Food Research International 62 (2014) 375–381

Contents lists available at ScienceDirect

Food Research International

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

Pre-extrusion aromatization of a soy protein isolate using volatile compounds and flavor enhancers: Effects on physical characteristics, volatile retention and sensory characteristics of extrudates

Talita Maira Goss Milani [a], Michele Eliza Cortazzo Menis [a], Amanda Jordano [b], Maurício Boscolo [b], Ana Carolina Conti-Silva [a,*]

[a] Department of Food Engineering and Technology, Instituto de Biociências, Letras e Ciências Exatas, UNESP — Univ Estadual Paulista, Rua Cristóvão Colombo, 2265, CEP 15054-000, São José do Rio Preto, SP, Brazil

[b] Department of Chemistry and Environmental Sciences, Instituto de Biociências, Letras e Ciências Exatas, UNESP — Univ Estadual Paulista, Rua Cristóvão Colombo, 2265, CEP 15054-000, São José do Rio Preto, SP, Brazil

ARTICLE INFO

Article history:
Received 13 January 2014
Accepted 11 March 2014
Available online 26 March 2014

Keywords:
Thermoplastic extrusion
Expansion
Texture
Aroma intensity
Sensory acceptability

ABSTRACT

The effect of aromatization of a soy protein isolate, using volatile compounds (isovaleraldehyde, ethyl butyrate and butyric acid) and flavor enhancers, with extrusion under different conditions, on the physical characteristics, volatile retention and sensory characteristics of extrudates was investigated. With 30% feed moisture and 170 °C processing temperature, the extrudates had greater expansion ratio and lower density, cutting force and compression force when rehydrated. Under the same extrusion conditions, addition of flavor enhancers to the soy protein isolate resulted in greater retention of isovaleraldehyde and ethyl butyrate. The aroma intensity significantly decreased and sensory acceptability significantly increased as the feed moisture reduced and processing temperature increased. Based on principal component analysis, the soy protein isolate with added volatile compounds and flavor enhancers, which was extruded under 30% feed moisture and 170 °C temperature, resulted in extrudates with desirable physical characteristics, improved volatile retention and greater sensory acceptability.

1. Introduction

Aroma is an important sensory attribute that can determine product acceptability among consumers and lead to purchases. However, it is one of the attributes most affected during thermal processing, such as in thermoplastic extrusion, because of volatile compound losses (Yuliani, Bhandari, Rutgers, & D'arcy, 2004). Consequently, aromatization of extrudates using a lipid carrier such as hydrogenated vegetable fat or vegetable oil is applied post-extrusion in the food industry, in order to add aroma and flavor to snacks. These fats or oils contribute towards bestowing high lipid content and high caloric value on the extruded snacks (Heyhoe, 2000).

Pre-extrusion flavoring is an alternative for improving the nutritive value of extruded snacks, since aromatization with a lipid carrier is unnecessary. In an attempt to enable aroma retention in pre-flavored extrudates, studies have been conducted using encapsulated aroma precursors (Kollengode & Hanna, 1997; Yuliani et al., 2004; Yuliani, Torley, D'Arcy, Nicholson, & Bhandari, 2006a,b), volatile compounds (Menis, Milani, Jordano, Boscolo, & Conti-Silva, 2013) and flavor enhancers (Conti-Silva, Bastos, & Arêas, 2012). However, difficulties in retaining the volatile compounds added to the raw material prior to extrusion remain.

Although addition of the flavor enhancers monosodium glutamate and disodium inosinate was found to reduce the retention of some volatile compounds during extrusion of corn grits (Conti-Silva et al., 2012), it seems that flavor enhancers are able to change the texture of protein materials, measured both using instruments and through sensory perception, which may be a result of protein–protein interactions that occur during the process (Cassar, Sardinha, & Arêas, 2008). Moreover, there is a lack of studies on aroma retention in matrix protein extrudates. Thus, extrusion of a soy protein isolate (90% protein on dry basis) may provide important information for understanding the changes to the final product that are caused by different extrusion and aromatization conditions.

Therefore, the aim of this study was to investigate the effects of pre-extrusion aromatization of a soy protein isolate, using volatile compounds and flavor enhancers (monosodium glutamate and disodium inosinate), and the effects of extrusion conditions on the physical characteristics, volatile compound retention, aroma intensity and sensory acceptability of the extrudates.

* Corresponding author. Tel.: +55 17 32212548; fax: +55 17 32212299.
E-mail addresses: talitagoss@yahoo.com.br (T.M.G. Milani), m.eliza@yahoo.com.br (M.E.C. Menis), jord_amanda@yahoo.com.br (A. Jordano), boscolo@ibilce.unesp.br (M. Boscolo), contisil@ibilce.unesp.br (A.C. Conti-Silva).

http://dx.doi.org/10.1016/j.foodres.2014.03.018
0963-9969/

2. Material and methods

2.1. Material

The soy protein isolate Protimart M 90, with at least 90% protein (w/w) (dry basis), was supplied by Marsul Proteinas Ltda (Montenegro, Brazil). Three liquid volatile compounds were used for flavoring the raw material: isovaleraldehyde, ethyl butyrate and butyric acid (Sigma-Aldrich, Milwaukee, USA). The flavor enhancers, monosodium glutamate monohydrate and disodium 5-inosinate, were provided by Ajinomoto Biolatina Ind. e Com Ltda (Laranjeira Paulista, Brazil). Liquid natural carmine dye (Chr. Hansen Ind. e Com. Ltda, Valinhos, Brazil) was used for measuring the residence time.

2.2. Adjustment of the moisture content of the soy protein isolate

The initial moisture content of the soy protein isolate was determined (AOAC, 1997) and was found to be 7.1 g/100 g (dry basis). Portions of 220 g of soy protein isolate were then prepared to achieve moisture contents of 30, 35 and 40 g/100 g on a dry basis. The amount of water required to adjust the moisture content was added to the feed, before aromatization and extrusion, under constant stirring with the aid of a planetary mixer at low speed. Every 3 min, 8 mL of water were added to the material using an account-drop, until the total amount of water has finished. After addition of water, the samples were packed in polyethylene bags and refrigerated for 48 h for homogenization. The final moisture content of the soy protein isolate, after adjustment to the desired values, was then determined by drying at 105 °C overnight (AOAC, 1997).

2.3. Aromatization of the soy protein isolate

Portions of 220 g of soy protein isolate were flavored under two conditions: (i) addition of 1.5 g/100 g of each volatile compound; and (ii) addition of 1.5 g/100 g of each volatile compound + 0.5 g/100 g of monosodium glutamate + 25 mg/100 g of disodium inosinate (5% in relation to glutamate monosodium) (Conti-Silva et al., 2012).

The volatiles were added by volume, based on the density of the compounds. Thus, 4.14, 3.75 and 3.46 mL of isovaleraldehyde, ethyl butyrate and butyric acid, respectively, were added to each 220 g of soy protein isolate (or 174, 129 and 170 μmol of volatile, respectively, per gram of soy protein isolate). Firstly, the flavor enhancers were added to the soy protein isolate and then the volatile compounds. For each aromatization condition, six portions of 220 g were flavored and homogenized manually in the packaging and then the packages were sealed and kept at room temperature for 2 h before extrusion.

2.4. Extrusion process

The soy protein isolate (with and without pre-aromatization) was extruded in an extruder (LAB 20, AX Plásticos, Diadema, Brazil) with a barrel of length/diameter ratio of 26:1 and a single screw of constant pitch, with a compression ratio of 4.6:1 and one exit. The die diameter was 3.3 mm and the pre-die had 34 holes of 1.9 mm each. The feed rate was kept constant at 45 g/min and the screw speed at 170 rpm. The extruder has four independent heating zones, and the first, second and fourth zones were maintained at 50, 90 and 120 °C, respectively.

The pre-aromatized and non-aromatized soy protein isolates were extruded under three conditions, which had been determined in preliminary tests: (i) intermediate condition (35% moisture and 150 °C); (ii) low moisture content and high temperature (30% moisture and 170 °C), called the most severe condition; and (iii) high moisture and low temperature (40% moisture and 130 °C), called the least severe condition. The temperature tested related to the third heating zone.

The extrusion was carried out with two repetitions to evaluate the repeatability of the process, thus totaling eighteen tests. The sequence of the tests was established from the highest to the lowest temperature and, within the same temperature, the extrusion sequence was "without volatile compounds", "with volatile compounds" and "with volatile compounds and flavor enhancers".

The torque of the process and the residence time were monitored. Ten torque measurements were collect from the extruder panel, every 30 s. To measure the residence time, half a gram of soy protein isolate blended with a drop of natural carmine dye was placed in the feeder, and the time taken for the colored extrudate to be put out was taken to be the residence time of the extrusion. Three measurements of residence time were made: at the start of the extrusion, approximately in the middle of the extrusion and at the end of the extrusion.

2.5. Evaluation of the physical parameters of the extrudates

2.5.1. Expansion ratio and density

Fifteen random measurements of the diameter and length of the extrudates were made, using digital calipers (Digimess IP54), and the weight was determined on an analytical balance. The expansion ratio was the ratio between the diameter of the extrudates and the diameter of the extruder die (Parada, Aguilera, & Brennan, 2011). The density (g/cm^3) was calculated as $\rho = 4\,W/\pi D^2 L$, where W is the weight of the extrudate (g) and D and L are the diameter and length of the extrudate (cm), respectively (Chávez-Jáuregui, Silva, & Arêas, 2000).

2.5.2. Instrumental texture analysis

Two instrumental analyses on the texture of the extrudates were performed using the TAXT2i texturometer (Stable Micro Systems, Godalming, England) and the "Texture Expert" software (Stable Micro Systems, Godalming, England).

The cutting force was measured using the Warner Bratzler probe, with a test speed of 1 mm/s. Ten samples of approximately 5 cm in length were cut perpendicularly by the probe, and the peak maximum force required, in Newtons (N), was taken to be the cutting force of the extrudate.

The extrudate was also rehydrated to measure the compression force. Ten samples of approximately 2 cm in length were immersed under water at 100 °C, without boiling, for 5 min. After this, a cylindrical aluminum probe of 2.5 cm in diameter compressed the samples at a test speed of 1 mm/s, and the force required to compress the sample to 50% of its height, in Newtons (N), was taken to be the compression force of the rehydrated extrudate.

2.6. Analysis on volatile compound retention in the extrudates

Half-gram samples of milled extrudate were weighed in vials (in duplicates for each sample type), and the volatile compounds present in the extrudates were isolated using an automated headspace sampler (40 HStrap, Perkin Elmer, Shelton, USA). The conditions used were: heating the vial at 90 °C for 30 min; needle temperature of 80 °C; vial pressurization time of 3 min; transfer line temperature of 210 °C; injection mode constant; injection duration of 0.1 min; injection pressure of 193 kPa; and column pressure of 159 kPa.

The compounds were then analyzed using a gas chromatograph (Clarus 680 T, Perkin Elmer, Shelton, USA) coupled to a mass spectrometer (Clarus 600 T, Perkin Elmer, Shelton, USA). A fused silica capillary column was used (Elite 5MS; 30 m × 0.25 mm × 1.4 μm; Perkin Elmer, Shelton, USA) with helium at a rate of 1 mL/min as the carrier gas. The gas chromatographic conditions used were: injector at 230 °C; splitless mode until 1 min, split 1:100 until 1.5 min and split 1:200 until the end of the run; column programming starting at 40 °C for 3 min, with elevation to 210 °C at 25 °C/min, and remaining at 210 °C for 2 min (total run time 12 min). The following mass spectrometer conditions were used: interface temperature 230 °C; ionization source for electron impact at 70 eV and 210 °C; and extension of mass between 40 and 120 m/z.