2. Flour analysis

The mass ratios of sprouted WWF to regular WWF blends were 0:100 (control), 25:75, 50:50, 75:25, and 100:0, respectively. Protein (AACCI 46–30.01), moisture (AACCI 44–15.02), ash (AACCI 08–01.01), damaged starch (AACCI 76–30.02), wet gluten and gluten index (AACCI 38–12.02), falling number (AACCI 56–81.03), and color (AACCI 14–30.01) of five flour blends were determined according to the AACC International Approved Methods (AACC International, 2010). The thermomechanical characteristics of each flour blend were measured using the Mixolab analyzer (Chopin Technologies, Villeneuve-La-Garenne, France) (AACCI 54–60.01). The parameters obtained from the Mixolab included the percent of water required for the dough to produce a torque of 1.1 ± 0.05 Nm (water absorption, g/100 g), the time to reach the maximum torque at 30 °C (dough development time, min), the elapsed time that the torque was maintained at 1.1 Nm (stability, min), protein weakening (C2, Nm), starch gelatinization (C3, Nm), stability of the hot-formed gel (C3–C4, Nm), and starch retrogradation during the cooling phase (C5, Nm) (Huang et al., 2010). In addition, the solvent retention capacity (SRC) values of flour blends were determined according to the AACCI Method 56–11.02, with four solvents as lactic acid SRC (LA-SRC), sodium carbonate SRC (SC-SRC), sucrose SRC (Suc-SRC), and water SRC (W-SRC). Gluten performance index (GPI), which was defined as GPI = LA-SRC/(SC-SRC + Suc-SRC), was also calculated (Kweon, Slade, & Levine, 2011).

2.3. Tortilla preparation

2.3.1. Formulation

Ingredients included flour (1000 g), salt (15 g), sugar (5 g), shortening (70 g), sodium aluminum phosphate (SALP, 10 g), sodium bicarbonate (10 g), sodium stearoyl lactylate (SSL, 5 g), potassium sorbate (4 g), calcium propionate (5 g), and water. All ingredients were scaled on the basis of 1000-g flour weight. Different amounts of water for each flour blend was added based on the water absorption data from the Mixolab and dough handling properties.

2.3.2. Process

The tortillas were produced on pilot-scale tortilla plant equipment at the Wheat Marketing Center (Portland, OR). The ingredients were weighed and added to a Hobart Mixer (Model A-120, Hobart MFG. Co, Troy, OH) equipped with a spiral mixing head to mix for 4 min at the 1st speed and 2–4 min at the 2nd speed until the dough fully developed. Ice water was used to obtain a desired dough temperature of 29–30 °C. Tortillas were processed according to the procedures described by Liu, Hou, Book, and Marquart (2016). Freshly baked tortillas were cooled on a metal rack for 5 min, packed into Ziploc bags, and stored at room temperature.

Table 1
Flour analysis of whole-wheat flour (WWF) blends substituted by sprouted WWF.[a,b]

Flour properties	Sprouted WWF substitution (g/100 g)				
	0 (control)	25	50	75	100
Moisture (g/100 g)	8.70 ± 0.01a	9.02 ± 0.04b	9.48 ± 0.05c	9.76 ± 0.06d	10.12 ± 0.03e
Protein (g/100 g)[c]	12.23 ± 0.13a	12.29 ± 0.06a	12.55 ± 0.05b	12.71 ± 0.11bc	12.91 ± 0.02c
Ash (g/100 g)[c]	1.55 ± 0.00c	1.53 ± 0.01bc	1.53 ± 0.00b	1.52 ± 0.01b	1.50 ± 0.01a
Falling number (s)	416.0 ± 2.8e	406.0 ± 5.7d	349.5 ± 2.1c	300.0 ± 2.8b	266.0 ± 5.7a
Wet gluten (g/100g)[c]	22.65 ± 0.33a	23.82 ± 0.27b	28.41 ± 0.54c	29.11 ± 0.07d	30.67 ± 0.07e
Gluten index	93.7 ± 2.0d	90.0 ± 0.2c	87.9 ± 0.1b	85.9 ± 0.2b	80.9 ± 1.0a
Damaged starch (g/100 g)[c]	4.52 ± 0.02e	4.28 ± 0.01d	3.95 ± 0.04c	3.64 ± 0.01b	3.32 ± 0.02a
Particle size (μm)	98.94 ± 0.64d	96.92 ± 0.24c	94.99 ± 1.12b	94.65 ± 0.48b	93.03 ± 0.05a
Color (L*)	83.63 ± 0.10a	83.94 ± 0.04b	84.50 ± 0.20c	84.97 ± 0.04d	85.39 ± 0.02e
Color (a*)	−0.18 ± 0.01d	−0.20 ± 0.00bc	−0.21 ± 0.01b	−0.24 ± 0.01a	−0.25 ± 0.01a
Color (b*)	11.99 ± 0.09e	11.55 ± 0.02d	10.87 ± 0.10c	10.3 ± 0.02b	9.67 ± 0.06a

[a] L*, lightness; a*, redness-greenness; b*, yellowness-blueness.
[b] Results are shown as means ± standard devitions (n = 3). Means in the same row followed by different online letters are significantly different at $P < 0.05$.
[c] 14 g/100 g moisture basis.