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Physicochemical properties, lipid oxidation and sensory attributes of pork patties with lupin protein concentrate stored in vacuum, modified atmosphere and frozen state

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ABSTRACT

The effect of lupin protein concentrate (LPC) addition on selected physicochemical properties, lipid oxidation and sensory quality of pork patties was investigated. LPC was added at the level 1%, 2% and 3%. Patties were packed in vacuum and modified atmosphere (MA) and stored 42 days in a refrigerator while aerobically packed patties were stored 84 days in a frozen state. Patties with LPC showed a lower cooking loss, were less cohesive and juicy, and demonstrated a non-typical flavour compared to the control samples. The inhibitory effect of LPC on lipid oxidation was observed after cooking. During storage this effect was noted mainly in patties with 2% and 3% of LPC stored in frozen state while in vacuum- and MA-stored products it was demonstrated only at some measuring points. After 42 days of storage only sample with 3% LPC packed in modified atmosphere was scored below the borderline of overall acceptance.

1. Introduction

Comminuted meat products are commonly accepted components of human diet due to their flavour enhanced by additives such as herbs and spices, and relatively low price resulting from the use of lower quality meat in their production. These products usually show a rather high fat content which makes them susceptible to oxidative changes and flavour deterioration during storage, and affect their nutritional value. Numerous studies have shown that addition of fibre, plant proteins, vitamins and herbs can positively modify nutritional, sensory and storage properties of such products (Ikhlas, Huda, & Ismail, 2012; Serdaroğlu, Yıldız-Turp, & Abrodimov, 2005).

So far, soybean flours, protein concentrates and isolates are commonly utilized in commercial meat products. Moreover, soybean is the most frequently consumed legume in human diet, but lupin is considered its strongest competitor as it has a comparably high protein content and in contrast to soybean can be grown on poor soil or in moderate European climate (Lizarazo et al., 2015; Lucas et al., 2015). Lupin has been traditionally cultivated in the Mediterranean area, along the Nile and in Andean highlands. It is used mainly as an animal fodder (Thambiraj, Philips, Koyyalamudi, & Reddy, 2015), but examples of its use in human diet, are reported (Lucas et al., 2015; Sujak, Kotlarz, & Strobel, 2006). Lupin is worth of wider interest from food technologists as its seeds contain 30–48% protein, which can be used for enriching other products (Lizarazo et al., 2015; Sujak et al., 2006), less undesirable anti-nutritional compounds than other legumes (Harisa & Alanazi, 2015; Martínez-Villaluenga et al., 2009) and numerous bioactive compounds (Khan, Karnpanit, Nasar-Abbas, Huma, & Jayasena, 2015). Petterson & Crosbie (cited after Hall & Johnson, 2004) suggested that the blander and less beany flavour of low-alkaloid or alkaloid-free, so called sweet lupin, can favour its use over soy as a food ingredient. In contrast to soybean, lupin is not genetically modified which can be its advantage for consumers concerned about GMO (www.lupins.org).

Another advantage of lupin products incorporation into various foods could be its potential antioxidant activity which can be expected on the basis of research on other legumes, especially soybeans. Legumes contain considerable amounts of phenolic compounds and tannins which possess antioxidant properties (Amarowicz & Pegg, 2008). Tsaliki, Lagouri, and Doxastakis (1999) demonstrated that lupin flour and lupin protein isolate extracts had better antioxidant properties than soy flour, but lupin seed flour from which alkaloids were removed showed lower antioxidant activity than soy flour, probably as a result of polyphenols content reduction after alkaloids removal. Lampart-Szczapa, Korczak, Nogala-Kalucka, and Zawirska-Wojtasik (2003) reported antioxidant activity of lupin flour and hull, and no correlation between the antioxidant properties and the content of natural lupin antioxidants. Oomah, Tiger, Olson, and Balasubramanian (2006) con-

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firmed weak antioxidant activity of *L. angustifolius* genotypes and no association between its antioxidant activity and phenolic content. Thambiraj et al. (2015) reported antioxidant activity of lupin polysaccharides and its relationship to their mono-saccharide composition.

Several studies have been undertaken to investigate the usefulness of lupin as processed food ingredient. Numerous authors observed positive effects of lupin flour addition to wheat-based products (Dervas, Doxastakis, Hadjisavva-Zinoviadi, & Triantafillakos, 1999; Hall & Johnson, 2004; Villarino et al., 2015) and beef burger patties (El-sayed, 2013), protein isolate addition to fermented frankfurters and sausages (Alamanou, Bloukas, Paneras, & Doxastakis, 1996; Papavergou, Bloukas, & Doxastakis, 1999) and lupin protein concentrate use in a vegetable meat analog (Herskowitz, Segal, & Moraru, 2005).

Functional properties of lupin products, together with consumers' reluctance towards chemical food additives, can make lupin seeds a valuable component of human diet. To the authors' best knowledge, so far no research has been undertaken to investigate the effect of lupin protein addition on the sensory quality and storage stability of pork patties. Therefore, the aim of the study was to investigate the physicochemical and sensory characteristics of pork patties prepared with the addition of lupin protein concentrate with special interest in storage stability of products.

2. Materials and methods

2.1. Preparation of patties

Post-rigor pork ham muscles and back fat were purchased from a commercial abattoir. Muscles were trimmed of visible connective and adipose tissue. Each muscle was cut into three approximately equal parts and each part was designated for a different storage experiment, i.e. vacuum, modified atmosphere and freezing. Meat and fat were packed in bags of five-layer PE-LD/ADH/PA/ADH/PE-PD film and kept frozen at − 18 °C until use. Patties for particular storage experiments were manufactured at 10 days intervals. After thawing overnight in a refrigerator (3 ± 1 °C), meat and fat were separately minced through a 4 mm plate, divided into four parts and each part randomly assigned to the treatment with different amount of lupin protein concentrate. Control samples consisted of 75% pork, 15% plain dried wheat roll soaked in water, 5% pork back fat, 5% egg and 1% salt in relation to the total weight of other components. Lupin protein concentrate (JRS, Rosenberg, Germany) was used in experimental patties to replace the lean meat to obtain the final content of meat in patties 74%, 73% and 72% and lupin protein concentrate 1%, 2% and 3% respectively.

The raw mixture was formed into 90 g patties (9 cm diameter, 1.5 cm thickness). Patties were cooked in a preheated BECK FCV 4EDS steam-convection oven (BECK GmbH, Jagsthausen, Germany), using hot air of 200 °C in combination with 30% steam, to the internal temperature 75 °C. After cooling down at a room temperature the patties were packed in bags (two patties/bag) of five-layer PE-LD/adh/PA/ADH/PE-PD film (oxygen permeability – 40 $mLm^{-2}24\ h^{-1}\ bar^{-1}$, water vapour permeability – 10 $gm^{-2}24\ h^{-1}\ bar^{-1}$) using Multivac A300 packaging unit (Multivac, Wolfertschweden, Germany). The patties were packed under vacuum (VAC) or modified atmosphere (MA) using 20% CO_2/80% N_2 gases mixture and stored at 3 ± 1 °C for 42 days. Sixty patties in total were used for each storage experiment. Patties destined for frozen storage (FRO) were packed aerobically and stored at − 18 °C for 84 days. The total number of patties used in frozen storage experiment was eighty four. Patties were evaluated at 7 days intervals and frozen patties additionally at 14 days intervals between 42 and 84 days of storage. The whole study was repeated twice using separate batches of meat, purchased on separate occasions, and treated in the same way in each of the study replication.

2.2. Cooking loss

Cooking loss was calculated from the difference between raw and cooked patties weight in relation to the raw patties weight.

2.3. Instrumental texture analysis

Texture attributes of pork patties were assessed through the application of shear and compression tests conducted with the use of an Instron universal testing machine (Model 4301, Instron Corp., Canton, MA, USA) equipped with a 1000 N load cell. Shear test was conducted using a Warner-Bratzler Shear fixture Type 2830–013 (Instron Corp.). The blade speed was 50 mm/min. A uniaxal single compression between two plates test was performed using Compression Anvil Assembly unit Type 2830–011 (Instron Corp.). The probe moved downwards with a constant speed of 50 mm/min to compress the sample to the 70% displacement. Tests were performed at ambient temperature on 10–12 specimens (1 cm × 1 cm × 2.5 cm for shear test and 1 cm × 1 cm × 1 cm for compression test) from each treatment.

2.4. pH determination

Five grams of comminuted sample was homogenized with 50 mL of distilled water. Measurements were taken with pH meter ATC Piccolo 2 (Hanna Instruments, Woonsocket, USA) calibrated at pH 4 and 7.

2.5. Water activity

Water activity of comminuted products was determined at 20 °C using a water activity analyzer (AWC 203-C, Novasina, Pfäffikon, Switzerland) calibrated with a set of Novasina humidity sources.

2.6. Lipid oxidation

Lipid oxidation was assessed by the distillation method according to Pikul, Leszczyński, and Kummerow (1989). The absorbance was measured at 532 nm (Optizen, Mecasys, Korea). The content of thiobarbituric acid-reactive substances (TBARS) was calculated from the standard curve prepared with 1,1,3,3-tetraethoxypropane and expressed as mg malondialdehyde (MDA)/kg sample.

2.7. Sensory evaluation

Sensory evaluation was performed by the seven members panel (the same staff members of Department of Human Nutrition of the University of Warmia and Mazury throughout the whole study) experienced in sensory evaluation of food. Before the experiment, in three training sessions, the panel members were familiarized with the evaluation procedure and the quality of freshly prepared and stored pork patties. During the experiment the assessment of patties was performed shortly after heat treatment and then during storage in two sessions at each storage time. Stored samples were warmed to 60 °C in a microwave oven (DMR-901, Daewoo, Roissy, France) before the evaluation. All panelists received all treatments during each session in random order. The patties were assessed for selected flavours intensity (meaty, fatty, sour, rancid, non-typical), cohesiveness, and juiciness using a 7-point category scale (1 - not detectable, low and dry, and 7 - very intense, very high, and very juicy, respectively). Overall acceptance was also evaluated using 9-point scale (1 - not acceptable and 9 - very acceptable). Sensory evaluation was conducted according to ISO 4121 (2003). Water and unsalted crackers were provided to clean the palate between samples.

2.8. Statistical analysis

When not otherwise stated, analyses were performed in triplicate on