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Sensory properties and aromatic composition of baked snacks containing brewer's spent grain

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ABSTRACT

The incorporation of brewer's spent grain (BSG) into baked snacks (crispy-slices) was investigated in terms of nutritional, sensory and aromatic properties. Wheat flour was replaced with BSG at the levels of 10, 15 and 25%. Snacks containing 10% BSG exhibited high Crispiness index (C*i*), low Crispiness work (*Wc*) and a high number of peaks during texture analysis, indicating that the crispiness of the samples was not negatively affected. However higher levels of BSG affected the texture and the crumb structure of snacks and the results were significantly different to the 100% wheat control. Addition of BSG altered the odour profile of the snacks as shown by the volatile profiles, however sensory results indicated that BSG-containing snacks at a level of 10% were highly acceptable and highlighted the possibility of using BSG as a baking ingredient in the formulation of enhanced fibre baked snacks.

1. Introduction

By-products of plant food processing have attracted much attention for their functionality and potential as food ingredients in recent times (Stojceska et al., 2008a; Sudha et al., 2007). Such by-products, although considered agricultural waste, are rich in fibre and bioactive compounds, and efforts have been made to utilise them as functional ingredients and to enrich food products (Rodriguez et al., 2006). An example of such a material is brewer's spent grain (BSG), which is a by-product of the brewing industry. BSG usually contains the residues from barley, malted barley and/or other grains e.g. wheat or sorghum. It is high in dietary fibre (Mussatto et al., 2006) and protein (Santos et al., 2003) and mainly consists of the husk–pericarp–seed coat layers that covered the original barley grain. Additionally, depending on the brewing practices used, there could also be residues of starchy endosperm and walls of empty aleurone cells (Mussatto et al., 2006).

Previous work has shown the effect of BSG on the nutritional properties of baked products (Stojceska and Ainsworth, 2008) and on the quality of baked and extruded products (Stojceska et al., 2008b). The quality was affected mainly because of the high fibre content of the BSG; a decrease in volume, increase in crumb hardness, loss of crispiness, dense crumb grain structure, and reduced expansion have been reported (Ainsworth et al., 2007; Stojceska and Ainsworth, 2008). Therefore, the main issue associated with the incorporation of BSG in food products is the effect on texture and flavour.

There is limited recent information relating to the effect of the addition of BSG on the flavour and acceptability of baked products. Prentice and Dppolonia (1977) reported that breads with 5 and 10% BSG had good sensory properties and were favourably accepted by consumers; Kissell and Prentice (1979) found that BSG addition was limited to 15% before an unacceptable flavour developed in cookies. More recently (Kim et al., 2001) reported that the overall sensory score deteriorated when biscuits contained more than 15% BSG.

The aroma of baked products is a key characteristic of their quality and many studies have dealt with the analysis of bread aroma and flavour (Cho and Peterson, 2010; Poinot et al., 2008, 2007; Pozo-Bayon et al., 2006). Solid-phase microextraction (SPME) is a popular technique that has been used for analysis of the volatile aroma compounds in food products (Matsakidou et al., 2010; Poinot et al., 2007); it has advantages over more traditional methods due to its rapid sampling, low-cost and high sensitivity (Ruiz et al., 2003). SPME has been used to study the effect of different processes and formulations on the volatile profile of

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breads (Poinot et al., 2008). Identification and quantification of 46 volatile compounds was carried out, and it was shown that the aromatic profile of the breads was influenced by changes in the formulation (different amounts of yeast and water) but not by different processes (freezing and partial baking).

The aim of this work was to examine the effect of BSG incorporation on the overall sensory and nutritional properties and also acceptability of baked snacks. Sensory properties such as texture, structure and flavour were the focus of this work. With regard to flavour, the objectives were to characterise the volatile compounds of snacks containing BSG, examine how BSG alters the aromatic profile of baked snacks, and to assess how this is perceived by sensory panellists.

2. Materials and methods

2.1. Materials

Commercial wheat flour (12.7% moisture, 13.1% protein, 0.5% fat, 0.9% ash, 74.4% total starch, and 4.1% Total Dietary Fibre (TDF) was purchased locally (Odlums Bakers Flour, Odlum group, Alexandra Road, Dublin, Ireland). Dried brewer's spent grain (BSG) (5.6% moisture, 20.8% protein, 4.5% fat, 3.2% ash, 3.3% total starch, and 60.5% TDF) was obtained from the micro-brewery establishment in University College Cork, Ireland. Before drying, the BSG was pressed to reduce the water content to approximately 50%–60%. Then the BSG was vacuum dried at 80 °C for up to 60 min. The BSG was milled using a Perten Laboratory Mill 3100, Perten Instruments AB, Sweden. The majority of the BSG flour (59.5%) consisted of particles sized between 355 and 250 microns, 23.5% consisted of particles of less than 250 microns, and 17% included particles larger than 355 microns.

2.2. Crispy-slices

The production of crispy-slices comprised two stages. In the first stage, pup loaves were baked from blends containing 0% (Control −100% wheat flour), 10%, 15%, and 25% BSG (wheat flour replacement). The bread samples were prepared by mixing 600 g flour, 12 g salt (table salt purchased locally), 12 g sugar, 6 g emulsified bread fat (Irish Bakels Ltd., Dublin, Ireland), and 9 g of instant yeast (Pante instant yeast, The Puratos group, Belgium) with water as per Farinograph value in a Kenwood mixer. The Farinograph water absorption was 62.8, 64, 68 and 72% for the control, 10, 15, and 20% respectively and the mixing times were 4, 4, 4.5, and 5 min respectively. After mixing, the dough was allowed to rest for 35 min in a proofing cabinet (35 °C, 80% RH) (Koma SDCC−1P/W, Koma Koeltechnische Industrie B.V., The Netherlands), divided into 65 g pieces, moulded into shape and placed in rectangular tins (108 × 64 × 37 mm). A proofing period of 45 min followed and the loaves were then baked for 20 min at 220 °C in a deck oven (Compacta, Tom Chandley Ovens, Manchester, UK). Breads were allowed to cool for 2 h before being placed in plastic bags. The second stage consisted of slicing the loaves to 5 mm thickness using an electric slicer and drying at 150 °C for 30 min 24 h post-baking.

2.3. Compositional analysis

The moisture content of the crispy-slices from each of the four formulations was analysed according to ICC method No 110 (ICC, 1976) using a Brabender moisture oven (Brabender OHG, Duisberg, Germany). Ten samples were ground using a Kenwood blender operated for a maximum time of 20 s to minimise heating of the sample. The ground sample was sieved to pass a 1750 micron sieve. Duplicate measurements per replicate were carried out.

Ash content was measured in duplicate according to AOAC method No 923.03 (AOAC, 2000).

Total starch was measured using the Megazyme Assay procedure (K-TSTA, Megazyme, Bray, Ireland) based on AACC 76.13 and AOAC 996.11 methods.

Total dietary fibre analysis was conducted using the Fibertec System E (Foss Analytical, Slangerupgade, Denmark) according to the AOAC Method 985.29.

The protein content was determined using a nitrogen analyser (FP-328 Leco Instrument; Leco Corporation, St Joseph, Michigan, USA) based on the Dumas principle (Nx6.25).

Fat analysis was performed by acid hydrolysis following the AOAC method 922.06 (AOAC, 1990) and the modifications as described in (Alvarez-Jubete et al., 2009).

2.4. Baking quality

2.4.1. C-cell image analysis

Crumb structure was evaluated by digital image analysis. The samples were analysed using the C-Cell Bread Imaging System and C-Cell Version 2 Software (Calibre Control International LTD, UK) and information on slice features (slice area, concavity, break points etc) and cell characteristics (number of cells, cell area, wall thickness, cell diameter etc) were obtained. The results are the average of 16 measurements per sample.

2.4.2. Colour measurement

Colour measurements were carried out on ground samples using a Hunter Lab colorimeter (Hunter Lab, UltraScan XE, Reston, VA, USA). L*, a*, and b* values were recorded. The results are the average of 3 measurements per sample.

2.4.3. Texture analysis

Texture analysis of the samples was performed using a Texture Analyser (TA-XT2*i*, Stable Microsystems, Surrey, UK) equipped with Exponent software version 5.0.6.0. The HDP/BS: Blade with knife edge attachment set was used. Fifteen samples were used per replicate. Each slice was placed centrally under the knife edge on top of the slotted insert. The blade moved downwards at 1 mm/s and cut the samples. Peak force, distance and time were recorded. The force-displacement data was analysed to obtain parameters such as the area under the curve (A) (Nm), the number of peaks (No peaks), the average force of the peaks (F_{mean}) (N), the maximum force of the peaks (F_{max}) (N), the linear distance of the actual curve (Heidenreich et al., 2004.) and the ratio of the linear distance of the actual curve to the linear distance of the smoothed curve (LD/LDs), to characterise the crispiness of the samples. All of the above parameters were calculated using built-in functions of the Exponent software. These parameters were used to calculate the crispiness index (*Ci*) and crispiness work (*Wc*), as referenced by Arimi et al. (2010) using equations (1) and ((2) defined in Heidenreich et al. (2004) and Van Hecke et al. (1998).

$$Ci = \frac{L_{\text{Dnormalised}}}{A^{*}F_{\text{Mean}}} \tag{1}$$

where

$L_{\text{Dnormalised}}$ is the linear distance (LD) divided by the maximum force (F_{max})

A and F_{Mean} is the area under the curve and the average peak force respectively calculated by the Exponent software.