Food Hydrocolloids 67 (2017) 94–103

Contents lists available at ScienceDirect

Food Hydrocolloids

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

The effect of composition and aeration on selected physical and sensory properties of freeze-dried hydrocolloid gels

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ARTICLE INFO

Article history:
Received 21 December 2015
Received in revised form
21 December 2016
Accepted 31 December 2016
Available online 3 January 2017

Keywords:
Aeration
Hydrocolloids
Freeze-drying
Sensory analysis
Porosity
Sugar

ABSTRACT

This study shows the effect of an aerated structure changed by the addition of sugar and citric acid as well as aeration time on selected physical and sensory properties of freeze-dried hydrocolloid gels. Different hydrocolloids were used to prepare 3 types of gels: low-methoxyl pectin, a mixture of xanthan gum and locust bean gum, and a mixture of xanthan gum and guar gum, with and without sugars and citric acid. Gels were aerated for 5 and 9 min and after gelation were frozen (−45 °C, 2 h) and freeze-dried (30 °C, 24 h). Porosity, texture properties and color of the freeze-dried gels were investigated in relation to their sensory attributes. The flavor of the obtained samples was investigated as well. It was demonstrated that, in most cases, elongation of aeration time had no influence on the investigated properties, and that the type of hydrocolloid allowed obtaining diverse structures as well as physical properties and sensory analysis of the finished products. The addition of sugar and citric acid was found to strengthen gels structure.

1. Introduction

Consumers are interested in food products which are health-promoting as well as attractive. For food quality and attractiveness, texture and flavor are very important (Lawless & Heymann, 1998). Texture of dried foods can be described with the use of crispness and hardness as important criteria that affect consumer acceptance (Huang, Zhang, Mujumdar, & Lim, 2011; Salvador, Varela, Sanz, & Fiszman, 2009; Szcześniak, 2002). This parameter may be defined as "all the mechanical, geometrical and surface attributes of a food product perceptible by means of mechanical, tactile and, where appropriate, visual and auditory receptors" (Barbosa-Cánovas, 2009). Texture investigations very often involve sensory analysis techniques with the use of panel members who can perceive and describe specific textural attributes such as "hardness, firmness", because a sensory properties cannot be measured in simply way by analytical tests, but detected by several senses (Salvador et al., 2009; Szcześniak, 2002). It is still not known exactly whether the panelist will react to the physical stress or to the strain, but although some of texture estimation is performed visually, the main evaluation occurs in the mouth (Szcześniak, 2002).

From a perception point of view, firmness is the most important sensory attribute for consumer preference in organoleptic quality of a product and for its attractiveness and nice mouth-feel (Renard, van de Velde, & Visschers, 2006). Mechanical property as hardness is an important parameter in dried fruit related to expansion, whereas crispness is synonymous of freshness related to the cellular structure of food (Saeleaw & Schleining, 2011).

The incorporation of air allows changing of food mass and volume which affect satiety as well as texture and firmness, thus making the product softer, but also changes its appearance, color and mouth-feel (Labbafi, Thakur, Vial, & Djelveh, 2007; Rolls, Bell, & Waugh, 2000). The new aerated food products which appear on the market seem to have less calories, because food aeration reduces the weight and consumed energy, but obtained results showed that volume is independent of weight, and can have an effect on food and energy intake (Osterhold, Roe, & Rolls, 2007). Aerated gels with tailored texture, lowered density and attractive flavor properties can be used in developing new dietetic food. In comparison to traditional products, aerated gels may confer sensory and marketing advantages such as softness, more uniform distribution of flavors and an enhanced homogeneity of food products (Labbafi et al., 2007; Zúñiga & Aguilera, 2008).

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http://dx.doi.org/10.1016/j.foodhyd.2016.12.042

For food producers, who want to manufacture attractive gelled food products, it is important to understand the relationships between the perception of food texture and its structure. The replacement of different ingredients usually changes food structure. Consumers often perceive such a product as with less attractive texture or mouth-feel. The key to prevent the rejection of a new food product by the consumers is the control and adjustment of sensory perception. The relationship between food structure and its sensory properties is very important (Renard et al., 2006). Wilson and Brown (1997) showed that increasing hydrocolloid content as well as sugar addition allowed modifying the mechanical properties and had a significant effect on the perceived flavor intensity of the gelatin gel. Different matrix structures and compositions influence on the release of flavor from food matrices.

Pectins are anionic polysaccharides extracted from cell walls of most plants, consisting of a backbone of polygalacturonic acid (Fang et al., 2008; Galus & Lenart, 2013; Siew & Williams, 2008). Amide pectin is formed by hydrolysis of high-methoxyl pectin. This hydrocolloid needs less calcium to gel than the non-amidated pectins and obtained gels are thermoreversible (Tho, Sande, & Kleinebudde, 2005; Świderski & Waszkiewicz-Robak, 2003).

Combining the xanthan gum with guar gum and locust bean gum allows increasing synergistic viscosity (Copetti, Grassi, Lapasin, & Pricl, 1997). The relations between xanthan gum and locust bean gum and gel properties are influenced by a number of variables, such as gum concentration, gum ratio and hydrogen ion concentration. The synergistic gelling reaction can be used to add new and to improve the existing texture and rheological characteristics of food products, which may reduce polymers coasts (Renou, Petibon, Malhiac, & Grisel, 2013; Williams & Phillips, 2000, pp. 1–19).

Hydrocolloid gel products can be preserved by the freeze-drying process, which enables the development of their interesting properties (Ciurzyńska, Lenart, & Traczyk, 2013). This method is recommended for the drying of hydrogels, because their porous structure is not damaged (Sundaram & Durance, 2008). Such a product is an easy model system in the study of cellular solids. Some researchers (Gibson & Ashby, 1997; Nussinovitch, Velez-Silverstre, & Peleg, 1993) argue that microstructure and mechanical properties of sponges may be controlled by gel composition and preparation conditions. Therefore, an attempt to create the structure and properties of the freeze-dried gels by the diverse composition and aeration time was made.

The aim of this work is to study the influence of aerated structure created by hydrocolloids in freeze-dried gels on the development of physical and sensory properties of these products. The scope of the research involves analysis of the effect of composition changes by sugar addition, aeration time and hydrocolloid type on the structure and physical as well as sensory properties of the final product.

2. Materials and methods

2.1. Materials and samples preparation

An amidated low-methoxyl pectin ***LMP,*** a mixture of xanthan gum and locust bean gum ***KG*** + ***LBG*** and also a mixture of xanthan gum and guar gum ***KG*** + ***GG*** were used to prepare gels. Pectin Amid AF 020-E with degree of amidation 18–23%, and degree of esterification 27–32%, (Herbstreith & Fox KG Pektin Fabriken, Germany), xanthan gum E 415, guar gum 5000–5500 CPE E 412, and locust bean gum E 410 (Company Trade and Industry “Standard” Lublin, Poland) were purchased from Sovit Jarosław Buczkowski general partnership. Calcium lactate (manufactured by Hortimex, Poland) was added to the gels with amidated low-methoxyl pectin.

The effect of composition modification was investigated by adding sugars (crystal sucrose) – Sugar Factory Glinojeck S.A., Poland; crystal glucose (8% water content) produced according to PN-84/A-74771 – JAR manufacturer, Jaskulski Flavors, Poland); and citric acid (Hortimex Company) in values typical of strawberry fruit to obtain a strawberry model. This product will allow developing an innovative strawberry product with tailored structure.

The same gel preparation parameters for all types of hydrocolloids were maintained and described by Ciurzyńska and Lenart (2016). Powdered hydrocolloids were added to distilled water (~70 °C) in amounts determined experimentally for obtaining a compact gel cubes. During the mixing with a hand mixer Bosch MSM87160 (max 10 secounds) ingredients were dissolved. Next, sugars and citric acid were added to samples were composition was changed and mixture were mixed about 10 secounds and then aerated for 5 and 9 min at a temperature of ~60 °C, which prevented quick gelation during aeration. After solidification aerated gels were poured out on a plate, and cut into cubes (1 cm). The gels cubes were frozen (freezer mod 51.20, IRINOX SPA -45°C/2 h) and freeze-dried (Alpha 1–4 LSC Plus Christ Company, constant parameters: pressure 63 Pa, and temperature 30 °C/24 h). Freeze-dried gel cubes were tightly closed in glass vessels and stored in a dark place at room temperature until analyzed. The composition of the obtained freeze-dried hydrocolloid gels is presented in Table 1.

2.2. The sensory analysis

The sensory analysis of texture was conducted for freeze-dried gels with the use of a 9-point rating scale (with 1 as the worst, and 9 as the best on the scale). Estimations were carried out by a team of staff and doctoral students from the Department of Food Engineering and Process Management of Warsaw University of Life Sciences, including ten persons. Assessment was made on the basis of the scale developed in accordance with: PN-ISO 4121 and PN-ISO 11036. Sensory evaluation of texture changes was made based on the evaluation of aeration and hardness (PN-ISO 11036). Color changes and flavor were assessed with the use of PN-ISO 4121.

2.3. Color determination

Color of the freeze-dried gels surface was measured with the use of Konica Minolta Company Spectrophotometer CM-5 in CIE L^*, a^*, b^* system. The measurements were made in 5 replications for all dried samples. The average value was calculated from the obtained results (Ciurzyńska & Lenart, 2009, pp. 217–224).

2.3.1. The absolute difference in color

$$\Delta E = \sqrt{\left(L^{*\prime} - L^*\right)^2 + \left(a^{*\prime} - a^*\right)^2 + \left(b^{*\prime} - b^*\right)^2} \qquad [1]$$

where:

ΔE – the absolute difference in color
L^* - the lightness coefficient
a^* - the red color coefficient
b^* - the yellow color coefficient
′ - coefficients of the gels before freeze-drying.

2.4. Porosity determination

Porosity of the raw material was measured with a helium pycnometer (Quantachrome Company, USA) according to the producer's instruction (Ciurzyńska & Lenart, 2016; Szulc & Lenart, 2013). The apparent density of the investigated samples was