# Radiation Protection by Ascorbic Acid in Sodium Alginate Solutions

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***Abstract***

Alginates are gelling hydrocolloids extracted from brown seaweed used widely in the nourishing and pharmaceutical industries. As alginic acid gellification retard food entrance in the stomach alginate is an additive used in diets. The objective of this work was to study the protective action of the ascorbic acid in alginate solutions against the action of $^{60}$Co gamma radiation. One % (w/v) solutions of alginate had been used and concentrations of ascorbic acid varied from 0 to 2.5% (w/v). The solutions were irradiated with doses up to 10 kGy. Viscosity/dose relationship and the pH of the solutions at 25°C were determined. Ascorbic acid behaved as an antioxidant against radiation oxidative shock in this model system of an irradiated viscous solution. Besides its radiation protective role on alginate solutions ascorbic acid promoted a viscosity increase in the range of concentrations employed.

## 1. INTRODUCTION

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 [1]. The major matrix component in brown algae is a gelling polyuronide called alginate. Alginate forms strong gels in the presence of excess calcium cations. Guluronic acid-rich sodium alginate is more soluble in water than manuronic acid-rich sodium alginate. Solubility seems to be a leading cause of retardation of food intake in alginate diets, due to the gelling of alginic acid in the stomach. Animals fed guluronic acid-rich alginate display a significantly lower food intake and grow more slowly than those consuming manuronic acid-rich alginate. In addition, sodium alginate slows gastric evacuation in humans [2].

Ascorbic acid and tocopherols are widely distributed in human diet and have been reported to scavenge active oxygen species and prevent cell damage [3]. There are evidences that antioxidants can scavenge or quench free radicals generated by irradiation

[4]. Nutrients like ascorbic acid or vitamin C present a crucial role in the prevention or delay of the onset of degenerative diseases. These nutrients act as antioxidant, being responsible for the neutralization of oxidative processes generated by free radicals in animal organisms. Ascorbic acid is noted for its complex multi functional effects. Depending on conditions ascorbic acid can act as an antioxidant, pro-oxidant, a metal chelator, a reducing agent or an oxygen scavenger. In aqueous systems containing metals, ascorbic acid can act as a pro-oxidant by reducing the metals, which become more active catalysts of oxidation in their lower valence state. In the absence of added metals, ascorbic acid is an effective antioxidant at high concentrations. In non-aqueous media, ascorbic acid and esters are not good antioxidant [5].

The interest in using natural antioxidants as additives by the food industry continues to grow because they are presumed to be safe since they occur in foods and have been used for centuries, and the question of safety of synthetic compounds can thus be avoided [5]. Antioxidants are substances that can delay the onset or slow the rate of oxidation of autoxidizable materials. Literally hundreds of compounds, both natural and synthesized, have been reported to possess antioxidant properties. Their use in food, however, is limited by certain obvious requirements not the least of which is adequate proof of safety. For maximum efficiency, sometimes primary antioxidants are often used in combination with other phenolic antioxidants or with various metal sequestering agents [6].

There is an increasingly important research discipline that studies physical properties at the macromolecular and particle scale in complex food structures. Research techniques are also getting more sophisticated, including increasing use of oscillatory rheometry for viscoelasticity measurements, a wide range of microscopy and light-scattering techniques for quantitative structural analyses, and complex calorimetric analyses for thermal properties and glass transitions, to name a few [7]. The sensitivity or stability against ionizing radiation of ascorbic acid present in food or in vitro systems was the subject of different research [8][9]. On the other hand, the capability of ascorbic acid as radioprotector itself was establish in diverse systems. Using bacteria as an in vitro model system it was found that ascorbic acid is a rather efficient radiation-protecting agent [10].

Unlike in the electronics industry, where mind-boggling innovations are almost a daily occurrence, changes in foods and food processing are typically evolutionary. Abundant evidence clearly indicates the difficulty (impossibility) of persuading consumers to adopt revolutionary changes in food they consume. One example that provides conclusive support to this statement is related to the ability to preserve food by ionizing radiation. This process was developed more than a half century ago, yet the progress is not widely accepted, even though its ability to greatly inhibit spoilage and lessen transmission of disease has been clearly demonstrated. And its safety has been more rigorously established than those to thermally sterilized or dehydrated foods [11].

The aim of this work was to assess the radioprotecting capability of ascorbic acid in solution when applied to an in vitro system based on alginate, a polysaccharide used regularly as food additive by following the viscosity profile of the experimental mixtures.

## 2. MATERIALS AND METHODS

### 2.1. Materials

Alginic acid sodium salt, Sigma-Aldrich for industrial application was used. One % (wt/v) dilutions were prepared added with crescent percentages of ascorbic acid analytical grade.

### 2.2. Irradiation

Irradiation were performed in a Co-60 Gammacell 220 (AECL), dose rate 4.64 kGy/h with doses of 0, 1.0, 2.5, 5.0 and 10.0 kGy dose uniformity factor: 1.13. For the irradiation procedure the samples were contained in 100 ml-glass tubes.

### 2.3. Viscosimetry

Viscosimetric techniques developed previously at the laboratory were applied [11]. A Brookfield viscometer, model LV-DVIII, spindle SC4-18, with an adapter for small samples (8 ml) and a Neslab water bath, model RTE-210 precision ± 0,1°C was employed. Alginate dilutions were prepared at 1%{wt/v} by slowly addition of the product to distilled water at about 100°C stirring for 2 minutes before adding the AA. To the solutions already prepared ascorbic acid was added to attain 0, 1,0, 1,5, 2,0 e 2,5% (w/v). final concentrations. Reported viscosity measurements were the average of at least 5 determinations.

### 2.3. pH Measurements

The pH measurements were performed in a pH Analyzer model 300 at 25°C.

## 3. RESULTS AND DISCUSSION

As previously mentioned, the aim of this experiment was to examine the hypothesis of ascorbic acid been used as a radioprotector in an experimental system made of a common additive used as thickener by the food industry. In table I the pH values of the irradiated alginate solutions with increasing ascorbic acid concentrations are presented. As expected the pH was inversely proportional to the ascorbic acid concentration remaining almost unchanged with the increasing irradiation doses.

Figure 1 presents the viscosity values of alginate solutions as a function of dose measured at 25°C and an angular speed of 250 rpm. The viscosity curves reflect the depolimerization action of radiation treatment characterized by a diminution on molecular weight. The radiation-induced degradation of polysaccharide macromolecules was already observed by

**Table I. Measurement of pH of irradiated sodium alginate solutions with different ascorbic acid concentrations at 25°C**

| Irradiation Dose (kGy) | Ascorbic acid (% w/v) | | | | |
|---|---|---|---|---|---|
| | 0 | 1.0 | 1.5 | 2.0 | 2.5 |
| 0 | 5.28 | 3.62 | 3.51 | 3.40 | 3.30 |
| 1.0 | 5.17 | 3.64 | 3.51 | 3.42 | 3.34 |
| 2.5 | 5.24 | 3.65 | 3.50 | 3.40 | 3.35 |
| 5.0 | 5.34 | 3.63 | 3.55 | 3.43 | 3.35 |
| 10.0 | 5.27 | 3.64 | 3.54 | 3.43 | 3.35 |

Aliste [13]. Nagasawa et al. [14] had already reported that in aqueous solution alginate suffers an important indirect radiation effect coming from the water molecules, indicated by a chain scission of alginate molecules. As can be seen the addition of ascorbic acid induced a viscosity increase for all the applied doses of 1.0 kGy, 2.5 kGy, 5.0 kGy and 10.0 kGy comparing to the solutions of alginate alone, being this effect more accentuated for the lower doses. At 2.0 % (w/v) ascorbic acid concentration the viscosity attained the highest values.

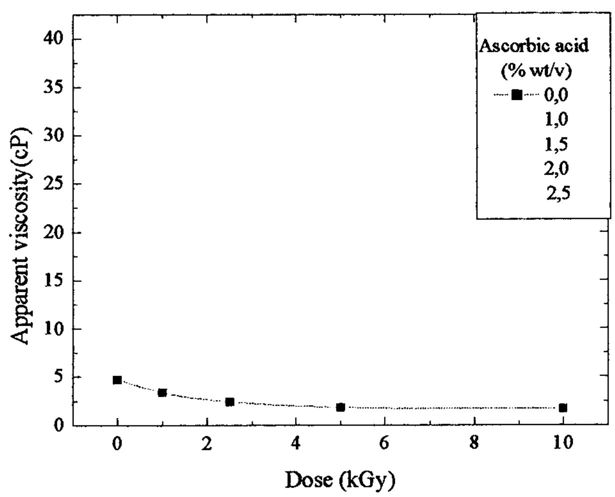


**Figure 1. Viscosity as a function of the radiation dose of the sodium alginate solutions. (250 rpm, 25°C).**

## 4. CONCLUSIONS

Ascorbic acid acted as an antioxidant against radiation oxidative shock in a model system of an irradiated viscous solution made of a common food additive alginate. Besides its radiation protective role on alginate solutions ascorbic acid promoted a viscosity increase in the range of concentrations employed.

## ACKNOWLEDGMENTS

The author A.J.A. is recipient of a doctorate fellowship; N.L.d.M. of a research productivity fellowship from the Brazilian National Research Council (CNPq). Financial support from FAPESP is gratefully acknowledged.

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