LWT - Food Science and Technology 53 (2013) 255–261

Contents lists available at SciVerse ScienceDirect

LWT - Food Science and Technology

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

Textural characterisation of gellan and agar based fabricated gels with carrot juice

Soumya Banerjee, R. Ravi, Suvendu Bhattacharya*

Central Food Technological Research Institute (Council of Scientific and Industrial Research), Mysore, India

ARTICLE INFO

Article history:
Received 4 June 2012
Received in revised form
15 December 2012
Accepted 12 February 2013

Keywords:
Gel
Carrot
Hydrocolloid
Texture
Sensory

ABSTRACT

Carrot juice (1:1, w/w) based gels, made from gellan and agar with sucrose (7.5 and 15 g/100 g), have been examined for the mechanical characteristics (fracture force and strain, and energy for compression) in addition to sensory attributes and syneresis. Incorporation of carrot juice in gellan gels markedly increases fracture force and energy for compression; syneresis increases to as high as 2 g/100 g. The fracture strain for gellan gels (30–40%) is higher than that of the agar sample (18–22%) meaning the more brittle nature of the latter samples. Gellan gels are much tougher and resist compression compared to agar samples at solid concentrations of 1 g/100 g. The sensory cohesiveness for carrot juice–gellan gels is higher than the corresponding gellan gels without carrot juice. In the case of agar gels, an increase in the sugar level increases sensory hardness, springiness, stickiness and cohesiveness while juiciness shows a different trend. The addition of sucrose in all these formulations improves cohesiveness. The application of principal component analysis to interrelate sensory and objective parameters indicates that the sensory juiciness stands separated from the remaining objective and sensory attributes.

1. Introduction

Several hydrocolloids like agar, alginate, carrageen, gellan, xanthan, gelatin and their mixtures are frequently used for developing specialty and fabricated food gels. Among these gel forming hydrocolloids, agar does not require the presence of any cation for gelation. In hot dispersions, agarose molecules tend to behave as stiffened coils, and form turbid gels of reversible characteristics when they are cooled below 40 °C (Aguilera & Stanley, 1999). The microbial polysaccharide gellan gum produces gels at a low concentration when its hot dispersion is cooled. The substituted form of gellan produces soft elastic gels whereas the un-substituted types yield hard and brittle gels (Ortega & Sanderson, 1994). Mixed gels using more than one hydrocolloid are also used to develop specialty products. A binary blend of gelling polymers can provide superior properties than a single component system (Banerjee & Bhattacharya, 2011). Mixed gels may also be superior for consumer acceptance, economic advantage and nutritional status (Kayacier & Dogan, 2006). For example, oxidised cellulose with other gelling agents has drawn attention as the cholesterol reducing agent in functional foods (Agoub & Morris, 2008). It is also interesting to understand the characteristics of mixed gels particularly when other additives are incorporated in the formulations.

Fruit purees/juices along with a gelling agent can develop novel food products (Mancini & McHugh, 2000). Ortega and Sanderson (1994) have studied the characteristics of alginate–gellan mixed gels; the mechanical properties of pure gels are different from the gels made with pulp. An increase in the concentration of pulp reduces the strength of the gel while the addition of agar offers brittle and stiff gels (Nussinovitch & Peleg, 1990). The use of fruit juice/pulp in gelled and similar products has been reported (Liang et al., 2006; Manjunatha & Das Gupta, 2006; Mouquet, Dumas, & Guilbert, 1992; Nussinovitch, Kopelman, & Mizrahi, 1991; Saha & Bhattacharya, 2010).

Gels formed by gellan gum are characterised by their sparkling clarity, good flavor release, rapid setting behavior and the requirement of low gelling concentrations (Sworn, 2000). Several factors influence the texture of gellan gels; these include gum concentration, pH, temperature and the presence of metal ion, acid and a co-solute like sugar. Yamamoto and Cunha (2007) have studied the effect of pH, concentration and heat treatment on gellan gel along with the use of a slow acid releasing agent like glucono-δ-lactone (GDL). The effect of sugar on texture has been investigated for gellan gels (Bayarri, Costell, & Duran, 2002; Gibson, 1992; Saha & Bhattacharya, 2010; Sworn & Kasapis, 1999; Tang, Mao, Tung, & Swanson, 2001). The use of carrot juice and fibre/pulp in gels has been reported by Liang et al. (2006) and Manjunatha and Das Gupta (2006). The general conclusion that can

* Corresponding author. Food Engineering Department, Central Food Technological Research Institute, Mysore 570020, India. Tel.: +91 821 2513910; fax: +91 821 2517233.
E-mail addresses: suvendu@cftri.res.in, suvendu1111@yahoo.co.in (S. Bhattacharya).

0023-6438/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.lwt.2013.02.011

be derived from these studies is that a nutritious gel with carrot can be developed particularly with gellan.

However, data on the detailed textural attributes of carrot juice/pulp based gellan/agar gum gels with different additives are scarce. A study on the development of such a nutritious gel including its textural attributes possesses a good chance of commercial application. Therefore, the objective of the present investigation is to determine the textural attributes of carrot juice–sucrose based gellan and agar gels.

2. Materials and methods

2.1. Materials

Food grade powders of agar agar and gellan gum were procured from Loba Chemie and Himedia Laboratories, Mumbai, India, respectively. The proximate composition and mineral contents of gellan gum and agar powder were reported earlier (Banerjee & Bhattacharya, 2011). Carrot was procured from a local supermarket. Distilled deionised water and analytical grade chemicals were used throughout the study. Standard β-carotene was purchased from Sigma–Aldrich, St. Louis, MO, USA. Sucrose in the form of cane sugar crystals was procured from a local supermarket.

2.2. Methods

2.2.1. Aqueous dispersion of hydrocolloid

Agar and gellan (1 g/100 g, w/w) as individual samples were dispersed in deionised distilled water with continuous stirring for 30 min followed by hydration for 16 h at the cold room temperature (about 10 °C). Latter, these hydrocolloid dispersions were heated in a water bath maintained at 90 °C for 30 min.

2.2.2. Carrot gel

Carrots were washed with water, peeled and grated using a stainless steel domestic grater. The approximate length and thickness of grated carrots were 22.7 ± 1.2 and 0.7 ± 0.1 mm, respectively. Carrot juice was squeezed out after boiling 100 g grates in 100 g of boiling water for 10 min; latter, the juice was added to hydrocolloid dispersions (1:1, w/w) for preparing gels. Sucrose (7.5 and 15 g/100 g of the total mass of juice and hydrocolloid sol) was added to this juice–hydrocolloid sol followed by mixing for 5 min in a magnetic stirrer; the temperature at the time of mixing was between 80 and 90 °C. After an initial cooling to about 65 °C, the sol was transferred to petri plates (internal diameter 34 mm and height 11 mm) and allowed to set for 20 h at room temperature with cover. Afterward, the gels were manually removed from the petri plates to obtain short cylindrical gels for further testing. The experimental plan for developing gellan and agar based gels with carrot juice is shown in Table 1. All experiments were repeated thrice.

2.2.3. Texture

The formed gels (average diameter and height were 33.8 and 10.7 mm, respectively) were subjected to texture testing in an universal texture measuring instrument (Model # TA-HD, Texture Analyser, Stable Microsystems, Surrey, UK) with a full load capacity of 50 kg. The top and bottom parts of gels were covered with a thin sheet of polypropylene while the sides were lubricated with paraffin oil to avoid moisture loss during testing. Samples were compressed by a flat compression plate of diameter 100 mm, and compressed up to 50% of its original height by employing a cross-head speed of 1 mms^{-1}. The different textural indices like fracture force, fracture strain and energy for compression were computed by analyzing the force–deformation curves (Ravi, Roopa, & Bhattacharya, 2007). Fracture force was the force at which there was a sharp decrease in force due to fracture; the corresponding strain was calculated as the height at which fracture force was exhibited divided by the un-deformed height of the sample, and expressed as per cent basis. The energy for compression was noted by determining the area upto 50% compression. Five samples were tested each time.

Table 1
Experimental plan for developing gellan and agar based gels with carrot juice.

Experiment no.	Concentration of hydrocolloid (g/100 g)		Carrot juice (g/100 g)	Sugar (g/100 g)	Water (g/100 g)
	Gellan	Agar			
1	1.0	0	0	0	99.0
2	1.0	0	0	7.5	91.5
3	1.0	0	0	15.0	84.0
4	1.0	0	50	0	49.0
5	1.0	0	50	7.5	41.5
6	1.0	0	50	15.0	34.0
1	0	1.0	0	0	99.0
2	0	1.0	0	7.5	91.5
3	0	1.0	0	15.0	84.0
4	0	1.0	50	0	49.0
5	0	1.0	50	7.5	41.5
6	0	1.0	50	15.0	34.0

2.2.4. Syneresis

Syneresis of gel was determined by using the method of Keogh and O'Kennedy (1998). Hot hydrocolloid dispersions (30 ml) were allowed to set for 2 h in graduated centrifuge tubes of capacity 50 ml followed by storing in a refrigerator at 4 °C for 72 h. Latter, the samples were allowed to warm in a water bath, maintained at 30 °C for 2 h. These centrifuge tubes containing pre-weighed gel samples were centrifuged at 6000 rpm (3204× *g*) for 10 min in a laboratory model centrifuge (Model # TC 4100D, Eltek Research Centrifuge, Mumbai, India). The supernatant was poured off, weighed and expressed as per cent syneresis considering the original mass of the sample.

2.2.5. Composition

The oven drying method was used to determine the moisture content of carrot and carrot juice (AOAC, 2005). The pectin and β-carotene contents of carrot and carrot juice were determined as per the method mentioned by Ranganna (1991). All determinations were conducted on triplicate samples. The pectin content was reported as calcium pectate and expressed as percent basis using Eq (1), while Eq (2) was used to calculate the β-carotene content.

$$\text{Calcium pectate}(\%) = \frac{\text{Mass of calcium pectate} \times 500 \times 100}{\text{Amount of filtrate for estimation} \times \text{Mass of sample}} \quad (1)$$