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Antioxidants and shelf life of whole wheat bread

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ABSTRACT

Industrially produced bread normally operates with a shelf life of several weeks at room temperature and indications of storage-related off-flavour development as a consequence of lipid oxidation have been suggested. The present study has tested enrichment of whole wheat bread with α-tocopherol or commercially used rosemary extracts for production of bread loaves with higher oxidative stability and hence better overall sensory quality. Bread quality was evaluated by sensory profiling, determination of antioxidative capacity, determination of lipid hydroperoxides as primary oxidation products, and analysis of volatile compounds including secondary lipid oxidation products. Enrichment of bread with α-tocopherol resulted in higher degrees of rancid aroma and flavour in fresh samples, which was explained by higher levels of secondary oxidation products, whereas enrichment of bread with rosemary extracts did not have any effect. Accordingly, application of antioxidants cannot, based on the current data, be recommended for achievement of bread with improved sensory properties during storage.

1. Introduction

Modern food production necessitates a certain shelf life and longer shelf life is often considered as a competitive advantage due to more flexible and centralised production, longer display time during retail, and increased convenience for the consumer. Extended shelf life is achieved by control of key reactions decisive for shelf life and therefore other reactions normally considered to be of less importance may become important in determining shelf life.

Shelf life of bread products are normally limited by bread firming and microbial growth (Fernandez et al., 2006). Currently, bread producers can, by controlling these parameters, achieve products with a shelf life of up to 4 weeks (Sargent, 2008). Management of firming rate and microbial activity means that other parameters like flavour and aroma may become the limiting factor for shelf life of baked products (Holtekjoelen et al., 2008; Jensen et al., 2010, in press).

The aroma and flavour of bread has long been acknowledged to influence the desirability of baked products and a vast number of studies employing sensory analysis and chemical characterisation of volatiles have been performed (Chiavaro et al., 2008; Schieberle and Grosch, 1992; Seitz et al., 1998). Most of these studies concern flavour and aroma of fresh bread, and only very few studies touch upon changes of these parameters in bread products as a consequence of storage. Chiavaro et al. (2008) found a decrease in the total content of volatiles after 4 days of storage and Schieberle and Grosch (1992) detected a decrease in the concentration of selected volatiles after 8 days of storage, and concluded this decrease to be of utmost importance for the acceptability of the bread product in question. Significant changes in aroma, flavour, and taste of wheat bread and whole wheat bread during 3 weeks of storage were previously reported together with a build up of hexanal and heptanal (Jensen et al., accepted for publication). Formation of primary lipid oxidation products as precursors for these volatiles indicates that oxidative reactions probably have a high impact on the flavour and aroma profile of bread with extended shelf life (Jensen et al., 2011b).

Effective control of lipid oxidation in food includes reduction in loss of antioxidants naturally present in the raw materials by modification in processing steps, elimination of metal contamination, addition of antioxidants, and implementation of appropriate packaging technologies (Fernandez et al., 2006; Frankel, 1996; Paradiso et al., 2008). Use of synthetic antioxidants in food products has for many years been an effective and relatively cheap way to achieve more oxidative stable products (Pokorny, 1991). However, synthetic antioxidants such as butylated hydroxyanisole and butylated hydroxytoluene may present a risk of carcinogenesis

Abbreviations: ANOVA, Analysis of variance; DM, Dry matter; GC–MS, Gas chromatography mass spectroscopy; ORAC, Oxygen radical absorbance capacity; PC, Principal component; PLS, Partial least squares; POV, Peroxide value; TEAC, Trolox equivalent antioxidant capacity.

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which is why the interest in natural antioxidants has been intensified (Yanishlieva and Marinova, 1992; IARC, 1986a, 1986b).

Apart from ascorbic acid normally considered being an antioxidant, but which in bread is used to achieve increased dough stability and bread volume (Grosch and Wieser, 1999), addition of antioxidants is not common for bread products. Enrichment of bread dough with antioxidants represents a strategy for production of bread loaves with a higher degree of oxidative stability and hence better overall sensory quality during storage, but only few studies concerning addition of antioxidants to bread products are available. Peng et al. (2010) studied the effect of grape seed extracts on the antioxidative capacity in bread made from refined wheat flour and found the oxidative status of the enriched bread to be greatly enhanced. These bread loaves were further evaluated to have a more desirable crust colour when compared with control bread prepared without the addition of grape seed extract. Other than the composition of the bread matrix, the effect of an antioxidative extract in food products depends on the type of antioxidants present in the extract and their solubility in the specific food matrix. Furthermore, the concentration of the individual antioxidants and their combined effect are important as well as the compatibility of the antioxidants with the processing and packaging methods employed. Benefits in bread production with one type of antioxidative extract is, due to the above mentioned factors, not necessarily valid for other antioxidative extracts or for other types of bread.

The present study investigates the effect of adding naturally occurring antioxidants, α-tocopherol and two different rosemary extracts, to bread and monitoring the effect of these on bread quality during extended storage. α-Tocopherol is a lipophilic antioxidant naturally present in wheat, particularly in wheat bran (Zhou et al., 2004), while the antioxidative effect of rosemary extracts have been assigned to the high content of carnosol and carnosic acid (Aruoma et al., 1992). Bread quality was evaluated by sensory profiling, changes in antioxidative capacity, formation of primary oxidation products, and analysis of volatiles.

2. Materials and methods

2.1. Types of bread and preparation

Whole wheat bread was made from stone milled fine whole wheat flour (min. 14% protein) and the ingredients listed in Table 1. All ingredients were obtained from commercial suppliers in EU except from stone milled fine whole wheat flour and azodicarbonamide, which was obtained from commercial suppliers in the US. The bread was prepared according to a sponge and dough procedure and the four different bread varieties were prepared differing with respect to antioxidative additives: 'α-tocopherol', 'fat soluble rosemary extract', 'water dispersible rosemary extracts' and 'no additive'. The fourth bread prepared without any antioxidative additive was included as a control sample. α-Tocopherol (>97) was purchased from Sigma–Aldrich (Sigma–Aldrich Inc., Steinheim, Germany) and fat soluble and water dispersible rosemary extracts (GUARDIAN™ Rosemary Extract 201 and GUARDIAN™ Rosemary Extract 202) were kindly donated by Danisco (Danisco A/S, Brabrand, Denmark). The rosemary extracts were practically flavourless and contained 96% natural rosemary extract, 4% phenolic diterpenes (compounds present in rosemary extract), together with propylene glycol, E1520. In addition, GUARDIAN™ Rosemary Extract 202 also contained polyoxyethylene (20) sorbitan monooleate, E433. The list of ingredients for each of the bread varieties are given in Table 1.

Novamyl 10.000 BG and Fungamyl Super MA were both from Novozymes (Novozymes A/S, Bagsvaerd, Denmark). Novamyl is a maltogenic amylase and Fungamyl Super is a blend of fungal α-amylase and xylanase. Microbial growth was prevented by addition of propanoic acid and by surface treatment with a 6% calcium sorbate solution of the baked bread. After surface treatment, the bread was further baked for 1 min to evaporate excess water from the sorbate treatment. Moisture loss during baking was not determined in the present baking experiment, but for this type of bread a moisture loss of 11–13% is normal. After cooling, the bread was packed in commercially used plastic bags (polyethylene, 25 μm, Multiline A/S, Soroe, Denmark) with high oxygen-permeability. Bread was prepared over a five week period providing bread stored for 0, 1, 2, 3, 4, and 5 weeks. All samples were analysed by sensory analysis and GC measurements at the same dates. Bread loaves were stored at room temperature (approximately 22 °C) and samples stored for 4 and 5 weeks were only subjected to chemical analysis due to safety reasons (microbial status was not evaluated, but no visible mould growth was observed). For analysis of the overall antioxidative capacity and peroxide value, approximately 40 g of bread crumb was frozen rapidly by immersing samples directly into liquid nitrogen. The frozen bread pieces were ground and vacuum packed in non-transparent oxygen-impermeable aluminium foil bags (PETP12/ALU9/LLDPE75, Dansico Flexible, Horsens, Denmark) in sample portions of approximately 3 g. The foil bags were stored at −80 °C until the dates of analyses. Samples were frozen on the same dates as the sensory analyses and the GC–MS measurements were carried out. All bread loaves were produced by the same baker to ensure uniformity in the baking procedure.

Table 1
Ingredients per kilo whole wheat flour [g].

Ingredients	[g/kg whole wheat flour]	Control	α-Tocopherol	Rosemary (lipophilic)	Rosemary (hydrophilic)
Water	629.5	x	x	x	x
Salt	20.0	x	x	x	x
Glucose syrup	80.0	x	x	x	x
Cane syrup	40.0	x	x	x	x
Soy oil	20.0	x	x	x	x
Yeast	50.0	x	x	x	x
sodium stearoyl-2-lactylate	5.0	x	x	x	x
Ascorbic acid	0.06	x	x	x	x
Calcium propionate	2.5	x	x	x	x
Mono and di-glycerides	10.0	x	x	x	x
Azodicarbonamide	0.04	x	x	x	x
Novamyl 10.000 BG	0.25	x	x	x	x
Fungamyl Super MA	0.04	x	x	x	x
α-Tocopherol	1.0		x		
Rosemary extract (fat soluble)	1.0			x	
Rosemary extract (water dispersible)	1.0				x