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**The Effect of Long-wavelength UV-radiation on Tocopherol Content  
in Swelling and Germinating Wheat-grains**

Wpływ promieniowania ultrafioletowego na zawartość tokoferoli w pęczniejącym  
i kiełkującym ziarnie pszenicy

Влияние ультрафиолетового излучения на содержание tokoферолов в набухающих  
и прорастающих зернах пшеницы

INTRODUCTION

The effect of radiation on plant growth and development is considered above all with regard to the visible spectrum. There are considerably fewer papers dealing with the effect of UV-radiation which as a portion of solar radiation also modifies various processes in plants. This effect which depends on the wavelength, energy and radiation time refers under natural conditions only to long-wavelength UV, which reaches the surface of the earth.

The stimulating effect of UV on plant growth was shown among others by Denffer and Schlitt (4) and Brodführer (3). When taking into consideration on the one hand the fact that low UV intensity stimulates growth and flowering of plants and, on the other hand, that tocopherols take part in replacing thermo- and photoinduction (1, 10) we are induced to study the relationship which occurs between the action of UV and accumulation of tocopherols in plants. The effect of short-lived UV action on plants growing under natural conditions and on the accumulation of tocopherols in them was studied by Zolotnicka and Akopjan (11). The results obtained by them supported to some extent the known fact concerning a higher accumulation of tocopherols in high mountain plants.

The participation of tocopherols in plant growth seems to indicate a more general character of the action of these compounds and their derivatives.

Without going into a detailed analysis of UV effect on plant growth and changes of the content of terpenoid quinones, what is to be the subject of a separate paper, preliminary studies on the effect of long-wavelength UV on the dynamics of tocopherols in the process of swelling and early germination phases of wheat kernels were carried out. Quantitative changes in tocopherol content in favour of  $\alpha$ -tocopherol under the influence of UV might point to more advanced development processes (2).

#### MATERIAL AND METHODS

For the investigations wheat kernels of the Dańkowska Selekcyjna variety from the Plant Growing Station at Dańków were used.

The content of tocopherols during 24 hrs of grain swelling was examined. The swelling was performed in a thermostate at a constant temperature of 23°C.

Tab. 1. Effect of UV-light on tocopherol content in swelling wheat grains

Time of grain swelling in hrs	Tocopherols in $\mu\text{g/g}$ of dry weight								Moisture of grain %
	Control				UV-irradiated				
	$\alpha$ -T	$\alpha_3$ -T	$\beta$ -T	$\beta_3$ -T	$\alpha$ -T	$\alpha_3$ -T	$\beta$ -T	$\beta_3$ -T	
0	12.7	2.4	4.3	14.2	12.5	2.4	4.3	14.1	4.0
1	13.1	3.3	4.7	14.7	16.9	2.9	4.4	15.0	22.5
6	8.9	4.1	8.6	17.3	10.2	3.6	7.1	17.6	32.6
12	8.8	2.4	5.0	17.1	10.9	2.7	5.7	13.0	36.4
24	9.8	2.7	5.4	15.4	10.5	3.2	5.4	14.6	40.3

Explanation:  $\alpha$ -T —  $\alpha$ -tocopherol,  $\alpha_3$ -T —  $\alpha$ -tocotrienol,  $\beta$ -T —  $\beta$ -tocopherol,  $\beta_3$ -T —  $\beta$ -tocotrienol.

Tocopherols were determined after 1, 6, 12 and 24 hrs of swelling. A part of the kernels was irradiated by a quartz lamp with a UV filter, type UG<sub>1</sub>, of max abs. 366 nm and energy of  $10^3$  ergs/cm<sup>2</sup> sec for 30 min before the tocopherols were determined.

Furthermore, the influence of the time of UV radiation on the content of tocopherols in grains after 6 hrs of swelling was examined applying 10, 30 and 60 min illumination periods.

In a separate series of experiments the effect of variable UV radiation energy was examined using successive energies of  $0.5 \times 10^3$ ,  $1 \times 10^3$ ,  $5 \times 10^3$ ,  $10 \times 10^3$  and  $15 \times 10^3$  ergs/cm<sup>2</sup>sec during 30 min.

The effect of UV on the content of tocopherols in germinating grains was examined in the following way: wheat grains were soaked in water for 24 hrs so as to obtain 40% of moisture and then they were put on wet filter paper and placed in a dark thermostate at 23°C. The change of tocopherol content in control kernels and in those treated with UV was examined after 0, 3, 5, 7 and 24 hours

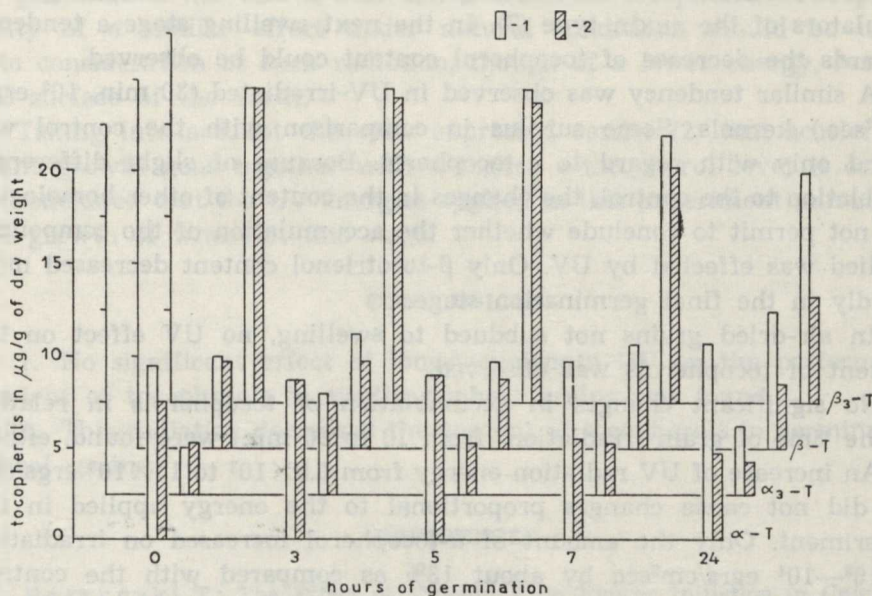


Fig. 1. Effect of UV-light on the tocopherol composition in germinating wheat grains; 1 — control, 2 — UV-irradiated grains

24 hrs counting from the moment of depositing the kernels on the filter paper. For irradiation of the germinating grains the energy of  $10^4$  ergs/cm<sup>2</sup>sec was applied for 30 min directly before analysis. The control material was kept in darkness during the irradiation period.

Tocopherols were determined by the method of Green and coworkers (5) in three independent replicas. The results of analysis were shown in table and diagrams.

## RESULTS AND DISCUSSION

The purpose of this paper, in reference to studies on the relationship between  $\alpha$ -tocopherol synthesis and growth processes in plants, was to examine, firstly, the dynamics of tocopherols in swelling wheat grains and, secondly, to check the effect of long-wavelength UV on the pattern and content of tocopherols during swelling and germination

of grains assuming that UV effects the growth of plants. The increase of  $\alpha$ -tocopherol ratio to the total amount of vitamin-E-active compounds might indicate acceleration of growth processes by UV already in the early growth phase.

It was found that the amount of all four homologues ( $\alpha$ -tocopherol,  $\alpha$ -tocotrienol,  $\beta$ -tocopherol,  $\beta$ -tocotrienol), present in wheat kernels during their swelling, slightly increased in the first stage of swelling (up to 6 hrs), but at a considerably lower rate than the natural growth regulators of the auxin type (7). In the next swelling stage a tendency towards the decrease of tocopherol content could be observed.

A similar tendency was observed in UV-irradiated (30 min,  $10^3$  ergs/cm<sup>2</sup>sec.) kernels. Some surplus in comparison with the control was found only with regard to  $\alpha$ -tocopherol. Because of slight differences in relation to the control, the changes in the content of other homologues did not permit to conclude whether the accumulation of the compounds studied was effected by UV. Only  $\beta$ -tocotrienol content decreased more rapidly in the final germination stage.

In air-dried grains not subdued to swelling, no UV effect on the content of tocopherols was observed.

No significant changes in accumulation of tocopherols in relation to the time of grain irradiation (from 10 to 60 min) were found, either.

An increase of UV radiation energy from  $0.5 \times 10^3$  to  $15 \times 10^3$  ergs/cm<sup>2</sup> sec did not cause changes proportional to the energy applied in the experiment. Only the amount of  $\alpha$ -tocopherol increased on irradiation at  $10^3$ — $10^4$  ergs/cm<sup>2</sup>sec by about 13% as compared with the control.

The results obtained in this series of experiments show that UV does not effect significantly the pattern and content of tocopherols in swelling grains except for slight changes in the amount of  $\alpha$ -tocopherol.

This indicates that either long-wavelength UV applied in these studies is physiologically inactive, or the seed coat protects the grain sufficiently from radiation effects (quoted after Lockhard et al. (9).

To clarify which of the two possibilities is more probable, the grains were germinated after 24 hrs of swelling and tocopherols were determined after 0, 3, 5, 7 and 24 hrs. The appearance of tocopherols in the control series coincided quite well with the data of Hall and Laidman (6) who also found that in this period the amount of tocopherols in the grain underwent slight changes. Without going into a closer evaluation of the results obtained as far as the biogenesis of the particular homologues is concerned, it appears from the diagram presented that long-wavelength UV decreases the content of tocopherols in the living parts of germinating wheat grains. The content of particular homologues decreases distinctly already after 5 hrs of germination.

After 24 hrs of germination tocopherols in UV-irradiated grains are in relation to the control: 51.5%  $\alpha$ -tocopherol, 53.3%  $\alpha$ -tocotrienol, 53.3%  $\beta$ -tocopherol and 56.0%  $\beta$ -tocotrienol, respectively.

The destructive effect of short-wavelength UV on  $\alpha$ -tocopherol is also known from the studies of Lichtenthaler and Tevini (8) carried out on isolated chloroplasts of spinach.

From the data given it appears that long-wavelength UV applied in germination has also a destructive effect on tocopherols. The possibility of a similar effect under natural conditions should be taken into consideration as such radiation, though of a lower energy, reaches the surface of the earth.

Taking into account the view expressed earlier (2) that accelerated plant growth goes together with a higher  $\alpha$ -tocopherol level it cannot be concluded that the UV energies applied in this experiment stimulated the growth of wheat at this stage.

#### CONCLUSIONS

1. No significant effect of long-wavelength UV on the pattern and content of tocopherols in swelling wheat grains was found.
2. This radiation decreased the content of tocopherols in germinating wheat grains.

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## STRESZCZENIE

Badano skład jakościowy i ilościowy tokoferoli w procesie pęcznienia i kiełkowania pszenicy ozimej odm. Dańkowska Selekcyjna oraz wpływ bliskiego UV na zachowanie się tokoferoli w ziarnie. Jako źródła promieniowania użyto lampy kwarcowej z filtrem UF typu UG<sub>1</sub> o maks. abs. 366 nm. Stosowano różne energie i czas naświetlania. Tokoferol oznaczano według metody Greena i współprac. (5).

Nie stwierdzono, aby bliski UV w warunkach doświadczenia wpływał na zawartość tokoferoli w czasie pęcznienia ziarniaków. Stwierdzono natomiast destrukcyjny wpływ UV na poziom tokoferoli podczas kiełkowania pszenicy.

## РЕЗЮМЕ

Исследовали качественный и количественный состав токоферолов в процессе набухания и прорастания озимой пшеницы, сорт Dańkowska Selekcyjna, а также влияние близкого ультрафиолетового излучения на поведение токоферолов в зерне. Источником излучения была кварцевая лампа с фильтром УФ типа УГ<sub>1</sub> с макс. абс. 366 нм. Применяли разную энергию и разное время облучения. Токоферолы обозначали методом Грина и соавторов (5).

При исследованиях констатировали, что близкое ультрафиолетовое излучение не влияло на содержание токоферолов во время набухания зерновок. Зато во время прорастания пшеницы констатировали деструктивное влияние ультрафиолетового излучения на уровень токоферолов.