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Faba bean flavour and technological property improvement by thermal pre-treatments

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2-Methylfuran
2-Pentylfuran
Hexanal
Nonanal
2-Heptanone
Peroxidase
Lipoxygenase

ABSTRACT

Food-use of faba bean has been commonly limited by the unpleasant “beany flavour” that can be induced by untreated beans. Pre-treatment of faba beans with microwave heating for different durations and with conventional oven heating was investigated, in order to resolve the “beany flavour” problem. Heating the seeds by microwave for 1.5 min at 950 W was found to be an optimum pre-treatment method that effectively inactivated the endogenous peroxidase and lipoxygenase, which are responsible for the beany flavour causation. In addition, the treatment improved the technological properties of the beans as it decreased seed hardness, improved milling quality, and increased flour pasting viscosity. It slightly decreased protein solubility, while heating with microwave for 2 min or longer decreased the protein solubility more severely and decreased the flour pasting viscosity. Conventional oven heating at 170 °C for 30 min also inactivated the peroxidase and lipoxygenase. The microstructure of the particles in flour-water-suspension was changed by both microwave and conventional oven heating methods, which induced the formation of water-insoluble starch-protein aggregates. Microwave heating for 1.5 min provided an excellent balance of improved milling properties, preserved protein solubility and minimized activity of enzymes that are detrimental to product flavour.

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1. Introduction

The faba bean (*Vicia faba* L.) is a widely grown food and feed crop on all of the inhabited continents (Jamalian & Ghorbani, 2005). It has the highest world average yield of the cool-season grain legumes and can tolerate harsh growing conditions such as in Northern Europe and Canada. Its seed composition averages about 29% protein and 39% starch (Crepon et al., 2010). It has a long history of cultivation in Finland (Stoddard, Hovinen, Kontturi, Lindström, & Nykänen, 2009), where its protein content is consistently above world average figures (Lizarazo et al., 2014). The functionality of faba bean protein for food uses, especially as a protein isolate, has been studied at the laboratory scale, and has shown good solubility, emulsifying, foaming and gelling properties (Boye, Zare, & Pletch, 2010; Cai, Klamczynska, & Baik, 2001). Faba bean starch has been utilized for centuries in Asian countries for glass noodles that mainly consist of starch and have less than 1.3% protein (Tan, Li, & Tan, 2009).

The food use of faba bean, especially for the protein-rich components, is still minor in spite of its high nutritional value and the globally increasing interest of developing plant-based protein-rich foods for a sustainable human nutrient supply (Boye et al., 2010). The utilization of protein-rich faba bean components in foods presents challenges concerning sensory quality, because the activity of endogenous enzymes can cause an undesirable “beany flavour”. An important enzyme is lipoxygenase that catalyses oxidation of fatty acids, such as linoleic and linolenic acids, to

Abbreviations: TA, texture analyser; RVA, rapid visco-analyser; HS-SPME-GC-MS, headspace solid-phase microextraction gas chromatography–mass spectroscopy; GC, gas chromatography; MS, mass spectroscopy; PCA, principle component analysis; MWT, microwave treatment; CTT, conventional thermal treatment.

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hydroperoxides (Baysal & Aslıhan, 2007) that may react further to volatile and non-volatile off-flavour compounds, in oxidation reactions either promoted by treatments such as heating, or catalysed by other endogenous enzymes, such as peroxygenase (Hamberg & Hamberg, 1996). Plant tissues also contain peroxidases that catalyse various oxidation–reduction reactions that affect lipids. Because peroxidase is normally the most heat-stable enzyme in plants, it is generally used to indicate adequacy of heat treatments (Akyol, Alpas, & Bayindirli, 2006).

In most dry and wet fractionation processes for protein enrichment, the oxidizing enzymes tend to appear together with the main mass of protein, so the beany flavour is problematic for any protein-rich food product made from faba bean, and inactivation of these enzymes is crucial. A possible method to resolve the beany flavour problem of faba bean is to inactivate those oxidizing enzymes by thermal treatments such as microwave heating, oven heating, steaming, kilning and autoclaving. Microwave heating has some advantages over traditional oven-based heating methods, for example, it can achieve high heating rates and reduce processing time (Chandrasekaran, Ramanathan, & Basak, 2013; Vadivambal & Jayas, 2007). In addition, there are advantages to imposing the thermal pre-treatment before milling, so the endogenous enzymes do not come in contact with the lipids.

On the other hand, thermal treatments may change the properties of other compounds, and hence affect the milling quality, moisture content, protein extraction efficiency and flour pasting quality. These technological properties are important for various food processing purposes including baking, beverage production and noodle making. The proteins and starches in faba beans are good in technological functionality but heat-sensitive. There is no literature reporting the microwave pre-treatment on whole faba beans, especially for the purposes of inactivating their endogenous enzymes. The technological properties of the protein and starch of faba beans after heat pre-treatment have not been previously studied thoroughly. Moreover, there are very few studies about microwave pre-treatment of other starch-containing grain legumes such as peas and mung beans. Nevertheless, microwave pre-treatment was shown effective in inactivating soybean lipoxygenase and decreasing the protein solubility (Wang & Toledo, 1987). Faba beans have different structure, composition, and processing methods than soybeans. Most importantly, faba beans contain a much lower amount of lipids than soybeans do. Due to these differences, the effects of microwave pre-treatment on faba bean endogenous enzymes and storage proteins can be different from those on soybeans. In addition, industrial applications with microwaves in food processing are still emerging and further information on the benefits of microwave treatments is needed.

The aim of this work was to study if microwave treatment provides a means for appropriate thermal pre-treatments of faba beans, which would inactivate their endogenous lipoxygenase, eliminate the factors causing off-flavours, and maintain or even improve the technological properties for food use, such as the milling quality, protein extraction efficiency and flour pasting quality. We compared the microwave heat treatments of different durations to a conventional oven heating method. The volatile compounds related to the flavour of heated and unheated faba bean products were also analysed.

2. Materials and methods

Faba bean (cultivar "Kontu", harvest year 2011) was grown in a Finnish experimental field, (Lizarazo et al., 2014). After harvest and cleaning, the beans were kept in a cool and dry storage room at 10 °C. A domestic microwave oven equipped with a three-dimensional microwave distribution system was used (double microwave emission technology, microwave frequency 2450 MHz, Whirlpool JT-379, USA). The initial moisture content of the beans before treatments was 11.8% (Fig. 1).

2.1. Heat treatments

A glass beaker containing 200 g of faba beans was heated in a microwave oven at 950 W. In order to achieve an even treatment of the beans, the heating was divided into 30-s rounds, and the beans were mixed thoroughly by stirring using a spoon for about 10 s after each round. With two, three, four, six and eight rounds of heating, the beans were treated for 1, 1.5, 2, 3 and 4 min, accordingly. The surface temperature of the beans was measured using a hand-held scanning thermometer (Raytek® Raynger® ST™, TYP ST 2, Fuchs, Gütersloh, Germany) immediately after heating. The beans were poured into a plate and allowed to cool to ambient temperature (~22 °C). Five replicates were prepared in this way.

In order to prepare conventional thermal treated faba beans, a sealed glass bottle containing 250 g of faba beans was heated in an oven at 170 °C for 30 min. After heating, the beans were cooled as described above. Triplicates were prepared. Unheated beans used as controls were labelled as "unheated faba beans".

2.2. Analysis of seed hardness

Seed hardness of unheated and heat-treated seeds was analysed with a texture analyser (TA; TA-XT2i, Stable Micro Systems Ltd., England). Sixty faba beans of each group were tested individually. Each bean was attached to the plate of the TA using double-sided adhesive tape. Then the TA probe equipped with a craft knife blade (A/CKB) did a single compression on the bean. The measurement program was set as using pre-test speed of 1.5 mm/s, test speed of 1 mm/s, post-test speed of 10 mm/s, compression target at strain 40%, and trigger force of 15 g. The cutting force-depth curves were plotted and the peak force of each measurement was recorded.

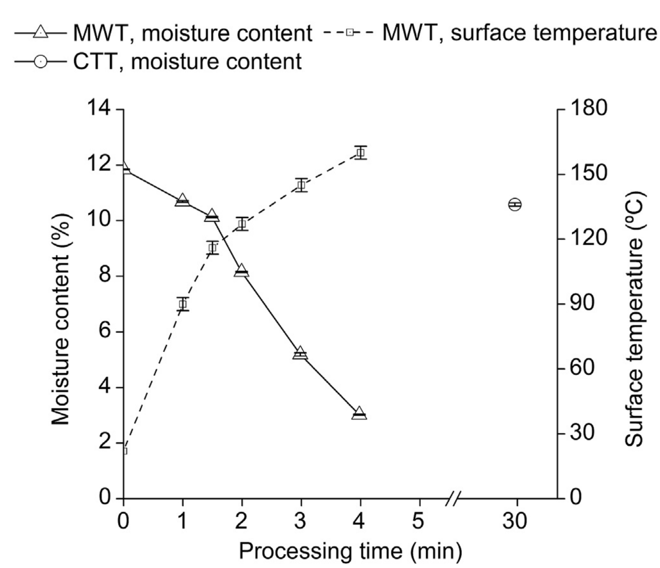

Fig. 1. Moisture content and surface temperature of faba beans after microwave (MWT) and conventional thermal (CTT) treatments. Error bars for the moisture content show standard deviation, which are very small and hardly visible in the figure. Error bars for the surface temperature show the measurement error range of the hand-held scanning thermometer.

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