Food Chemistry 169 (2015) 203–210

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

# Effects of infrared treatment on urease, trypsin inhibitor and lipoxygenase activities of soybean samples

Seda Yalcin [1], Arzu Basman *

*Hacettepe University, Food Engineering Department, Beytepe, Ankara, Turkey*

ARTICLE INFO

*Article history:*
Received 7 May 2014
Received in revised form 19 July 2014
Accepted 23 July 2014
Available online 8 August 2014

*Keywords:*
Infrared treatment
Soybean
Trypsin inhibitor
Urease
Lipoxygenase

ABSTRACT

In this study, infrared (IR) treatment at different powers (814 W, 1003 W, 1208 W, 1342 W) and times (10 min, 15 min) were applied to unsoaked and soaked (30 min, 45 min) soybeans (cvs. Adasoy, Nazlican). Effects of IR treatment on urease, trypsin inhibitor, lipoxygenase-1 and lipoxygenase-3 activities were investigated. Infrared treatment caused a substantial reduction in urease and trypsin inhibitor activities and considerable decrease was observed as the IR power increased. Urease inactivation in unsoaked samples was achieved at even lower power (1208 W). In contrast to urease activity, IR treatment had a more pronounced effect on trypsin inhibitor and lipoxygenase activities of soaked soybeans as compared to unsoaked counterparts. Maximum trypsin inhibitor reduction in IR-treated samples was 95% for cv. Adasoy and 97% for cv. Nazlican. IR power of 1003 W was sufficient for complete inactivation of lipoxygenase-1 and lipoxygenase-3, regardless of the moisture contents of the samples.



## 1. Introduction

Soybean has great importance in nutrition and health due to its high protein and isoflavone content. Consumption of soybean may be associated with reduced risk of cardiovascular diseases, osteoporosis, breast, prostate and colon cancers (Venter, 1999; Wiseman, 2006). However, soybeans contain some undesirable components such as trypsin inhibitor, urease and lipoxygenase. Trypsin inhibitor adversely affects the enzymes having a role in protein digestion (Janssen, 1996) and urease decomposes urea to ammonia and carbon dioxide (Prachayawarakorn, Prachayawasin, & Soponronnarit, 2004). Inactivation of urease is almost identical to that of trypsin inhibitor and therefore, urease test has been used as an indirect method that indicates the level of trypsin inhibitor (Prachayawarakorn et al., 2004). Lipoxygenase is responsible for the development of undesirable flavour formed by oxidation of polyunsaturated fatty acids in soybean (Iassonova, Johnson, Hammond, & Beattie, 2009).

Various treatments, such as microwave heating, fluidised-bed drying, spouted bed drying, extrusion, superheated steam and boiling can be used for the inactivation of the undesirable components of soybean (Krishnamurthy, Khurana, Jun, Irudayaraj, & Demirci, 2008). Osella, Gordo, Gonzalez, Tosi, and Re (1997) investigated the effects of fluidised bed drying on urease and trypsin inhibitor activities of soybeans. Soybeans with different moisture contents (125, 175, 235 g/kg moisture content) were treated at different temperatures (100, 110, 120, 130, 140 °C) for different times (1, 3, 5, 7, 10, 15, 20, 25 min). Urease was completely inactivated at 130 °C for 3 min, whereas trypsin inhibitor was completely inactivated at 140 °C for 10 min. Osman, Reid, and Weber (2012) reported 96% reduction in trypsin inhibitor activity of soybean after autoclaving (121 °C) for 60 min. In a study by Prachayawarakorn, Prachayawasin, and Soponronnarit (2006), urease was inactivated between 135–150 °C in hot-air fluidised beds and below 135 °C in superheated steam fluidised beds. In another study, a decrease in trypsin inhibitor level and an increase in total phenolic contents were reported for soybean samples to which γ-radiation was applied (Toledo, Canniatti-Brazaca, Arthur, & Piedade, 2007). Alajaji and El-Adawy (2006) investigated the effects of microwave cooking (2450 MHz, 15 min), boiling (100 °C, 90 min) and autoclaving (121 °C, 35 min) on the nutritional composition and antinutritional factors (trypsin inhibitor, tannins, saponins) of chickpeas. It was reported that cooking treatments caused significant decreases in antinutritional factors. Reductions for autoclaving, boiling or microwave cooking were reported as 83.87%, 82.27% and 80.50%, respectively. Wang and Toledo (1987) reported that inactivation of lipoxygenase is higher in soybean samples at higher moisture contents and process

* Corresponding author. Address: Hacettepe University, Faculty of Engineering, Food Engineering Department, 06800 Beytepe, Ankara, Turkey. Tel.: +90 312 297 71 15; fax: +90 312 299 21 23.
*E-mail address:* basman@hacettepe.edu.tr (A. Basman).
[1] Present address: Afyon Kocatepe University, Afyon Vocational School, Food Technology Programme, Afyon, Turkey.

http://dx.doi.org/10.1016/j.foodchem.2014.07.114
0308-8146/

temperatures. Zhu, Riaz, and Lusas (1996) indicated that lipoxygenase-1 and lipoxygenase-3 in soybeans were inactivated at extrusion temperatures of 107 °C and 96 °C, respectively. Shin, Kim, and Kim (2013) stated that lipoxygenase activity of soy flour decreased from 279 U/g to 106 U/g by steaming (95 °C, 1 h), to 69.1 U/g by roasting (140 °C, 30 min).

Infrared (IR) treatment has obtained a great interest in the food industry, due to its advantages over conventional heating. It is an efficient and energy saving food processing technology, due to characteristics such as thermal efficiency, fast heating rate/response time, wavelength, direct heat penetration into the product and reflectivity (Datta & Almeida, 2005; Sakai & Mao, 2006; Skjöldebrand, 2001). IR treatment has been used in various food processes such as drying, baking, roasting, blanching, pasteurisation and sterilisation. Infrared treatment has been used to reduce moisture contents of grains, legumes, fruit and vegetables (Hebbar, Vishwanathan, & Ramesh, 2004; Nimmol, Devahastin, Swasdisevi, & Soponronnarit, 2007; Nowak & Lewicki, 2004; Wang & Sheng, 2006). Several researchers reported some advantages of infrared treatment in legumes. Infrared treatment reduces cooking time of legumes by providing a more open microstructure that improves water absorption characteristics, provides softer texture, improves dehulling characteristics, increases starch gelatinisation degree, decreases protein solubility and reduces antinutritional factors of legumes (Arntfield et al., 1997; Bellido, Arntfield, Cenkowski, & Scanlon, 2006; Kayitesi, Duodu, Minnaar, & de Kock, 2013; Krishnamurthy et al., 2008; Mwangwela, Waniska, Mc Donough, & Minnaar, 2007; Mwangwela, Waniska, & Minnaar, 2006; Oomah, Kotzeva, Allen, & Bassinello, 2014; Scanlon et al., 1998; Wiriyaumpaiwong, Soponronnarit, & Prachayawarakorn, 2004).

To the best of our knowledge, researches about the effects of infrared treatment on urease (Dondee, Meeso, Soponronnarit, & Siriamornpun, 2011; Wiriyaumpaiwong et al., 2004) and trypsin inhibitor (Bekric, Bozovic, Pavlovski, & Masic, 1990) are limited. A wide range of processing conditions was not investigated and the effects of infrared treatment on lipoxygenase together with antinutritional factors (urease, trypsin inhibitor) were not studied under the same processing conditions. Wiriyaumpaiwong et al. (2004) investigated the effects of infrared treatment on urease activity of soybean at only one power by using a laboratory-scale infrared dryer with two 650 W infrared bulbs. Treatment at 160 °C for 10 min was sufficient for the urease inactivation (<0.3 pH difference). Dondee et al. (2011) reported residual urease activities of soybeans as 70%, 52%, 39% with IR treatments at 4 kW, 6 kW and 8 kW, respectively. Bekric et al. (1990) reported that the level of trypsin inhibitor in soybean decreased from 53.25 TIU/mg to 2.66 TIU/mg after infrared treatment but the process parameters (IR power, treatment time) were not defined in the study.

Therefore, in this study, infrared treatments at various powers (814 W, 1003 W, 1208 W, 1342 W) and times (10 min, 15 min) were applied to unsoaked and soaked (30 min, 45 min) soybean samples (cv. Adasoy and cv. Nazlican) and effects of IR treatment on urease, trypsin inhibitor, lipoxygenase-1 and lipoxygenase-3 activities of soybean samples were investigated.

## 2. Materials and methods

### 2.1. Materials

Soybean samples (cv. Adasoy and cv. Nazlican) were obtained from Cukurova Agriculture Research Institute, Adana, Turkey. Soybean samples were sieved and samples with uniform size ($6 < x < 8$ mm) were used in the study. Moisture, protein and ash contents of the soybean samples were determined according to AACC Approved Methods (2000).

### 2.2. Infrared treatment

Soybean samples (cv. Adasoy and cv. Nazlican) were soaked in water (7/40; w/v; 30 °C) for 30 or 45 min. After soaking, excess water on the surface of the soybean seeds was removed by paper towel. Samples were allowed to rest in plastic bags at 30 °C for 5 h, in order to let the water move to the centre of soybean. The moisture contents of Adasoy and Nazlican samples were found to be 40.4% and 48.5% after 30 min soaking time and 44.8% and 51.7% after 45 min soaking time, respectively. Infrared treatment was applied to unsoaked and soaked soybean samples at four different powers (814 W, 1003 W, 1208 W, 1342 W) for 10 min or 15 min. In preliminary studies, different IR powers and treatment times were tested. For selection of the appropriate IR power and time, moisture content and colour of the samples were taken into account. The temperatures at the surface of the soybean samples were detected by an IR thermometer (MX6 infrared thermometer; Raytek Corporation, Santa Cruz, CA). Surface temperatures for 30 and 45 min soaked soybean samples were similar and the temperatures for the 10 min and 15 min treated samples were found to be between 60–99 °C and 70–120 °C min, respectively. Higher surface temperatures were detected for unsoaked samples and the temperatures for the 10 min and 15 min treated samples were found to be 90–160 °C and 100–170 °C, respectively.

Laboratory scale infrared equipment (Biasis Ltd. Sti., Ankara, Turkey) was used in the study. The system includes a closed drying chamber fitted with twelve 150 W halogen lamps (Infrared, R125 IR; Philips, Eindhoven, The Netherlands) and two aeration channels (12 V each). The halogen lamps have a wavelength spectrum (0.2–4 μm) with a pronounced peak at approximately 1 μm. Aluminium reflectors used on the walls of the equipment prevent absorption of the light. Infrared power can be set between 310 W and 1595 W by a dimmer. The distance between the lamp system and sample tray was adjusted to 20 cm for the study. IR treatment for each trial was carried out as two replicates and the samples were combined in a large batch. Infrared-treated samples were rested in a fermentation cabinet at 30 °C for 20 h in order to obtain final moisture contents lower than 9% in all soybean samples. The dried soybean samples were ground to pass through a 212 μm sieve for analysis.

### 2.3. Urease activity

Urease activity is an indirect method. The value is a reliable indicator of the adequacy of heat processing, and hence the degree of trypsin inhibitor activity (Wiriyaumpaiwong et al., 2004). Soy flour (0.2 g) was dissolved in 10 mL of urea solution (pH 7.0) in a water bath at 30 °C for 30 min. The urea solution was replaced with phosphate buffer for preparation of the blank for each sample. The change of pH, caused by the conversion of urea to ammonia by the urease enzyme of the sample, was measured by AACC Method No: 22-90.01 (AACC, 2000). Analyses were performed in duplicate.

### 2.4. Trypsin inhibitor activity

Samples were defatted with hexane until the sample became fat-free. Defatted soy flour (<212 μm, 1 g) was homogenised with 50 mL NaOH (0.01 N) by stirring for 3 h. Trypsin inhibitor activity (*TI*) of the extract was determined according to the method of Kakade, Rackis, McGhee, and Puski (1974), using benzoyl-DL-arginine-*p*-nitroanilide (BAPA) as substrate. Trypsin inhibitor activity is expressed in terms of trypsin units inhibited. One trypsin inhibitory unit (TIU) is defined as an increase of 0.01 absorbance units at 410 nm per 10 mL of the reaction mixture. Analyses were performed in duplicate.