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Radiation effects on agar, alginates and carrageenan to be used as food additives

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Abstract

Agar, alginates and carrageenan are hydrocolloids that induce stabilization of physical properties of the food product during shelf life and prevention of undesirable changes such as moisture migration, gas cell coalescence or textural profile changes. In this work, agar, alginates and carrageenan was irradiated as powder with different doses (0–10 kGy) of Co-60 and the rheological functional performance of water solutions of these irradiated additives was studied. The results are analyzed taking in account the future applications of those additives in irradiated foods. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: Agar; Alginates; Carrageenan; Ionizing radiation; Viscosimetry

1. Introduction

Food additives are chemical substances able to enhance flavor, to add color, to preserve or to change the consistency. They are usually controlled by legislation in the form of lists of permitted substances and their presence in food has to be indicated in the manner laid down in regulations governing food-labeling (Yudkin, 1986).

In the human food industry, agar is used mainly as a gelling agent and in a secondary way as a stabilizing agent and for controlling viscosity. It is used in confectionery to prepare jellies, marshmallows and candies or candy fillers. Because the human body does not easily digest agar, its calorie contribution is negligible and thus agar can be used in special diet food.

Alginates have a long history of use in foods and their uses are based mainly on their thickening, gelling, film formation, stabilizing and general colloidal properties. Thickening is useful in sauces, syrups and toppings for ice cream, in pie fillings it reduces moisture retention by the pastry, in cake mixes it thickens the batter aids moisture retention and in canned meat and vegetables it can give either temporary or delayed-action thickening.

Carrageenans are used in emulsion stabilization, for syneresis control and for bodying, binding and dispersion. Major uses are in foods, particularly dairy applications (McHugh, 1987). Carrageenans and cellulose gels are used to improve texture and flavor in reduced fat and caloried confections to simulate full-fat products by providing the necessary viscosity and stability (Izzo et al., 1995).

As commercial applications of food irradiation become more accepted and viable, the technology will increasingly be applied not only to agricultural products, as a pest disinfestation method, but also on food ingredients and ready meals. In that sense, ir-

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radiation is often viewed as being the last process after packaging to control pathogenic and spoilage organisms.

The purpose of the present study is to investigate the effects of Co-60 ionizing radiation on the rheological behavior of agar, alginates and carrageenans.

2. Materials and methods

2.1. Materials

Agar powder was purchased from Across Organics, NJ, USA. The carrageenan kindly supplied by Carragel/Namagel NM, a mixture of kappa- and iota-carrageenans distributed by Gelymar-Adicon Industria e Comércio de Aditivos Ltda, SP, Brazil, *and* the alginate was Kelgin® LV Algin from NutraSweet Kelco Co., of low viscosity, ground, granular sodium alginate suitable for use in industrial applications.

2.2. Irradiation

Irradiations were performed in a Co-60 Gammacell 220 (AECL), dose rate 8.4 kGy/h with doses of 0, 1.0, 2.5, 5.0 and 10.0 kGy, dose uniformity factor: 1.13. For the irradiation, the samples were contained in 30 ml-glass tubes.

2.3. Viscosimetry

Viscosimetry techniques developed previously at the laboratory were applied (Bernardes and Del Mastro, 1994). A Brookfield viscosimeter, model LV-DVIII, spindle SC4-18, with an adapter for small samples (8 ml) and a Neslab water bath, precision $\pm 0.1°C$ was employed. Dilutions of agar at 1% were prepared by heating directly in a flame until crystalline solutions were obtained. Alginate dilutions were prepared at 1% by slowly addition of the product to distilled water at room temperature stirring for 2 h. Carrageenan was prepared at 1% at about 70°C. Viscosity measurements were the average of at least 3 determinations.

3. Results and discussion

The effects of radiation on the viscosity of agar solutions were measured in the temperature range between fusion and gellification. Figs. 1a and b shows the agar viscosity measured as a function of dose at 45 and 60°C. The application of gamma-irradiation treatment resulted in a decrease of viscosity being the effect more evident at the lower temperature, near the gellification temperature.

For the solutions of agar at 45 and 60°C, the equations found were respectively:

$$y = 2.1031 + 3.01846e^{-x/9.71801} + 1.20446e^{-x/1.19781}$$

and

$$y = 1.9165 + 2.05987e^{-x/3.20620} + 1.15654e^{-x/14.25435}$$

Figs. 2a–c show the results of the measurements of rheological properties of alginate solutions prepared with irradiated samples. As expected, the lower the temperature, the higher viscosity values. The equations found for the relationship between viscosity and dose for alginate solutions at 25, 15 and 5°C were (1), (2) and (3) respectively:

$$y = 3.68896 + 52.13824e^{-x/5.1197} + 12.48919e^{-x/27.72652} \quad (1)$$

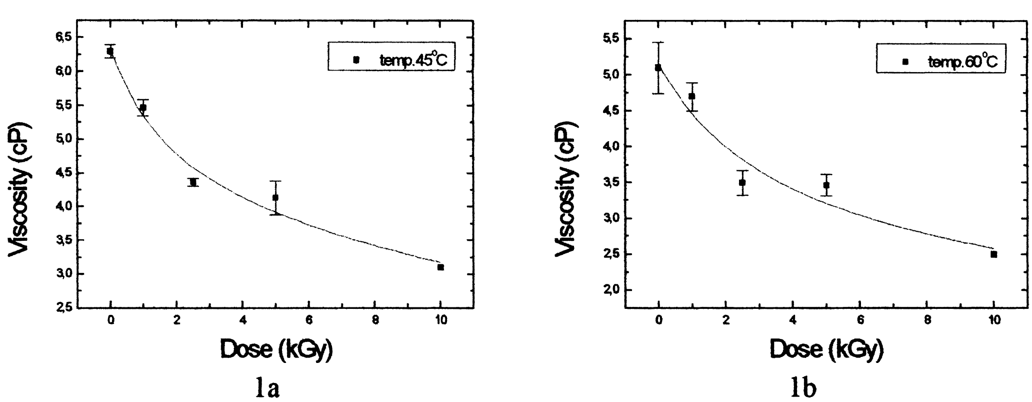

Fig. 1. Viscosity measurements of agar solutions vs radiation dose (a) readings at 45°C; (b) readings at 60°C.

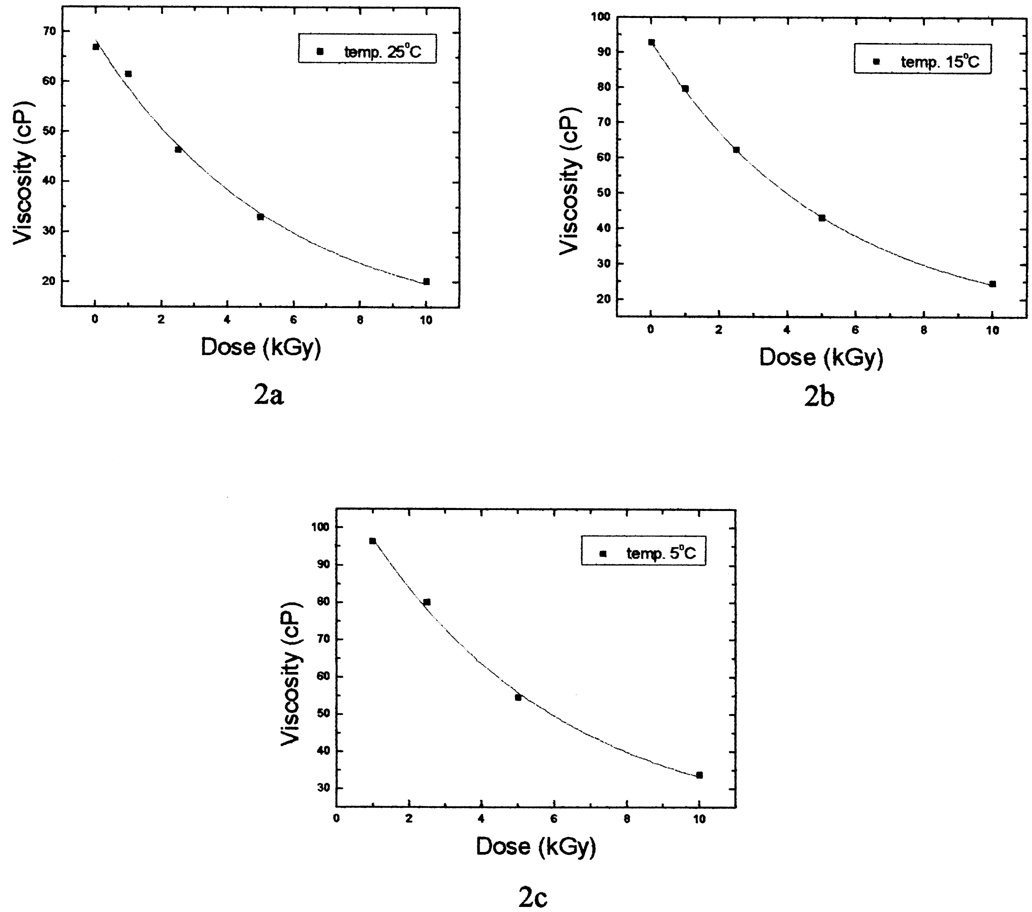

Fig. 2. Viscosity of alginate as a function of irradiation dose, 60 rpm at (a) 25°C, (b) 15°C and (c) 5°C respectively.

$$y = 10.43121 + 59.30079e^{-x/4.5752} + 23.43602e^{-x/8.61035} \quad (2)$$

$$y = 14.43453 + 58.87028e^{(-(x-1)/4.80477)} + 23.88089e^{(-(x-1)/10.03711)} \quad (3)$$

Similarly, the viscosity of carrageenan solutions of irradiated samples were compared with the unirradiated ones. Fig. 3 shows the result of that experiment, where the temperature of measurement was 50°C. A decrease in the viscosity is also shown as the radiation dose increased. It seems to be the radiation responsible by the degradation of the macromolecules producing smaller polysaccharide units. As it was established previously (Urbain, 1986), the most important change in polysaccharides caused by irradiation is the depolymerization of basic units by the breakage of glycosidic bonds, being the radiolytic products smaller polysaccharide units which give softer gels.

For the solutions of carrageenan at 50°C, the equation found was:

$$y = 1.42377 + 1.30806e^{-x/0.56339} + 1.70118e^{-x/3.14146}$$

For all the polysaccharides used, irradiation induced a decrease in viscosity as a function of dose. Other types

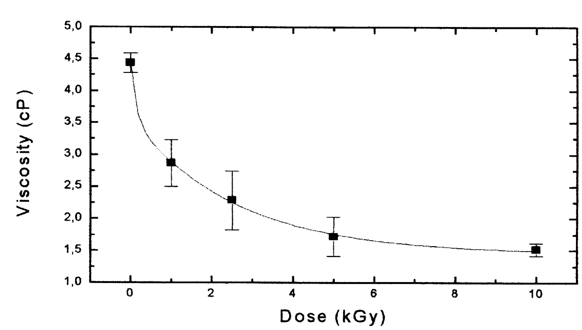

Fig. 3. Viscosity of carrageenan solutions vs radiation dose (average of 3 determinations), 250 rpm and 50°C.

of evaluation must be performed in order to assess the whole influence of radiation on the properties of these additives.

Anyway, as these phycocolloids are used at concentrations smaller than 2%, the partial loss of viscosity could be in most of the cases insignificant for the final product. Research efforts will continue to explore the versatility of these sorts of hydrocolloids especially in low-fat systems for all market segments of food industry.

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