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Effect of salt reduction on wheat-dough properties and quality characteristics of puff pastry with full and reduced fat content

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ABSTRACT

Puff pastry is a major contributor of fat and sodium intake in many countries. The objective of this research was to determine the impact of salt (0–8.4 g/100 g flour) on the structure and quality characteristics of puff pastry with full and reduced (−40%) fat content as well as the rheological properties of the resulting dough. Therefore, empirical rheological tests were carried out including dough extensibility, dough stickiness and GlutoPeak test. The quality of the puff pastry was characterized with the VolScan, Texture Analyzer and C-Cell. NaCl reduction significantly changed rheological properties of the basic dough as well as a number of major quality characteristics of the puff pastry. Significant differences due to NaCl addition were found in particular for dough resistance, dough stickiness, Peak Maximum Time and Maximum Torque ($p < 0.05$). Peak firmness and total firmness decreased significantly ($p < 0.05$) with increasing salt levels for puff pastry containing full fat. Likewise, maximal lift, specific volume, number of cells and slice brightness increased with increasing NaCl at both fat levels. Although a sensorial comparison of puff pastries revealed that salt reduction (30%) was perceptible, no significant differences were found for all other investigated attributes. Nevertheless, a reduction of 30% salt and 40% fat in puff pastry is achievable as neither the perception and visual impression nor attributes such as volume, firmness and flavour of the final products were significantly affected.

1. Introduction

Puff pastry, well known for its light and flaky texture, is a laminated dough, which is leavened without the use of yeast or any rising agents (Cauvain & Young, 2001). Puff pastry consists of the basic dough and a fat phase. Through a series of folds and sheeting of the pastry many thin fat and dough layers are obtained (Anonymus, 2000a). During baking the dough layers separate from each other as the pastry rises (Ghotra, Dyal, & Narine, 2002). Traditionally wheat dough is used for puff pastry production. Butter, margarines or various fat blends act as roll-in fat, which is important for the layering effect, flavour, flaky structure, texture, appearance, volume and lift (Boode-Boissevain & Van Houdt-Moree, 1996).

Sodium chloride (NaCl, or more commonly, salt) has been traditionally used in the production of baked goods since it positively influences several technological, rheological and sensory parameters. Generally, salt aids the workability of the dough during puff pastry production. It increases the mixing tolerance of doughs and also appears to have a beneficial effect on strengthening the gluten network and therefore increases the dough stability and flexibility (Kaur, Bala, Singh, & Rehal, 2011). Among others, this strengthening effect improves the gas retention properties of the puff pastry dough, which is important for steam retention during the baking process, leading to good pastry lift and volume. Salt also decreases stickiness and water absorption of the dough (Beck, Jekle, & Becker, 2012a). Therefore, decreasing NaCl concentration may induce less desirable properties such as stickier, difficult to process dough, and a lack of stability and lower resistance and extensibility will lead to products with poor quality. Furthermore, salt is responsible for the perception of 'saltiness', while it increases that of sweetness, decreases bitterness and enhances other flavours in food systems (Liem, Miremadi, & Keast, 2011). In additional, salt acts as a preservative in bakery goods by lowering the water activity and inhibiting microorganisms (Naidu, 2000).

High sodium intake is a leading cause of cardiovascular diseases and hypertension and has also been linked to an increased risk of stroke, stomach cancer, kidney disease and bone demineralization (Wardener & MacGregor, 2002). The effect of sodium on hypertension is dose dependent; the more sodium consumed, the greater the increase in blood pressure (Panel on Dietary Reference Intakes for Electrolytes and Water, 2005). Since these health issues came into focus, numerous national and international organisations have introduced recommendations and actions for the lowering of sodium chloride levels in foods. Processed foods account for about 70–75% of sodium intake (EFSA Scientific Panel on Dietetic Products, 2005) in western diets with up to

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35% of the daily sodium intake originating from cereal products (Angus, 2007). Among others, the World Health Organisation (WHO) and European Union (EU) have recommended cooperation with the food industry to encourage a reduction in sodium content in products to their lowest feasible level, including a target of reducing mean population NaCl intake by 30% to ≤5 g/day by 2025 (World Health Organization [WHO], 2013). Therefore, the main strategy to decrease the sodium intake is to lower the salt content in food products.

However, to date no studies regarding the effects of salt reduction on the structure and quality characteristics of puff pastry with full and/or reduced fat content have been published. Puff pastry contains approximately 1.0–1.2% NaCl (The French Information Center on Food Quality [CIQUAL], 2012). The aim of the present study was to evaluate the effects of various NaCl concentrations (0–84 g/kg flour) on the quality of puff pastry with full and reduced (−40%) fat content, including change in lift, volume and firmness of the baked puff pastries. Starting from a salt content of 21 g/kg flour (Control) all calculation were based on EU regulation (EC) No 1924/2006 "nutrition and health claims made on foods" and its Annex (European Commission (EC), 2006). Furthermore, a relationship between puff pastry quality parameters and empirical wheat dough properties, such as stickiness, resistance to extension and Peak Maximum Time was determined.

2. Materials and methods

2.1. Materials

In this study wheat flour (Grand Moulins de Paris, France, type T45 (45 mg ash/10 g flour), moisture 13.5%, Protein 11.5%), salt (Glacia British Salt Limited, UK), commercially available lemon juice (Tesco, Ireland), food grade ethanol (85%, (v/v), France Alcools, France) and tap water were used for the basic dough. A vegetable fat blend of 69% palm stearin and 31% rapeseed oil (s.a. Aigremont n.v., Awirs-Flemalle, Belgium) was used as roll-in fat.

2.2. Salt levels

In total, twelve puff pastry recipes with different salt (Table 1) and fat levels were prepared for the present study. The puff pastry dough used as Control contained 21 g salt and 740 g roll-in fat based on 1000 g flour. All calculations for salt levels in this study were based on the Control and on EU regulation 1924/2006 and its appendix (European Commission (EC), 2006). In the appendix of EU regulation 1924/2006 (EC) the sodium levels for sodium-reduced products are defined (25% reduction, compared to a reference), in addition for products containing low sodium (0.12 g/100 g), very low sodium (0.04 g/100 g) and no sodium (0.005 g/100 g). All ingredients were assumed as being basically sodium/salt free. Therefore, only the added sodium chloride has been considered for the calculation of the final sodium/salt levels in the products. For full fat (FFP) and reduced fat (RFP) puff pastry 740 g and 370 g roll-in fat were used, respectively. Full salt and four reduced salt levels were used for each fat level (see Table 1). Salt contents for low salt (LS) and very low salt (VLS) were based on baked pastries and a bake loss of approximately 20% determined in preliminary tests. For no salt (NoS) puff pastries, no salt was added. In addition, two-fold (2xS) and four-fold (4xS) salt amounts (compared to Control) were used in the FF puff pastries. Puff pastry with those high salt levels was not intended for consumption but only for the purpose of analysis.

Table 1
Salt levels for puff pastry doughs.

Salt level	Abbreviation	Salt [g/100 g flour]	Salt [g/100 g dough]
Full fat (FF)			
Fourfold salt	FFP 4xS[a]	8.40	3.50
Twofold salt	FFP 2xS[a]	4.20	1.79
Full salt	Control[a]	2.10	0.91
Reduced salt (−30%)	FFP RS[a]	1.44	0.67
Low salt	FFP LS[a]	0.56	0.25
Very low salt	FFP VLS[a]	0.19	0.08
No salt	FFP NoS[a]	0	0
Reduced fat (RF)			
Full salt	RFP FS	2.10	1.06
Reduced salt (−30%)	RFP RS	1.40	0.79
Low salt content	RFP LS	0.47	0.24
Very low salt content	RFP VLS	0.15	0.08
No salt	FFP NoS	0	0

[a] salt levels in basic dough used for dough extensibility test and dough stickiness test.

2.3. Dough preparation and puff pastry production

2.3.1. Basic dough preparation

The basic dough consisted of 1000 g wheat flour, 15 g lemon juice, 510 g water and the appropriate amount of salt (Table 1). Flour and salt were premixed, liquids were added and the dough was mixed for 2 min on speed one (48 rpm) and 3 min on speed two (90 rpm) in a standard mixer with a kneading hook (A200, Hobart Mfg.Co.Ltd., London, UK). After mixing the temperature of the dough was 23 ± 1 °C using tempered water. If not clearly identifiable by the context, hereafter, the term 'basic dough' refers to the mixture of ingredients (flour, salt, lemon juice and water) before incorporating the roll-in fat, the term 'dough' referring to the laminated mix of basic dough and roll-in fat before baking, and the term 'pastry' to the final baked product.

2.3.2. Puff pastry production

All doughs were prepared according to Silow, Zannini, and Arendt (2016). 1500 g basic dough was left to relax at room temperature (20 ± 2 °C) for 20 min. During all rest periods the dough was placed in an airtight bag to prevent dehydration. The basic dough was sheeted to a thickness of 7 mm (11 mm for RFP) using a Rondo sheeter (Model: SSO 605, Seewer AG, Burgdorf, Switzerland). A 15 mm thick (12 mm for RFP) block of roll-in fat was placed on the basic dough and encased with the same. Next, the layered dough was laminated to a thickness of 10 mm and the first folding turn was carried out followed by a rest period of 30 min. The dough was turned horizontally by 90° and the second turn was conducted followed by a rest period of 90 min. Subsequent turns followed with rest periods of 30 min.

For the FFP dough, four single turns (81 fat layers) were performed and for the RFP dough two double turns and one single turn (48 fat layers) were performed. After a 20 min rest the dough was sheeted to a final thickness of 2.50 mm (FFP) or 2.25 mm (RFP). 10 min after final lamination, squares of 10 × 10 cm were cut, stacked in units of eight using layers of baking parchment and stored chilled (4 °C) overnight in an airtight bag.

2.4. Dough extensibility test

Extensibility measurements of the basic dough were determined by the Kieffer dough extensibility test using a Texture Analyser equipped with a 5 kg load cell and the SMS/Kieffer rig (Stable Micro Systems Ltd., UK). As a small scale version of the standard Brabender Extensograph, the Kieffer rig produces values with significant ($p < 0.001$) correlation to results of a standard Extensograph (Grausgruber, Schöggl, & Ruckenbauer, 2002). Basic dough (500 g) with the corresponding amount of salt (see Table 1, only FF) was prepared as described under Section 2.3.1. The dough was directly transferred from the mixing bowl and carefully placed into a lubricated (mineral oil, Bio-Rad Laboratories, CA, USA) Teflon mold and compressed with the lubricated upper part of the mold. After 20 min rest at room temperature 10 strings per dough were tested. The dough strings were removed from the mold one at a time, clamped between the two plates of Kieffer rig and extended with the hook at a constant rate of 3.3 mm/s (Mode: compression, option: return to start, pre-test speed: 2 mm/s, post- test speed: 10 mm/s, distance: 75 mm, trigger

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