LWT - Food Science and Technology 74 (2016) 106–113

Contents lists available at ScienceDirect

LWT - Food Science and Technology

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

Effect of jet milled whole wheat flour in biscuits properties

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ARTICLE INFO

Article history:
Received 9 February 2016
Received in revised form
11 July 2016
Accepted 12 July 2016
Available online 14 July 2016

Keywords:
Biscuit
Jet mill
Whole wheat flour
Particle size

ABSTRACT

There is a great interest of improving the quality of whole wheat products. In our study whole wheat flour (WWF) was micronized substituting biscuit flour (BF) at different levels. Four micronized flours (JMWWF), of particle sizes ranged from d_{50}:53.49 μm to d_{50}:17.02 μm, were produced in different milling conditions. The water holding capacity (WHC) of the fine whole flour increased up to 9%. However, the viscosity of the produced batter was up to 8 fold greater than that of the control, negatively correlated with the particle size of JMWWF. Consequently, the produced biscuits became very hard as flour particle size decreased and substitution level increased, suggesting that the intense milling resulted in detachment of wheat compounds and enhancement of the interactions among different ingredients in baking process. Biscuits' snap force was further positively correlated with moisture, but negatively to spread factor (SF) and lightness. Biscuits prepared with WWF showed the strongest decrease (23%) in SF when substitution level increased from 18.5 to 100%. A reduced SF and a high density was noticed in all samples at 80% and 100% substitution level. Biscuits with 50% JMWWF had good sensory attributes. Higher substitution levels are not recommended.

1. Introduction

The majority of the consumers prefer products of refined white flour to whole wheat products, because they perceive that the textural properties, the appearance and the taste of whole grain products are less attractive (Boz & Karaoğlu, 2013). However, for health reasons a significantly higher daily consumption of whole grain products is desired. Whole grains provide dietary fiber, minerals, water- and fat-soluble vitamins, phenolics, and antioxidants (Weaver, 2001). The best way to stimulate the consumption of whole grain products is by improving their perceived attractiveness.

Jet milling is an alternative process to reduce flour particle size. It is a fluid energy impact-milling technique which is commonly used to produce particle sizes less than 40 μm (Chamayou & Dodds, 2007) and has a noticeable effect on the characteristics of wheat flour, such as the increase of water holding capacity (WHC), of lightness and G′ values under heating (Protonotariou, Drakos, Evageliou, Ritzoulis, & Mandala, 2014).

Short-dough biscuit is a popular product, which is characterized by a simple system, consisting of three main ingredients (flour, sugar and fat) distinguished from other biscuits in that it is not coherent under tension and breaks easily (Baltsavias, Jurgens, & van Vliet, 1997).

In a typical "digestive" type biscuit the amount of whole meal flour is 22% on a flour basis (Chamayou & Dodds, 2007). The degree of the substitution could increase by adding microparticulated flour, avoiding a gritty texture or low incorporation capability in the mix.

Until now, many researchers have focused on the influence of fiber enrich on biscuits' quality. Vratanina and Zabik (1978) studied the feasibility of producing high fiber cookies. Bran did not significantly affect the texture but reduced spread, darkened the color and produced a less crisp cookie. Sensory data revealed that at levels of 10 and 20% substitution, bran affected only surface and interior color. Similarly, Gujral, Mehta, Samra, and Goyal (2003) studied the effect of replacing wheat flour with wheat bran (0–10%) and coarse wheat flour (0–20%) on cookies' quality. Wheat bran increased dough cohesiveness and adhesiveness, lowered the spread factor and increased the fracture strength. Moreover, increasing levels of wheat bran lowered the overall acceptability of cookies in sensory evaluation. On the contrary, coarse wheat flour improved all cookies' characteristics including the sensory scores received.

According to Sudha, Vetrimani, and Leelavathi (2007) a decrease

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http://dx.doi.org/10.1016/j.lwt.2016.07.030

in spread factor upon incorporation of barley, rice and wheat bran to wheat flour was presented. Sozer, Cicerelli, Heiniö, and Poutanen (2014) produced biscuits with 5–15% coarse and fine wheat brans. Bran particle size reduction increased the hardness of biscuit that visually had a more compact structure than those with coarse bran. Moreover, sensory evaluation showed that roughness and breakdown of biscuits in the mouth was significant for the coarse bran with the highest level of bran addition. There are several research data on fiber enriched biscuits, but results might differ and substitution levels used are commonly low. There is a research gap in the effect of micronized whole wheat flours on biscuits and on its effect on their functionality at high substitution levels. A major problem associated with adding high levels of fibers in foods including confectionary goods is their negative effect on the physical and sensory properties of food products as in flavor, appearance and texture. Fine grinding of wheat bran has long been known to significantly improve dough functionality in baking (Lai, Hoseney, & Davis, 1989). It is interesting to mention that this happens partly due to an increased surface area for more rapid hydration and thus improved pliability as well as reduced ability to physically interfere with gluten stands (Awika, 2011). However, grinding of the whole wheat flour might have a different impact on the quality of the final products because protein, starch and fibers are simultaneously micronized and ingredients interactions might be favored.

In the present study the influence of jet milled whole wheat flour (JMWWF) in digestive biscuits (traditional brand of short dough biscuit) was investigated in order to increase the whole wheat flour content in this type of biscuits.

2. Materials and methods

2.1. Flours and milling

Commercial biscuit flour (BF) and whole wheat flour (WWF) was donated by the Company E.J. Papadopoulos S.A. Whole wheat flour was pulverized in a jet mill (Model 0101S Jet-O-Mizer Milling, Fluid Energy Processing and Equipment Company, Telford, Pennsylvania, USA) using four different conditions. Conditions of milling and physicochemical characteristics of WWF and jet milled flours are described in Table 1, as have been calculated in the article of Protonotariou, Mandala, and Rosell (2015).

2.2. Water holding capacity (WHC)

The water holding capacity (WHC) of the flour was determined using the centrifugal method of WHC where flour (0.5 g) was vortexed for 2 min with distilled water (5 mL) in pre-weighed tube and then centrifuged at 1000g for 30 min. The supernatant was decanted, the tube was weighed, and the absorbed water, was calculated by difference (sediment weight minus sample weight over dried sample weight × 100). Determination was carried out on triplicate.

2.3. Biscuit formula and preparation of biscuits

The basic recipe for the biscuit dough (based on 100 g of flour) was 28.3 g sugar (passing through a screen with 220 μm openings, Hellenic Sugar Industry S.A.), 12.5 g water, 35.3 g vegetable fat (nea fytini, Elais-Uniliver, Greece), 1.1 g salt and 1.3 g sodium bicarbonate. Sugar, water, vegetable fat, salt and sodium bicarbonate were creamed in a Hobart mixer (Hobart N50, Hobart Co., Troy, OH, USA) with a flat beater for 3 min at 475 rpm. Flour was added to the above cream and mixed for 3 min at 475 rpm to obtain a homogeneous cream. Dough was sheeted using a rolling pin of 7 mm thickness and were formed by a cutter of 6 cm diameter. Biscuit flour was substituted with whole wheat flour or JWWF at a range of 18.5, 30, 50, 80 and 100%. Substitutions were carried out for all flours (WWF and JMWWFs). Biscuits were baked at 190 °C for 10 min, cooled to room temperature for 30 min, packed in sealed plastic bags and kept at room conditions.

2.4. Apparent biaxial extensional viscosity of the dough

Dough samples, similar to biscuits' batter, at 100% substitution level, were prepared by sheeting portions of the dough, with a rolling pin and gauge strips of 1 cm. The sheeted doughs were cut so that the final samples were cylinders of 4 cm diameter and 1 cm height. Apparent biaxial extensional viscosity (ABEV) of the dough was measured using a Universal Testing Machine (Instron 1100, Massachusetts, USA), following the lubricated uniaxial compression method (HadiNezhad & Butler, 2009). The biscuit dough was placed on a disk and compressed with a plunger (4 cm, diameter) on 7.5 mm in a 500 N load cell at a cross-head speed of 10 mm/min. The first test was carried out 90 min after the end of mixing, and the average of three dough sample data was calculated.

The biaxial strain rate was calculated from the formula:

$$Strain\ rate = \nu/2(h_o - \nu t)$$

The apparent biaxial extensional viscosity (ABEV) of the dough was computed by the formula.

$$ABEV = 2F_t h_t \Big/ \pi R^2 \nu$$

where h_0 is the initial height of the test-piece; F_t is the compression force (N) at time t; h_t is the height of the dough sample (m) at time t; R is the initial radius (m) of the dough sample; ν is the crosshead speed (m/s).

2.5. Spread factor

After cooling for 30 min, biscuits were laid edge to edge and the width (W) of six biscuits was measured. By rotating the biscuits 90° and rearranging them, the average of six readings was calculated as biscuit width. For thickness (T) measurement, six biscuits were stacked on top of each other. By restacking them in different orders,

Table 1
Conditions of jet milling of whole wheat flour (WWF). Particle size (d_{50}) and chemical analysis data for Biscuit Flour (BF), WWF and jet milled WWFs.

Flour Abbreviation	Air pressure (bar)	Feed rate (kg/h)	Feedback	Particle size d50 (μm)	Moisture content (%)	Ash content (%, db)	Protein content (%, db)
BF	–	–	–	$67.42^b \pm 2.02$	$12.98^e \pm 0.03$	$0.58^a \pm 0.01$	$9.58^a \pm 0.05$
WWF	–	–	–	$84.15^a \pm 2.45$	$11.95^d \pm 0.00$	$1.31^b \pm 0.00$	$15.00^b \pm 0.18$
JWWF1	4	4.51	No	$53.49^c \pm 3.38$	$8.57^c \pm 0.01$	$1.31^b \pm 0.01$	$15.08^{bc} \pm 0.01$
JWWF2	8	5.18	No	$29.10^d \pm 3.09$	$7.84^b \pm 0.05$	$1.33^b \pm 0.02$	$15.22^{bc} \pm 0.09$
JWWF3	8	2.54	Yes	$17.02^e \pm 1.38$	$6.64^a \pm 0.08$	$1.33^b \pm 0.00$	$15.30^{bc} \pm 0.02$
JWWF4	8	0.67	No	$18.11^e \pm 1.73$	$6.61^a \pm 0.01$	$1.42^c \pm 0.00$	$15.51^c \pm 0.01$

The results are expressed as mean ± standard deviation. Values followed by the same letter in a column do not differ significantly ($P \leq 0.05$).