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Scaling down bread production for quality assessment using a breadmaker: Are results from a breadmaker representative of other breadmaking methods?

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ABSTRACT

Industrial breadmaking equipment typically processes batches of 200 kg or more of raw ingredients, while scaled down versions are widely used for research and development studies. A literature review shows that the use of domestic breadmakers has become routine to enable cheaper and more convenient small batch production of bread which facilitates assessment of new ingredients and formulations, and for other studies on bread and the breadmaking process. However, whilst recipe formulations can be scaled down, the process in a breadmaker may not be an accurate representation of industrial processes, leading to differences in aspects of bread quality and the nature and direction of ingredient effects. This short communication assesses whether breadmaker-produced bread is representative of bread produced using industrial methods, and therefore if the results of studies conducted on breadmaker-produced breads are representative of those that would be obtained on industrial equipment. A study of some quality parameters in breads made using a household breadmaker versus scaled down industrial breadmaking equipment showed an opposing trend for the relationship between sugar content and specific volume, and between sugar content and crumb firmness, in loaves made from both methods. The differing quality parameters of breadmaker-produced loaves compared to loaves produced in scaled down industrial breadmaking equipment suggested that breadmaker-produced breads can give misleading indications of likely ingredient effects at industrial scale.

1. Introduction

Bread is versatile and filling, and an affordable worldwide staple. Traditional home breadmaking involves kneading bread dough, proving it, knocking it back, and shaping the dough for a final proof before baking to transform it into bread. Household breadmakers first became available in Japan in 1987 and have become commonplace in many countries worldwide (Hironaka, 2000); they represent a major contribution this mainly rice-eating nation has made to the practice and consumption of bread (Campbell, 2002).

Household breadmakers require small quantities of ingredients, typically based on around 500 g flour, compared to industrial breadmaking and commercial test baking. For test

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bake work, which requires considerable skill and complex equipment, the attractions of producing bread in a breadmaker include the relative simplicity and uniformity of the process that can be imparted.

However, breadmaker models differ from one another in many ways such as the size and shape of their loaf tins, times and temperatures of each operation and impeller shape and mixing action. French and Perchonok (2004) investigated the breadmaking process in four different breadmakers and found significant differences in the volume and texture of the loaves produced.

Industrial breadmaking equipment typically processes batches of at least 200 kg of raw ingredients. This scale is costly and inconvenient for research and development studies. Scaled down versions of industrial equipment are widely used for these. For example, in the UK the Chorleywood bread process (CBP) is used to produce the majority of plant bread. 5 kg batches can be produced using the Tweedy 10 mixer which is a scaled down version of the mixers used in the CBP and gives loaves that are representative of that process at the industrial scale.

However, when comparing industrial breadmaking to producing bread in a breadmaker, the breadmaking process differs. Industrial CBP breadmaking begins with pressurised high speed mixing before mixing under a partial vacuum, whereas breadmakers operate at atmospheric pressure and mixing occurs at a lower speed over a longer time. In industry proving occurs at controlled temperatures and humidity, and the duration depends on the formulation. In a breadmaker only the temperature is controlled and proving times depend on the programme selected. Industrial bread loaves are baked in a steam oven. More heated air surrounds the loaves in industrial sized ovens compared to loaves in a compact breadmaker. It can therefore be expected that breadmaker-produced breads will differ to industrially-produced breads of the same formulation.

Studies of bread dough mixing and baking have shown that following the same process and maintaining geometrical similarity of mixer design are not sufficient to replicate full scale production process conditions and achieve representative bread products. Wilson et al. (1997) found that compared to doughs made in a laboratory scale mixer, doughs made in a full scale industrial mechanical dough development mixer required a greater work input for development. Martin et al. (2004) found increased aeration on scale-up when scaling-up mixing from laboratory to pilot plant scale. Sommier et al. (2011) investigated how the air and radiative temperature of the heating elements in a laboratory scale oven had to be adjusted to obtain comparable convective and thermal flux so that laboratory scale ovens would mimic industrial ovens for baked cereal products.

Bread typically contains 70–80% air by volume, contained within the gas cells in the product. These are responsible for a number of quality parameters in bread, such as the texture and brightness of the crumb, absorbance of sauces, and loaf volume. Softer products are perceived as fresher than their firm counterparts which are generally perceived as stale. Factors that determine how firm the crumb is include the density of the crumb and the quantity, volume and distribution of gas cells within the crumb. Brightness is particularly important in white bread and the whiter the bread, the higher its perceived quality. Loaf volume is often perceived by consumers as indicative of its value for money with a more aerated loaf perceived as better value. These are amongst the reasons why aeration during breadmaking is an important quality parameter and why dough voidage and cell size distribution have been widely studied. Density measurement has been used for measuring voidage due to its low cost, ease and convenience of the technique (Campbell et al., 2001; Chin et al., 2004). Additional techniques utilised for voidage measurement in breadmaking studies include ultrasound (Leroy et al., 2008 and X-ray computerised tomography (X-ray CT) (Bellido et al., 2006; Turbin-Orger et al., 2012; Trinh et al., 2013, 2015), whilst also measuring cell size distribution. Ultrasound has the disadvantage of poor resolution and small cells obscuring measurements. Microscopy has also been used to probe into the cell size distribution in bread dough (Campbell et al., 1991; Martin et al., 2004). However, microscopy is laborious in its preparation, and generates 2D images with a high probability of artefacts.

This short communication presents a literature review of the use of domestic breadmakers in the research literature. It then investigates whether using a breadmaker to assess changes in formulation is representative of industrial breadmaking processes. Bread was produced using both a breadmaker and a Tweedy-type mixer, a scaled down version of high speed industrial mixers, designed to mix approximately 0.45 kg of dough (about 1 pound, hence referred to as the Tweedy 1). Quality parameters (specific volume of the loaves, crumb firmness and cell size distribution) were assessed to determine if differences arose in the products from the two methods.

2. Literature review

A review of the use of domestic breadmakers in the research literature was conducted and is summarised in Table 1. The use of breadmakers can be split into two categories. The first is to provide a convenient means of producing small batches of consistent bread for various purposes. Campbell et al. (2003) produced bread in a breadmaker to monitor blood glucose levels following different daily regimes. Burton and Lightowler (2006) altered the structure of bread, through different formulations and by manually manipulating the proving times in a breadmaker, to assess the relationship between bread's structure and its effects on glycaemic response and satiety. Clark and Johnson (2006) added lupin kernel fibre to the formulation of several products including bread made in a breadmaker to assess panellists' hedonic responses to the nutritionally improved product, while Muir and Westcott (2000) developed and assessed a method for extracting and quantifying the health benefiting flax lignin in breadmaker-produced breads and other bakery products.

The second category is where breadmakers have been used to produce small batches of bread which have then been analysed for various quality attributes. For example, they have been used to produce doughs and breads to assess the effectiveness of new ingredients and formulations in improving quality parameters or nutritional value of wheat-based breads (Low et al., 2004; Seguchi and Abe, 2004; Loveday and Winger, 2007; Seguchi et al., 2007, 2009,2010; Curti et al., 2013; Sivam et al., 2013a,b; Hatta et al., 2015) or improving the quality of gluten-free bread so it more closely resembles gluten-containing breads (Kawamura-Konishia et al., 2013).

This review illustrates that domestic breadmakers have become routinely used in research studies. They have been shown to be a convenient way of producing a standardised