Int. Agrophysics, 1994, 8, 611-614

RHEOLOGICAL INVESTIGATION OF AGRICULTURAL AND FOOD-INDUSTRIAL PRODUCTS

K. Bajúsz-Kabók, J. Kispéter, P. Záhonyi-Racs, L.I. Kiss

College of Food Industry, Mars tér 7, H-6724 Szeged, Hungary

A b s t r a c t. For the past years physical methods - among them rheological investigations - have been widely applied in the field of agricultural and food industry. Rheological methods can be sucessfully used for the detection of irradiation in the case of treated foodstuffs.

We investigated the rheological properties of protein-containing food-industrial ingredients (milk protein concentrate powder and whole egg powder) as a function of absorbed γ-dose (max. 20 kGy), using rotational viscometers.

Our investigations form part of complex examination for comparing the above results with those of thermoluminescence, chemiluminescence and electron spin resonance methods applied for the study of irradiated foodstuffs. It was found that the rheological method was suitable for significant detection of irradiation in the case of protein-containing foodstuffs, even after a longer storage.

K e y w o r d s: rheology, agricultural products, food-industrial products, gamma-radiation

INTRODUCTION

Ionizing gamma-radiation is applied for quarantine treatment of agricultural products and for improvement of hygienic quality and prolongation the lifetime of preserved agro- and food-industrial products (spices, vegetables, herbs, protein-containing powdered ingredients). This requires the control of irradiation process, i.e., whether the products was irradiated or not, and a qualitative and, if possible, a quantitative detection of the degree of irradiation after radiation treatment and during storage.

Earlier studies have proved that physical, chemical and biological methods to be applicable for the detection of the degree of irradiation; among these methods, the physical ones are the most promising.

The following physical methods have been mainly used for the above-mentioned purposes [1]: electron spin resonance (ESR); thermoluminescence (TL), chemiluminescence (CL), near infrared spectroscopy (NIR), viscosimetry, and impedance measurement.

Viscosimetry has been extensively applied on the basis of the article by Mohr and Wichman [2].

Viscosity of suspended spices exhibited a close correlation between irradiated and unirradiated samples. Namely, the structures of starch, pectins and cellulose - the main components of foodstuffs of plant origin - are destroyed by ionizing radiation, resulting a change in the viscosity.

The viscosity of samples is influenced primarily by pH, temperature and concentration of the suspension, time of wetting and particle size. Therefore, great care must be taken during the preparation of sample suspensions [3].

Rheological investigations have been used mainly for the detection of irradiation in the case of different spices (e.g., white and black pepper, ginger, nutmeg, marjoram, allspice, onion powder, mustard seed, celery, shallot), [3,4].

The aim of our investigations was to test the applicability of viscosimetry for the detection of irradiation in the case of protein-containing ingredients (e.g., milk protein

concentrate powder and whole egg powder) as a function of storage time.

MATERIALS AND METHODS

Milk protein concentrate powder as a patented product was prepared at the Hungarian Dairy Research Institute (Mosonmagyaróvár, Hungary) with 75 % protein content [5]. The samples were irradiated with 5, 10, 15 and 20 kGy absorbed doses by means of a ^{60}Co radiation source. It should be mentioned that the internationally recommended dose is 10 kGy [6], the application of higher dose is necessary for basic research purposes. Samples were stored at room temperature and low relative humidity of 50-60 %.

For rheological measurements suspensions 20 wt/v % were prepared from milk protein concentrate powder with a homogenizer of type MPW-309. After homogenization, the foamed suspensions were stored at 10 °C for 24 h. Apparent viscosities were determined with rotational viscometers of types RV-2 Rheotest and Haake SV 500 at 10-12 different shearing rates. Temperatures between 5 and 50 °C were regulated with an accuracy of ±0.2 °C by means of a water jacket attached to the outer cylinder. The obtained results were evaluated with an IBM PC-AT computer.

Considering the proposal of Heide *et al.* [3] for working out the optimal conditions experimentally for each sample, on the basis of preliminary measurements, aqueous suspensions of 40 wt/v % were prepared from whole egg powder by the above-mentioned method.

RESULTS AND DISCUSSION

On the basis of our results it could be proved that the milk protein and whole egg powder suspensions behaved as non-Newtonian fluids; their flow curves could be described with the Ostwald's equation: $\tau = K D^{n}$ [7]. The decrease of apparent viscosity values as a function of shear stress was not linear and indicated greater changes.

The exponential temperature dependence of apparaent viscosity (η) is shown in Fig. 1 between 5 and 50 °C. The activation energy (E) values were determined from $\eta(T)$ curves. It was found that activation energy considerably decreased after irradiation in both cases of milk protein concentrate [8] and whole egg powder (Table 1).

Table 1. Activitation energy (E) values after milk protein and egg powder irradiation

Sample	E (J/mol)	
	Irradiaton (kGy)	
	0	10
Milk protein Concentrate	1272	1030
Whole egg powder	328.18	158.08

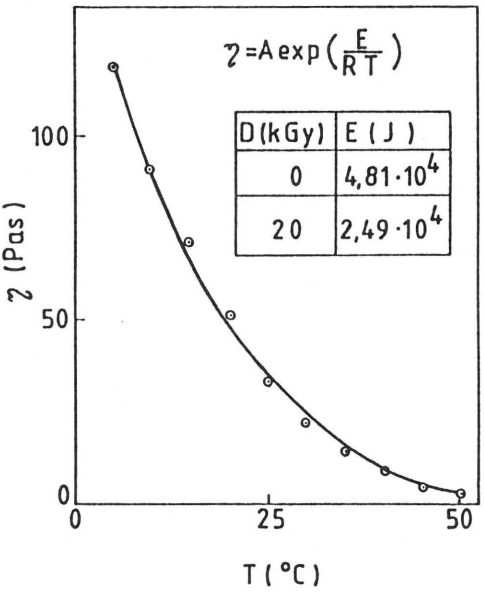

Fig. 1. Temperature dependence of apparent viscosity.

Figure 2 shows flow curves ($\tau(\gamma)$) as a function of absorbed dose. The consistency parameter (K) - which depends on the characteristics of the sample - increased markedly with the absorbed dose; the flow index

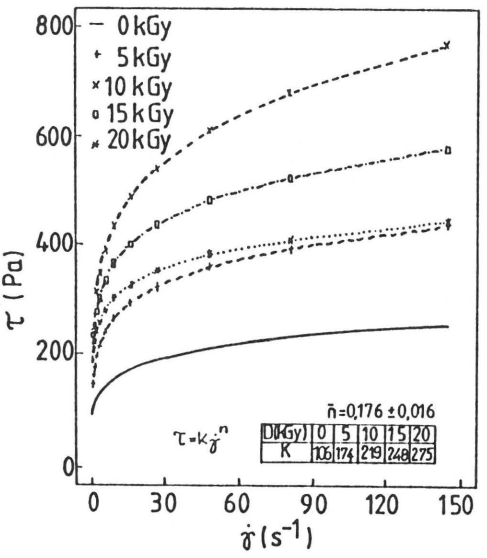

Fig. 2. Flow curves as a function of absorbed dose.

was constant (n=0.176) with a standard deviation of ±8 %.

Histograms of Fig. 3 show the dependence of apparent viscosity on absorbed γ-dose and storage time. It is apparent that these values are increasing with the absorbed dose at each moment, and have a decreasing tendency during storage.

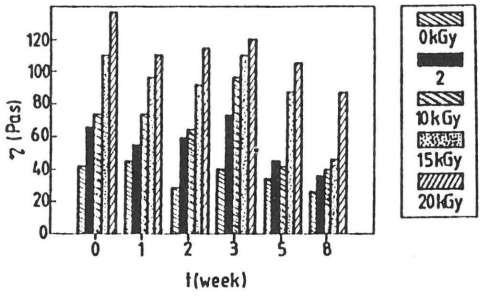

Fig. 3. Dependence of the apparent viscosity on the absorbed dose and storage time.

Similar behaviour was obtained in the case of aqueous suspensions of whole egg powder; in the course of storage, the difference between viscosity values of irradiated and unirradiated samples remained, though with a decreasing tendency (Fig. 4).

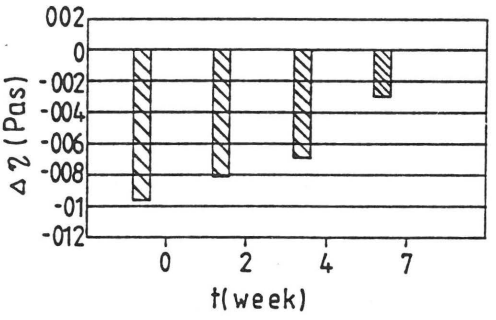

Fig. 4. Viscosity differences between irradiated (10 kGy) and unirradiated samples as a function of storage time.

The results of rheological (R) investigations can be compared with those of TL and ESR measurements [8], (Fig. 5). It can be established that signals of the latter two methods decrease quickly in time, and therefore the rheological method seems to be more suitable for the characterization of irradiation during longer storage.

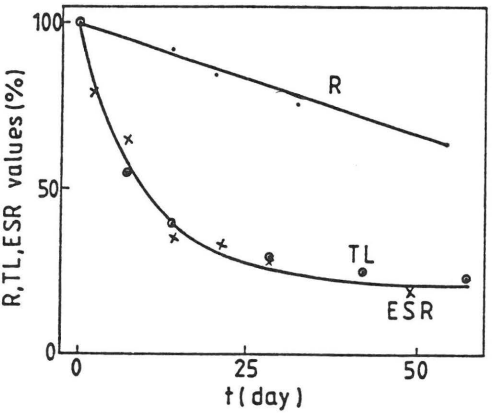

Fig. 5. Relative changes during storage in R, TL and ESR signals.

CONCLUSIONS

To sum up, it can be concluded that the apparent viscosity values increase unambiguously with the absorbed dose as a result of the partial irreversible change in the flow characteristics. This phenomenon can be attributed to the change of the protein structure caused by irradiation.

For the sake of well-evaluable radiation-induced responses, it is more expedient to apply more identification methods simultaneously, and to analyse the obtained signals specifically in the case of each product.

ACKNOWLEDGEMENT

This work was supported by the Hungarian National Science Research Foundation (OTKA grant I/3/153 to J. Kispéter).

REFERENCES

1. Research Co-ordination Meeting, ADMIT, Food Irradiation Newsletter, 15, 27-41, 1991.
2. **Mohr E., Wichmann G.**: Viskosittserniedrigungen als Indiz für eine Cobaltbestrahlung an Gewürzen. Gordian, 85/5, 96, 1985.
3. **Heide L., Nürnberger E., Bögl K.W.**: Investigation on the detection of irradiated food by measuring the viscosity of suspended spices and dried vegetables. Radiat. Phys. Chem., 36, 613-619, 1990.
4. **Farkas J., Sharif N.M., Koncz Á.**: Detection of some irradiated spices on the basic of radiation induced damage of starch. Radiat. Phys. Chem., 36, 621-627, 1990.
5. **Babella G., Novák Á., Jancsó J., Mike F., Molnár G.**: Elájrás teljes tejfehérje-koncentrátumok elöállítására (Procedure for preparing whole milk protein concentrates). National Patent Office, Hungary, Patent No. 183 726, 1987.
6. Report of Joint FAO/IAEA/WHO Expert Committee on the Wholisomeness of Irradiated Food. Geneva, (WHO/TRS 659), 1980.
7. **Mózes G., Vámos E.**: Reológia és reometria (Rheology and rheometry). Müszaki Könyvkiadó, Budapest, 1985.
8. **Kispéter J., Horváth L.I., Bajúsz-Kabók K., Kiss L.I., Záhonyi-Racs P.**: Identification of radiation treatment of mineral-enriched milk protein concentrate by complex test protocols. Food Structure (in press), 1993.