LWT - Food Science and Technology 87 (2018) 546–552

Contents lists available at ScienceDirect

LWT - Food Science and Technology

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

Influence of iota carrageenan addition on the properties of soya protein meat analogues

Megala Palanisamy [a, b, *], Stefan Töpfl [a], Kemal Aganovic [a], Ralf G. Berger [b]

[a] German Institute of Food Technologies (DIL e.V.), Prof.-von-Klitzing-Str. 7, 49610 Quakenbrueck, Germany
[b] Leibniz Universitaet Hannover, Institute of Food Chemistry, Callinstrasse 5, 30167 Hannover, Germany

ARTICLE INFO

Article history:
Received 15 June 2017
Received in revised form
27 August 2017
Accepted 18 September 2017
Available online 21 September 2017

Keywords:
High moisture extrusion
Soya protein
Meat analogues
Iota carrageenan
Texture improvement

ABSTRACT

The aim of the study was to investigate the effect of addition of iota (ι) carrageenan (ICGN) on physical properties (cooking yield, expressible moisture, and colour), texture, sensory parameters and microstructure of soya meat analogues produced by high moisture extrusion processing. The high moisture extrusion trials were carried out using soya protein concentrate with the addition of 0.75%, 1.5%, 2.25% and 3% ICGN (by dry mass). The colour of the extrudates was not affected drastically by the addition of ICGN. Expressible moisture and cooking yield were decreased and textural properties, such as cutting force and elasticity, were increased significantly upon the addition of ICGN. Scanning electron microscopic observations showed that increasing ICGN levels led to a more compact network in the meat analogues supporting the changes obtained in texture, cooking yield, and expressible moisture. Sensory evaluation results confirmed that the increase in ICGN concentration led to harder, more fibrous and less juicy products resulting in a significantly improved overall acceptance. The extrudate with 1.5% ICGN was preferred by the panellists.

1. Introduction

Plant protein texturization is used to develop meat analogues from plant based proteins to replace animal proteins in the human diet. One of the ways to texturize the plant proteins is through extrusion cooking. The plant-based meat analogues are produced in a way to mimic some of the qualities of meat such as texture, flavour and appearance. Since 1960, low moisture extrusion technology (<35% moisture) has been used to produce traditional meat analogues which have a sponge like texture, and these products are supposed to be rehydrated before consumption (Guy, 2001). However, these products are not well comparable in terms of appearance and texture to the meat. In recent years, high moisture extrusion technology was used to produce meat analogues and considered as a promising technology to obtain fibrous meat-like structures from plant proteins. Texturization with high moisture extrusion is entirely different from other protein texturization processes (e.g., manufacturing of sausages, cheese curds, tofu, fibre formation by spinning or by extrusion cooking, etc.) (Cheftel, Kitagawa, & Quéguiner, 1992). During extrusion, proteins are plasticized in the heating chamber of an extruder and texturized in a long cooling die at the end of the extruder by varying the moisture, temperature, pressure and shear, respectively (Noguchi, 1990). These products are semi–finished and have to be post-processed before being served (e.g., further cooking, marinating as in the meat product preparations). Traditionally, a twin screw extruder is used for texturization. In this study, a planetary roller extruder (PRE) was used which produced less shear during extrusion compared to a twin screw extruder. The most common protein source used for the meat analogues production until to date is soya beans. Soya bean based ingredients, such as soya flour, protein concentrate and protein isolate, have been successfully used in the food industry for many years to develop meat analogues. Other plant protein sources considered for meat analogue production are wheat, cotton seed, legumes, lupine, pea etc. (Asgar, Fazilah, Huda, Bhat, & Karim, 2010).

One of the main problems considering the consumer acceptance of meat analogue products is texture. The texture may be modified or improved by adjusting the process conditions or by incorporating food additives. Polysaccharides are one of the main additives generally used in food industries for texture optimization. The effect of hydrocolloids on low moisture texturized soya protein was

* Corresponding author. German Institute of Food Technologies (DIL e.V.), Prof.-von-Klitzing-Str. 7, 49610 Quakenbrueck, Germany.
E-mail address: m.palanisamy@dil-ev.de (M. Palanisamy).

https://doi.org/10.1016/j.lwt.2017.09.029

investigated by Boison, Taranto, and Cheryan (1983) and Berrington, Imeson, Ledward, Mitchell, and Smith (1984). To date, no studies were conducted on the effect of hydrocolloids on the soya protein texturization with high moisture extrusion.

In this study, iota (ι) carrageenan (ICGN) was chosen as an additive to incorporate during the extrusion process to improve the texture and functional properties of meat analogues. Carrageenans are sulfated anionic polysaccharides extracted from red algae. There are three main types of carrageenan called kappa (κ), iota (ι) and lambda (λ). They are differentiated based on the number and position of sulfate groups on the galactose/anhydrogalactose chain. κ-carrageenan contains one sulfate group, whereas ι and λ have two and three per disaccharide repeating unit, respectively (Imeson, 2000). Carrageenans are applied in food products as stabilizers, thickeners and gelling agents (Dickinson & Pawlowsky, 1997). Under certain conditions, κ-carrageenan and ICGN are able to form thermoreversible gels. In contrast, λ-carrageenan does not possess gelling capacity and is mainly used as thickening agent in foods (Yuguchi, Thu Thuy, Urakawa, & Kajiwara, 2002).

Various specific interactions, such as H-bonding, hydrophobic and steric interactions are responsible for the hydrocolloid-protein interactions (De Kruif & Tuinier, 2001). Sulfated polysaccharides form soluble complexes with proteins above their isoelectric pH (Kilara, 2005). Sulfate groups from the polysaccharides interact with positively charged sites available from protein moieties, such as ε-amino, α-amino, guanidinium, and imidazole. The intensity of the reaction varies depending on the number and distribution of these sites and overall charge of the protein.

In preliminary experiments, different types of carrageenans, such as κ-Carrageenan, sodium ICGN, calcium ICGN and λ-Carrageenan were used for the extrusion trials (results not shown). It was found that calcium ICGN had a positive influence on the texture. Hence, different percentages of ICGN were applied and the effects on the properties of soya meat analogues were investigated.

2. Materials and methods

2.1. Materials

Soya protein concentrate (ALPHA 8 IP) was purchased from Solae, LLC (St. Louis, Missouri, U.S.A.) and it contained 4.6% of moisture, 66.5% of protein and 2% of fat according to manufacturer's data. ICGN was obtained from Welding GmbH, Hamburg, Germany. According to manufacturer's information, ICGN contained 3% $CaCl_2$ as a residue from the manufacturing process.

2.2. High moisture extrusion cooking

The high moisture extrusion of soya protein concentrate and ICGN blends was carried out using a PRE (ENTEX Rust & Mitschke GmbH, Münster, Germany). The PRE is configured with a tempered jacket, rotating screws and an outlet die. The working mechanism of PRE is different compared to traditional single and twin screw extruders, as it works like a planetary gear. In twin screw extruders, mechanical energy dominates, whereas in PRE thermal energy is the dominant energy. An internal teethed pipe is connected to the jacket of the PRE. The long central screw is connected with the motor. When the extruder is operated, the central screw first starts to rotate and thereby initiating simultaneous the rotation of the planets. Thus, the material is conveyed by rolling up and drawn to the outlet die. The working principle of PRE is shown in Fig.1.

Length of the whole central pipe and teethed pipe is 1248.8 mm and 1348.5 mm respectively. Inside diameter of the outlet die is 14 mm. Inside the extruder there are three rotator parts, each with 400 mm length. In each of the rotators, six planets are integrated which are rotating the material inside, causing a thin layering of the material. Among the six planets, three are 399 mm and other 3 are 378 mm long.

At the end of the extruder, a cooling die was attached. Internal dimensions of the cooling die were 4.8 × 1.2 × 100 cm (W × H × L). ICGN was added with soy protein concentrate at the concentrations of 0.75%, 1.5%, 2.25% and 3% of dry mass, and the dry raw material blend was fed to the extruder at the rate of 6 kg/h. Water was fed at the rate of 10 kg/h. Temperature of zones 1 to 3 (60 °C, 135 °C, and 125 °C), cooling die (20 °C) and screw speed (50 rpm) were kept constant. A pressurized water unit system was used to heat the 3 extruder processing zones. The extrusion trials were performed in duplicates, and the samples were collected and stored at −20 °C until analyses.

2.3. Moisture content

The moisture content of the extruded meat analogue samples was analysed according to the AACC method (2000).

2.4. Physical properties

2.4.1. Cooking yield

The extruded samples were cut into 2 × 2 cm (L x W) cubes and cooked for 20 min in water at 80 °C. The mass before and after cooking was measured and cooking yield is calculated using equation (1).

$$\text{Cooking yield (\%)} = (\text{Mass of cooked sample/Mass of raw sample}) \times 100 \quad (1)$$

2.4.2. Expressible moisture

The modified Hamm procedure (Grau & Hamm, 1957) was used to analyse the expressible moisture. Around 1 g of cooked meat analogue was placed between two filter papers and placed under a manual press weighing around 10 kg. The sample was subjected to pressure for 2 min.

Mass of the sample was taken before and after the pressing, and expressible moisture was expressed as a percentage of the net mass difference from the initial mass (equation (2)).

$$\text{Expressible moisture (\%)} = (\text{initial mass - squeezed mass}) / (\text{initial mass}) \times 100 \quad (2)$$

2.4.3. Colour measurement

Colour measurements of the extruded samples and raw material mixtures were performed using spectrophotometer (CM-600, Konica Minolta Sensing Inc., Japan). The instrument records the L* (lightness), a* (green-red) and b* (blue-yellow) values. The measurements were taken at six different points on the surface of each of the samples. Total colour difference (ΔE) of the samples was calculated according to Altan, McCarthy, and Maskan (2008) using equation (3).

$$\Delta E = \sqrt{(L - L_0)^2 + (a - a_0)^2 + (b - b_0)^2} \quad (3)$$

The subscript 0 indicates the measurements of the raw material mixtures.