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Technological and sensory tools to characterize the consistency and performance of fibre-enriched biscuit doughs

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ABSTRACT

Demand for health-oriented bakery products with low sugar, low fat and high fibre contents is increasing. Incorporating dietary fibre in biscuit dough tends to require some increase in its hydration level depending on fibre types and contents. This correction is usually managed empirically by skilled operators or bakers. In order to improve the understanding of the impact of dietary fibre on dough processing and properties, two complementary approaches are proposed. The first is a sensory description that helps formalize the hydration correction of biscuit dough enriched in fibre. The second focuses on the prediction of biscuit dough hydration, based on the evaluation of fibre and sugar water holding capacity (WHC) with the Farinograph. A polynomial model was used to describe the Farinograph water absorption versus the powder content. The WHC was computed from data obtained with the Farinograph, and it was used in biscuit dough in order to try to predict biscuit dough hydration. This model was compared to the actual added water, evaluated by the sensory methodology. A simple relationship was found between the actual and predicted amount of water. These two approaches are tools that help the formulation of biscuits with high dietary fibre content.

1. Introduction

In the general context of weight management, the development of food products having a higher satiating power appears as an interesting alternative or a complementary answer to calorie-reduced diets or portion-size control. One possible solution to design satiating food products is to incorporate dietary fibres, especially viscous soluble ones, because it is well-established that these types of fibres have a positive impact on satiety (Slavin and Green, 2007). However these fibres generate processing issues which limit in practice their incorporation in food products. Cereal products such as biscuits, or cookies, are good candidates since they consist of concentrated suspensions in which these fibres can be dispersed. Yet the global nutritional profile of the biscuit has to be considered. Short biscuit dough usually contains a medium to high quantity of sugars and fats (Pareyt and Delcour, 2008) which provide plasticity and cohesiveness, and prevents the formation of a gluten network, unfavourable to the biscuit quality. Designing higher satiety biscuits therefore means both enriching the dough in dietary fibres and lowering sugar and fat contents, which is a difficult task when combined.

Several studies are available on the enrichment of biscuit in fibres, with different types of fibres, such as wheat bran, oat bran, rice bran, and barley bran (Ellouze-Ghorbel et al., 2010; Sudha et al., 2007), resistant starch (Laguna et al., 2011) and vegetables or fruits fibres (Ajila et al., 2008), but only with a limited dosage of soluble fibres. However, to develop a satiety product, it is essential to provide highly viscous soluble fibres such as cereal fibres (oat and barley beta-glucans) or guar gum (Kovacs et al., 2001; Turnbull and Thomas, 1995). The literature on biscuits enriched in soluble fibres such as guar gum or beta-glucan is scarce. Hydrocolloids, such as guar gum, are generally used as texturizing agents.

Highly viscous soluble fibres have a very high affinity for water. During dough mixing, they make unavailable a part of water for the dough creation, by absorbing it, and thus prevent the formation of suitable dough for subsequent forming. Fibre enrichment requires increasing the water content of the dough, impacting negatively on

Abbreviations: WHC, water holding capacity; BCS, sodium bicarbonate; BCA, ammonium bicarbonate; SAPP, sodium acid pyrophosphate.

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biscuit quality by initiating a gluten network, with an increase of biscuit hardness. It is therefore essential to determine precisely the minimal amount of water to add in order to avoid altering product quality.

It is possible to quantify the fibres affinity for water by measuring a parameter called water holding capacity (WHC). Different definitions were given in the literature, associated to specific methods. According to Robertson et al. (2000), it can be defined as the amount of water bound or retained by a known weight of fibre under defined conditions. The experimental conditions for measuring the WHC can be mainly of 2 types: a) dispersing the sample in excess water in certain conditions (time-temperature), followed by removal of the unabsorbed water using pressure, filtration or centrifugation and measurement of the water bound by gravimetry (Auffret et al., 1994; Chen et al., 1984; Mongeau and Brassard, 1982; Robertson and Eastwood, 1981; Zhang and Moore, 1997) or b) measuring the water uptake, in condition of limited water (Arrigoni et al., 1987). The water holding capacity (WHC) can thus be estimated as the amount of water released from the sample (water retention measurement) or as the amount of water absorbed or bound by the sample (water absorption measurement). In the first case, only the insoluble fibres (or with a high quantity of insoluble fibres) can be analysed (Cadden, 1987; Robertson et al., 2000), while the second method allows to take into account the impact of soluble fibres. Indeed, it is possible to classify all types of fibres, using the water absorption measured with the Farinograph, with regard to their behaviour in dough (Ajila et al., 2008; Chen et al., 1988; Zhang and Moore, 1997) or just to measure the water absorption capacity (Linlaud et al., 2009). These methods allow classification of fibres, with regard to their affinity for water.

Because of their unique water holding capacity, incorporating fibres in biscuits causes major changes in dough properties, process conditions and product quality. Formulating high-fibre-content biscuits requires going through all stages of manufacturing, from the ingredients to the finished product, going through the shaping step. In biscuit making, this is done by lamination, rotary moulding, wire-cutting, extrusion etc. Fibre incorporation in rotary dough causes technical hurdles to dough processability, which can be defined as the capacity of the dough to be moulded with a good yield. Therefore, the challenge of producing biscuits with high fibre content is to overcome issues regarding the manufacturing process, with a focus on moulding. The texture of the biscuit dough governs its ability to be shaped. The texture is largely linked to the hydration of the dough but not only that. In the case of moulded dough, the adjustment of the dough texture through its hydration is empirical and poorly formalized. The assessment of handling properties during shaping (sheeting and moulding) is generally made by the baker or operator. The usefulness of the assessment depends on the operator aptitude in evaluating the dough texture and in correcting it to reach “target behaviour”. These formulation steps require turning observations into appropriate descriptive terms, called sensory descriptors. The lack of existing methods to describe and quantify dough behaviour is a practical issue, making biscuit reformulation tedious and time-consuming. Most studies have focused on the analytical characterisation of dough behaviour, using empirical rheological tools like a Farinograph but without providing links with the technological behaviour experienced by the baker. Kilborn and Preston (1982) developed an apparatus to measure dough sheeting and moulding properties but they did not establish links with the operators’ terms. A test was developed 20 years ago by a French cereal technical center (CTUC) as a help to formulate laminated dough (Benoualid, 1987; Branlard et al., 1985; Tharrault, 1994). The objective of the test is to assess flour functionality in laminated dough, based on analytical characterisation (dough rheology and final product properties). A French specification on bread, AFNOR NF V03-716, based on a sensory description, assesses the quality of raw materials and processed products. Today there is no existing methodology for rotary moulded dough and the vocabulary used to describe the structure and texture of these materials is relatively limited. Thus, a sensory tool including a list of descriptors estimated during dough mixing was developed to help formulating high-fibre-content biscuits.

Moreover, the understanding of the level of hydration required to obtain processable dough is still poorly understood. As far as we know, there is no method that links the water holding capacity (WHC) of ingredients with biscuit dough technological behaviour. This lack has motivated the present study. The water holding capacity (WHC) of these ingredients was measured using the Farinograph water absorption and used to establish a predictive model of the biscuit dough hydration. The prediction model of the biscuit dough hydration was then compared to the sensory prediction and discussed.

2. Experimental

2.1. Materials

All the ingredients used in biscuits were provided by Mondelēz International (Biscuit R&D Centre, Saclay, France). Sugar, canola oil (rapeseed oil), wheat flour, salt, leavening powders such as sodium bicarbonate (BCS), ammonium bicarbonate (BCA) and sodium acid pyrophosphate (SAPP), and an emulsifier, soy lecithin were used in biscuit dough. Different sources of fibres were used, such as oat bran (OatWell® 22, CreaNutrition), barley bran (Barley Balance™,PolyCell Technologies), a concentrate of beta-glucan soluble fibre derived from whole grain barley (Barlív™ barley betafibre, Cargill) and guar gum (guar gum powder, Hindustan Gum). Oat bran, barley bran, barley concentrate of beta-glucan and guar gum contained, on a wet basis, respectively 44.0%, 44.1%, 71.2% and 77.9% of total fibres (with respectively 21.6%, 27.4%, 70.8% and 66.9% of soluble fibres and 22.4%, 16.7%, 0.4% and 11% of insoluble fibres). They also contained respectively 24.4%, 23.8%, 19.8% and 2.9% of carbohydrates (with sugars content below 1.5%); 4%, 3.6%, 0.1% and 0.6% of lipids; 20%, 17.2%, 2.2% and 4.2% of proteins and 5.3%, 9.2%, 4.4% and 13.9% of water. The rest was ash.

2.2. Biscuit dough preparation

2.2.1. Biscuit dough preparation for sensory dough evaluation

In these recipes, all fibre ingredients were used. Canola oil and sucrose were added in order to provide respectively 15 g/100 g of fats and 15 g/100 g of sugars in the finished biscuits after baking (also taking into account the fat and sugar contents of all ingredients). The fibre ingredients were added in replacement of flour, so that the total content of fibre and flour was constant (70 g/100 g of finished product). The dough containing fibres were prepared using the following method. Emulsifiers were dispersed in fats by heating in a microwave oven up to a temperature of 60 °C. Fibres were then added to the fat-emulsifier blend with a flat beater paddle for 5 min in a mixer VMI phebus 10 L capacity, at speed 2 (60 rpm). Mixing fibres with fat was intended to try to limit the water absorption of the fibres, by coating them. Ammonium bicarbonate and sugar were dissolved in water. The rest of the powders (flour, baking powder (BCS + SAPP) and salt) were added into the mixer. The sugar solution was transferred into the mixer and the contents were mixed for 4 min at 40 rpm. A slightly different process was used in recipes without fibres. In this case, the sugar was not dissolved in water but it was added to the first stage with the fat, instead of fibres. At the end of the kneading process,