Effects of $\gamma$-Irradiation on Some Properties of Gum Arabic (Acacia Senegal L)

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Abstract: The effects of gamma radiation with variable doses on some properties of gum Arabic (Acacia senegal) obtained from Blue Nile State, in Sudan season 2008 were investigated. Doses of 5.5, 6.5, 7.5, 8.5, 9.5, and 10.5 KGY were used respectively for irradiation of gum Arabic samples. The properties studied include the emulsifying stability, viscosity and absorption. It was found that the best emulsifying stability, highest relative viscosity and highest absorbance were obtained with the highest radiation dose (10.5 KGY). Absorbance increased drastically compared with the control sample (not irradiated sample). Redshift in the peak absorption wavelength was also observed. Change in the colour of irradiated samples occurred from white to red colour. It was concluded that gamma radiation is capable of enhancement of the properties of gum Arabic material.

Key words: Gum Arabic (Acacia senegal), $\gamma$-irradiation, absorbance, emulsifying stability, viscosity.

INTRODUCTION

Gum Arabic is a complex polysaccharide, comprised mostly of glucose, arabinose, rhamnose and glucuronic acid, with ~2 % proteins as an integral part of its structure\(^1\).

It is naturally obtained from Acacia (senegal and seyal) trees which are known to grow in the sub-Sahara region of the Sudan. The composition of gum Arabic is dependent to some extend on the location and age of the tree\(^2\). The material has many applications and uses, in confectionary, beverages, pharmaceuticals, backery, cosmetics,....., etc. During growth, harvesting, or transport it could be environmentally contaminated by some micro-organisms which subsequently affects its properties and functionality and hence its various uses. Properties of gum Arabic include emulsification, viscosity, colour, molecular weight, absorption, and chemical structure.

Recently decontamination of gum Arabic was tried\(^3\) by some researches using ionizing radiation. Although it is a well known tool in sterilization, ionizing radiation has some effects on the physical and chemical properties of the material. Up to now it is a challenge to obtain the optimum radiation dose which does the job of sterilization or enhancement of the properties without any side effects on the gum Arabic. For example $\gamma$-radiation is known to induce polymerization\(^{4,5}\), and hence change of the molecular weight of gum Arabic in its aqueous phase. In the solid phase on the other hand the change of properties is dependent on the amount of the radiation dose used. Many interactions cause the effects of radiation on gum Arabic in a way or another i.e. hydrogen bonds may be altered so that water molecules degrade producing hydroxyl groups. Water radiolysis could on the other hand produce hydrogen and hydrogen peroxide\(^6\). The objective of this work is to investigate the effects of $\gamma$-irradiation of variable doses on some properties of gum Arabic (Acacia Senegal). This is expected to give information about the correlation between the dose value used, and the change of the property under investigation.

MATERIALS AND METHODS

Samples of Acacia senegal gum Arabic used in this study were obtained from the Sudanese Gum Arabic Company in Khartoum, Sudan. Samples were collected from A-senegal (L) trees in Damazin zone, season 2008. Samples irradiated to selected dose each (i.e. 5.5, 6.5, 7.5, 8.5, 9.5, and 10.5 KGY). Irradiation was performed at the Sudan Atomic Energy Commission using cobalt-60 radioactive source. Samples were then packed into polythene plastic bags for 24 hours before analysis.
Viscosity: Viscosity was determined according to method described by AOAC \(^7\). It was measured using U-tube (type ATSM-IP/PSL/2B, serial No. 24676) for 20% aqueous solution at room temperature. The relative viscosity (\(\eta_r\)) was then calculated using the following equation:

\[
\eta_r = \frac{T - T_0}{T_0} \tag{1}
\]

Where;
- \(T\) = flow time of sample solution expressed in seconds.
- \(T_0\) = flow time of solvent (distilled water (DW)) expressed in seconds.

Emulsifying Stability: Emulsifying stability (E.S.) was determined according to method described by Murwan et al. \(^8\). Briefly, an aqueous gum Arabic solution, 20% was prepared overnight at room temperature. The emulsion was prepared by mixing the gum solution and oil (2:1) respectively. The mixture was mixed for one minute using normal mixer (Moulinix, made in France). The mixture was then diluted thousand times distilled water. Emulsifying stability was measured using Analogue spectrophotometer (Model No.6305 JENWAY) at hour intervals.

\[
\text{E.S.} = \frac{\text{Reading at time } T=0}{\text{Reading after time } T \text{ (in hrs)}} \tag{2}
\]

Absorption: The absorption of gum Arabic was measured by UV-VIS 1240 spectrophotometer from SHIMATZO Company in Japan. This spectrometer allows for scanning wavelength from 190 nm to 1100nm. Aqueous gum Arabic (Acacia senegal) 20% was prepared overnight at room temperature for this purpose.

Results Analysis: The results obtained from our work and their analyses are presented in the following figures. These included the absorbance, emulsifying stability, and viscosity respectively.

Discussion: Fig 1: a and 1: b showed the absorption spectra of the gum Arabic samples together with the control sample. The peak absorption of the control sample was found to be 1.85 (in arbitrary units) at 279 nm wavelengths, but for all irradiated samples the peak absorption was found to be 2.75 with redshift in the wavelength peak position to 286 nm. It was expected that the absorbance decreases due to gamma radiation, but astonishingly it increased, the thing which could be interpreted due to enhancement of polymerization of gum Arabic materials or due to dehydration of molecules of gum Arabic. The redshift of the wavelength could be due to slight changes in the geometrical structure of the molecules leading to enhancement of the optical absorbance.

Fig (2) showed the viscosity of irradiated and non irradiated sample (control). The relative viscosity of control sample was found to be 7 while it varied for irradiated samples due to the value of the radiation dose used. It decreased for the doses 5.5 and 6.5 KGY and then increased for the other doses. The highest value of relative viscosity was obtained with high doses of 9.5 and 10.5 KGY, respectively. The results indicated that radiation doses (9.5 and 10.5 KGY) enhanced the viscosity of gum Arabic sample under study.

The emulsifying stability was tested for a period of six hours only (See Fig 3). Within this period the instability of the emulsification was clearly observed for all samples except for one that exposed to the highest dose of gamma radiation (i.e.10.5 KGY). That means emulsifying stability was enhanced at dose of 10.5 KGY.

In addition to that there was some changed in the colour of gum Arabic samples that were subjected to gamma irradiation during the experiment. This change of colour from white to reddish could be a reason for activation Fe atom in gum Arabic molecule which was induced by gamma irradiation. This has direct effects on the optical properties of the gum Arabic material, especially the refractive index.

Conclusion: Properties of gum Arabic (Acacia senegal) were studied using variable doses of gamma radiation of 5.5, 6.5, 7.5, 8.5, 9.5, and 10.5 KGY, respectively. It was found that the highest dose of gamma radiation used achieved the best emulsification, viscosity and absorbance. The only drawback is the change of the colour of gum Arabic from white to dark red. This problem needs to be overcome for some applications.

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Fig. (1-a): Absorption spectra of control and irradiated samples of gum Arabic with different doses of $\gamma$-radiation. An increase in the absorbance of the irradiated samples relative to the control can be observed. Red shift of spectra is also clear in the figure.

Fig. (1-b): Enlargement of the peak absorption spectra of irradiated samples of gum Arabic. The value of the maximum absorbance is almost the same for the irradiated samples.
Fig. 2: Effect of $\gamma$-irradiation on the viscosity of gum Arabic (A-senegal) with doses 9.5 and 10.5 kGy. Viscosity clearly increased.

Fig. 3: Effects of $\gamma$-irradiation of different doses on emulsifying stability of gum Arabic (A-Senegal). Stability is investigated for six hours only. Stability was achieved with 10.9 Kgy

REFERENCES


