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Influence of preliminary thermal processing applying infra-red radiation on pea seeds cooking process

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A b s t r a c t. The paper presents results of a study on the influence of preliminary thermal processing using infra-red (IR) radiation on pea seeds cooking duration. Changes of compressive strength and pea seeds moisture content were recorded during cooking. The results revealed significant shortening of the boiling time of pea seeds that were preliminarily heated by IR radiation. IR treated pea seeds were characterized by higher moisture content and lower compressive strength as compared to those that were not heated prior to cooking.

K e y w o r d s: cooking, pea seeds, thermal processing, IR radiation, compressive strength

INTRODUCTION

Fast development of foodstuff market that adapts to modern consumer's high requirements and his varied needs has been recently observed. The ongoing economic, social and cultural transformations result in a change of modern man lifestyle, among others, by improvement of his awareness related to rational feeding. It is expressed in wider and wider utilization of plant-origin proteins and whole seeds, which is associated with consuming products with lower animal-origin fat contents with high percentage of saturated fatty acids and caloricity. High-protein plants like pea, soybean and other legumes may be raw material for such products. Those plants' seeds play an important role in nourishment: they may complete and even replace animal-origin nutrients.

One of the main factors limiting utilization of legumes is their long cooking time (Buckle and Sambudi, 1990). For example, it takes about 300 min for complete cooking of soy bean by open atmospheric boiling to obtain broth (Deshpande, 1990). Also hard to cook is bean which was stored under tropical conditions of high temperature and humidity (Aguilera and Stanley, 1985; Liu *et el.*, 1993). One of the ways to shorten the cooking time of legumes is addition of alkaline salts such as sodium bicarbonate ($NaHCO_3$) and sodium citrate. It reduces the cooking time to 75 and 60 min, respectively (Gandhi *et al.*, 1985). Chavan *et al.* (1983) reported the effect of pre-soaking treatments on the cooking quality of split legumes. Pre-soaking treatments of different split legumes in water or soaking solution at 25ºC decreased the cooking time substantially. Singh and Rao (1995) studied the cooking of split legume using $NaHCO_3$ and found this to significantly reduce the cooking time. However, cooking times are still in range from 30 to 70 min (Bhatty, 1995).

Another way to shorten the time of cooking is application of micronization. According to Zarkadas and Wiseman (2001), micronization refers to a short-time, high-temperature infra-red processing method that utilizes moisture, temperature and mechanical pressure to achieve conditions for optimum cooking and starch gelatinisation. Micronization increases digestibility of seeds and inactivates enzymes and antinutrients (Lawrence, 1975; Murray, 1987). That method is based on the material's ability to absorb and convert electromagnetic radiation energy into heat. Temperature of a material heated applying IR radiation increases fast, thus the duration of the process is greatly shortened and the efficiency is improved. The results of the thermal process depend on working parameters of the devices and qualitative traits of raw material being processed. In practical use the total efficiency could about 65% (Shuman and Stanley, 1950). Mwangwela *et al.* (2006) showed that micronisation of Bechuana white cowpea reduced the cooking time by 44%. Similar reduction in cooking time of micronized seeds have been reported for Laird lentils (50%) (Cenkowski and Sosulski, 1997).

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However, the effectiveness of micronization as a pre-cooking treatment is dependent on several process parameters and on the kind of raw materials. Also important are the physical properties of seeds obtained after their micronization and cooking.

The main legume grown in Poland is pea (Podleśny, 2005). Products made from pea are very tasty and are suitable for foods of the 'instant' type. In spite of this there is no the technology for low-cost production of quick-cooking pea.

The objective of the study was to determine the potential for reducing the cooking time of pea by micronization. To this aim the experiment consisting in comparison of moisture content and compressive strength of unprocessed and preliminarily thermal-processed pea seeds was carried out.

MATERIAL AND METHODS

Pea seeds of Pomorska cv. were material for study. They are characterized by beige-olive colour with violet dots; 1000 grain weight is about 230 g. The uniform material, referring to the variety, originated from 2006 harvest. Seed moisture content was about 10%.

Pea seeds were heated applying ceramic IR emitter of ECS-1 type, of 400 W power (Fig. 1). This device has a temperature radiator supplied by electric energy (230 V), having a fraction of visible range share in spectrum (dark radiator), that uniformly heats all points on surface (plane radiator). Mean temperature of filament surface is about 500°C, and λ=2.5-3.0 μm.

The seeds were heated at 180°C for 90 s (seeds thermally unprocessed and stored at ambient temperature – 20°C – were a blank sample). After heating, seeds were stored at 20°C for 24 h and then cooked. Seed samples were taken during boiling to determine moisture content and to measure the compressive strength.

Pea seeds were placed in a special basket and soaked in distilled water at constant temperature of about 100°C. After accepted time intervals (5, 10, 15, 20, 25, 30 min) about 5 g samples were taken out and placed on filter paper to dry their surface. Then moisture content was measured in accordance with the AACC Method 44-15A. Moreover, compressive strength of individual seeds was determined. All measurements were made in 10 replications presenting their arithmetic mean as final result.

The method used consisted in application of axial compression strength test for individual pea seeds placed between parallel plates of compression device Instron 4302. During testing, speed of moving plate was constant (10 mm min^{-1}). Single seed was placed with its cotyledon in parallel to the surface of the static plate, and then it was compressed using the mobile plate. Axis of pressure force crossed along the diameter of seed cross-section. The measurement was conducted till the seed broke, recording the compression force F_s at which it happened.

RESULTS AND DISCUSSION

Figure 2 presents changes in the moisture content of thermally untreated and treated pea seeds depending on cooking duration. Comparison of achieved results reveals great differences of water absorption rates during cooking between unheated and IR heated seeds.

Five minute cooking caused moisture increase of preliminarily thermally processed seeds to 35% and it was over 1.8 times higher as compared to untreated seeds and cooked for the same time. Such great moisture content differences also occurred after 10, 15, and 20 min of cooking. Differences within 5-20 min range were statistically significant at $\alpha < 0.05$. No statistically significant differences were found after 25 min and longer cooking. Changes of moisture content in pea seeds as a function of cooking duration were described by 2 order regression equations (Table 1). High values of determination coefficients prove good fitting of mathematical description to experimental data.

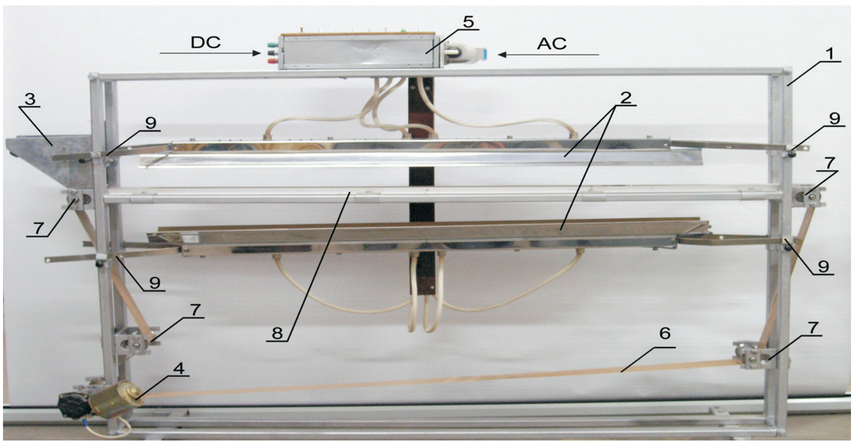

Fig. 1. Laboratory device for infra-red radiation treatment of pea seeds: 1 – frame, 2 – infra-red radiators, 3 – feeding tank, 4 – electric motor, 5 – control unit, 6 – conveyor belt, 7 – rollers, 8 – heating zone, 9 – adjustment of heads position.

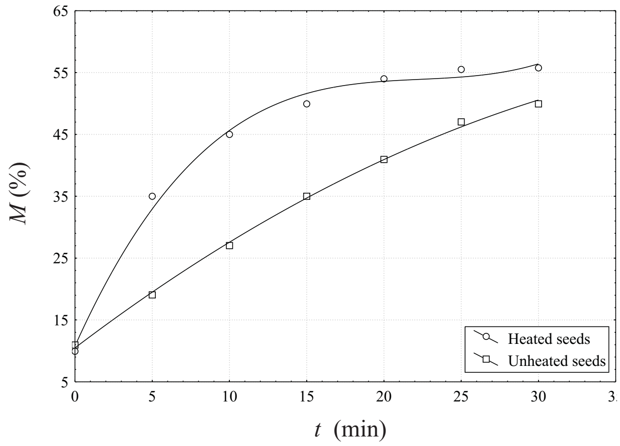

Fig. 2. Changes of pea seeds moisture content (*M*) during boiling (*t*).

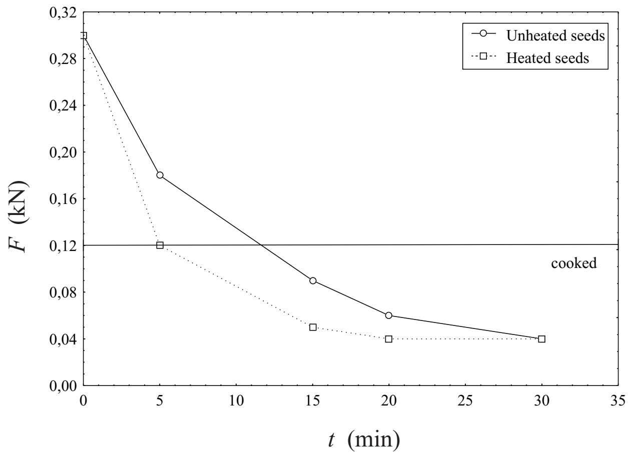

Fig. 3. Changes of single pea seeds compressing strength (*F*) during boiling (*t*).

Table 1. Regression equations for pea seeds moisture content (*M*) variation as a function of boiling time (*t*)

Seeds	Equation	R^2
Heated	$M = - 0.08\ t^2 + 3.74\ t + 13.54$	0.967
Unheated	$M = - 0.019\ t^2 + 1.89\ t + 10.5$	0.998

Water absorption during cooking of legume seeds is related to physical and chemical properties of the seeds such as seed coat properties, protein content and density (Sefa-Dedeh *et al*., 1979; Mwangwela *et al*., 2006).

Micronization significantly improved the amount of water absorbed by the pea during the first 25 min of cooking, possibly owing to reduced bulk density and development of fissures. The reduction in bulk density implies that micronized seeds have air space within them that would enhance water uptake (Mwangwela *et al*., 2007).

During cooking, also pea seed compressive strength was measured. Seeds were thermally untreated and IR processed. Results are presented in Fig. 3. Preliminary thermal processing of pea seeds applying IR radiation caused a decrease of compression force measured during cooking. The differences were as follows: values of the force measured for preliminarily thermally treated seeds after 5 min cooking were about 1.5-fold lower as compared to those achieved for untreated seeds, after 20 min cooking, value of compression force for preliminarily processed seeds was 0.04 kN, which was identical as after 30 min cooking untreated seeds. Tukey's test revealed significant differences after 5 min cooking at $\alpha < 0.05$, and after 15 min cooking at $\alpha < 0.1$; no significant statistical differences were found after longer cooking.

It should be stressed that the greatest decrease of compression force applied to seeds preliminarily IR-processed occurred after 20 min cooking. Further elongation of cooking time (up to 30 min) did not cause any decrease of measured force. These observations are consistent with conclusions drawn by Cenkowski and Sosulski (1997). They found that due to thermal processing applying IR radiation (processing time – 55 s) the cooking time for lentils seeds could be reduced from 30 to 15 min. Elongation of time of exposure to IR radiation to 85 s caused shortening of cooking time for lentils to 10 min; values of compression force in the case of preliminarily treated lentils seeds were the same after 10 min as after 30 min cooking of seeds untreated with IR radiation.

The influence of IR processing on shortening of lentils seeds cooking time was also studied by Arntfield *et al.* (1997). They found that not only temperature and duration of IR treatment of lentils seeds had an impact on shortening of their further cooking time, but also moisture content of seeds. In those authors' opinion, decrease of initial moisture content of lentils seeds (below 20%) does not guarantee favourable influence of IR processing on cooking time. This conclusion is consistent with results achieved by Abdul-Kadir *et al.* (1990) who were involved in the evaluation of the influence of preliminary IR processing on properties of cooked bean seeds. In another research, Arntfield *et al.* (2001) confirmed earlier observations. Thermally processed and preliminarily moisturized lentils, up to 33% for 16 h, were characterized – after cooking – by lower resistance to compression, contained higher levels of gelated starch and pectins, but less soluble proteins as compared to lentils not treated with IR radiation. The effect of preliminary IR processing temperature (138 and 170°C) on quality of cooked lentils seeds was also studied in those experiments. Quality of lentils processed at 138°C appeared to be better after cooking. After cooking, lentils seeds were harder and darker as a result of processing at 170°C, due to the moisture content decrease during IR treatment.

The softening of dry legume seed during cooking has mainly been ascribed to parenchyma cell separation along the middle lamella due to starch gelatinisation and elimination of pectic substances (Sefa-Dedeh *et al*., 1978; Coulate, 2002). Because both elimination of pectic substances and starch gelatinisation require water, increased moisture content during cooking of legumes may led to a reduction in cooking time.

CONCLUSIONS

1. Micronization of pea at temperature of 180°C is beneficial for further treatment of seeds. Pea seeds subjected to thermal processing applying IR radiation absorbed water faster than untreated ones. Micronization also shortens cooking time of pea seeds.

2. It should be noticed that the cooking times are shortened from 12 min for the control seeds to five 5 min for the seeds subjected to micronization. The longer time of cooking caused that the seeds were overcooked.

3. From the practical standpoint, micronization at 10% moisture content for 90 s could be used commercially to shorten the cooking time by over half for those pea seeds.

4. The short cooking times of pre-treatment pea seeds cause that micronization may be suitable for achieving food of instant type.

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