bhakur. The wet tissue, now discarded, contains 45% of fat, the recovery of which should be remunerative.

SUMMARY

1. The compositions of body, viscera and liver lipids from bhakur (*Catla buehanani*), and of liver fat of pahuna (*Wallago attu*) have been studied. Preliminary separations of the fatty acids into groups differing in unsaturation have been carried out with the help of lithium and lead salts in acetone and ethanol, respectively, and the compositions studied by the ester fractionation procedure.

2. The component acids of bhakur body, viscera and liver fats show significant differences in their proportions and degree of unsaturation. The fat content of viscera is remarkably high, 45%, as compared to 6.3% in the body and 8.5% in the liver on wet tissues, and industrial exploitation of the fat has been suggested.

3. The liver lipids of pahuna contain more phosphatides than bhakur liver fat, and there are minor differences in the acid components.

We are glad to express our most cordial thanks to Prof. T. P. Hilditch, F.R.S., for his very useful suggestions and kind help during the progress of this work.

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The Formation of Hydrogen Peroxide by α -Radiation in the Presence of the Enzyme Carboxypeptidase

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(Received 5 October 1951)

The enzyme carboxypeptidase is inactivated by exposure to either α -radiation or X-radiation in aqueous solution. In all except the most concentrated solutions, the inactivation is due almost entirely to energy dissipated as ionization and excitation, in the water, leading to the formation of radicals or other active chemical intermediates which enter into the reaction with the enzyme. Whilst this is true of both types of radiation, the number of enzyme molecules inactivated per unit energy dissipated in the water by α -radiation is only about one-twentieth of the number inactivated by an equal dose of X-radiation. When these experimental observations were reported (Dale, Gray & Meredith, 1949), it was pointed out that the small amount of inactivation brought about by α -radiation could, in fact, be reasonably ascribed to the very low energy electrons, or δ -rays, which branch off as spurs along an α -particle track, in which case it would

appear that the main part of the α -ray energy which is dissipated within a narrow column is almost without effect on the enzyme. It was natural to associate the absence of effect on the enzyme with the well established fact that α -ray energy, unlike X-ray energy, gives rise to hydrogen peroxide and hydrogen when dissipated in pure air-free water, and to suppose that at all enzyme concentrations used in our experiments the radicals formed at very high concentration within the α -ray column combine together to form hydrogen peroxide and hydrogen before diffusion has brought them into effective collision with enzyme molecules. In this case, the presence of the enzyme should have little or no effect on the hydrogen peroxide yield, since the enzyme does not react with hydrogen peroxide. An alternative interpretation might be to assume that, owing to the very high concentration of radicals, interaction with enzyme molecules is confined to

those few molecules lying close to the track, so that many radicals in succession give up their energies to a few already inactivated enzyme molecules. The presence of enzyme in this case should cause a decrease in hydrogen peroxide yield. The fact that carboxypeptidase activity is hardly affected by high concentrations of hydrogen peroxide has made possible a comparison of the hydrogen peroxide yield by α -radiation in water and in a solution of carboxypeptidase. The results show that the alternative mechanism has to be rejected.

EXPERIMENTAL

The experimental technique followed closely that of former experiments (Dale *et al.* 1949). Radon was divided approximately equally between, and sealed into, two small and thin glass bulbs. These were then broken within a few minutes of pumping, one in a gas-tight vessel completely filled with water, and one in a similar vessel filled with the carboxypeptidase solution. The amount of radon in each solution was measured by following the rise of the γ -activity of the solutions, using a conventional ionization chamber and electrometer valve circuit. An irradiation of

tion of H_2O_2 was carried out colorimetrically as its titanium compound with a Hilger absorptiometer.

The concentration of the enzyme solution was 0.1% (w/v). In order to render the H_2O_2 formed by α -radiation less liable to decomposition, the enzyme solution and the control were adjusted to pH 3.8 by addition of H_2SO_4 . This pH is on the acid side of the pH of minimum solubility and of the isoelectric point of the enzyme. All solutions contained O_2 in equilibrium with air.

Control experiments were made to determine the loss of water by evaporation during the blowing off of the radon.

RESULTS

The results of the experiments are set out in Table 1. As in the earlier experiments, the radiation received by the solution can be divided into three parts: (1) Radiation from active deposits laid down on the splinters of the glass bulb between the time of pumping the radon and breaking the bulb (half of this radiation is assumed to be absorbed by the splinters). (2) Radiation from radon and its active deposit during the time the radon is in solution. (3) Radiation from the active deposits remaining in the solution after removal of the radon, and continuing up to the moment of making the optical density measurement.

Table 1. *Effect of carboxypeptidase on the hydrogen peroxide yield from water irradiated at pH 3.8 by α -rays*

(Significance test of difference of ionic yield gives $d/\sigma = 1.02$ and $P = 0.30$.)

	Carboxypeptidase	Water
Time of breaking bulb (t_1) (min.)	2.7	3.2
Time of removing radon (t_2) (min.)	107	114
Time of measurement (t_3) (min.)	250	262
Initial amount of radon (mc.)	61.2	60.0
Volume of irradiated solution (ml.)	3.07	2.85
Volume of solution, after evaporation, used in measurement (ml.)	2.34	0.66
Estimated loss of water by evaporation (ml.)	0.20	0.05
Amount of H_2O_2 measured ($\mu g.$)	103.5	29.5
Fraction of H_2O_2 measured	0.83	0.25
Amount of H_2O_2 in irradiated solution ($\mu g.$)	125.0	118.1
α -Energy liberated in solution (joules)	43.0	44.9
β -Ray correction:		
β -Energy liberated in solution (joules)	2.2	2.3
Estimated H_2O_2 due to β -radiation ($\mu g.$)	3.1	3.2
Amount of H_2O_2 due to α -radiation ($\mu g.$)	121.9	114.9
Ionic yield for α -radiation	0.264	0.239
Estimated errors (%) of:		
Absorption measurement	2.4	8.5
Fractionation of solution	2	3
Relative amounts of radon	1	1
Total error (%)	3.3	9.6

about 1.5 hr. was given, and an attempt made to compensate for a small difference in the distribution of radon between the two glass bulbs by adjusting the time of irradiation. The irradiation was ended by pouring the solutions into shallow dishes in the open air and assisting the removal of the radon by a jet of air which also agitated the solution. A further period of 2 hr. was allowed for the decay of most of the active deposits remaining in solution, and then the estima-

The α -particles come from the disintegration of radon and the active deposits of RaA, RaC and RaC', and in calculating the energy delivered by them, account must be taken of the growth and decay of these products. This can most conveniently be done by calculating an auxiliary function, $F(t)$, which is the total energy delivered to a solution by the α -particles from radon and its products up to time t , after starting at time $t=0$ with radon free from active deposits.

It is convenient to normalize the function so that it has the value unity after full decay of the radon, and to use the fact that 1 mc. of radon going to full decay gives in α energy, from itself and its products, 54.09 joules. The function $F(t)$ has the form

$$F(t) = 1 - \sum_{r=1}^4 \gamma_r e^{-\lambda_r t}$$

with the following values for the constants λ and γ :

	1 (Rn)	2 (RaA)	3 (RaB)	4 (RaC)
λ	0.000126	0.227	0.0259	0.0352 min. ⁻¹
γ	+1.003800	-0.000179	-0.008369	+0.004745

It is then easy to show that the total energy delivered per mc. of radon to the experimental solutions, assuming half the radiation from the active deposits on the glass splinters to be absorbed by the glass, is 54.09 $\times E$ joules, where

$$E = \frac{1}{2} [F(t_3) + e^{-\lambda_1 t_1} F(t_3 - t_1) - F(t_1)] - e^{-\lambda_1 t_1} F(t_3 - t_2)$$

and t_1 , t_2 and t_3 are the times in minutes after pumping the radon to breaking the bulb, removing the radon and estimating the H_2O_2 produced. In these calculations it is assumed that the decay of short-lived RaC' (half life about 10^{-6} sec.) follows instantaneously after that of the parent RaC, and that the radiations from the long lived deposits RaD, etc., can be neglected.

The solutions are, in addition to the α -rays, irradiated by the β -particles, and the energy contributed by these is about 5.2% of the α -energy. Assuming that the β -radiation acts independently of the α -radiation, the amount of H_2O_2 produced by the β -radiation has been estimated from the experiments of Bonet-Maury & Lefort (1950), due allowance being made for dose rate and the pH of the solution.

In calculating the ionic yield, the energy expended per ion-pair was taken as 32.5 eV., leading to 1.92×10^{17} ion-pairs per joule.

The errors of the different parts of the experiment have been estimated and are shown in Table 1. The difference of the ionic yield with and without the enzyme, when compared with the estimated error of the difference was not significant.

DISCUSSION

The results show that the addition of the enzyme carboxypeptidase does not reduce the yield of H_2O_2 formed by irradiation of water with α -particles. Thus the second hypothesis put forward in the introduction as an explanation of the low α efficiency for inactivation of the enzyme must be discarded and the result is consistent with the first hypothesis.

It will be seen from Table 1 that an allowance of approximately 3% has been made for the H_2O_2 produced by the β -radiation which accompanies the

α -radiation. It is difficult to evaluate this correction with accuracy because of the complexity of various competing reactions. The α -radiation alone gives rise to a final H_2O_2 concentration of around 1000 μ mole/l. which, according to Bonet-Maury & Lefort (1950), approaches the steady state concentration of H_2O_2 resulting from the exposure of aerated water to X-radiation and which presumably is also comparable with the steady state concentration resulting from exposure to β -radiation.

There is, therefore, some doubt as to whether the β -radiation has augmented or decreased the H_2O_2 concentration produced by the α -radiation in pure water. It is also clear that when the concentration of H_2O_2 is such that there is an approximate balance between its rate of production and rate of destruction by radicals formed by β -radiation, the introduction of a solute, such as carboxypeptidase, may disturb the balance in either direction on account of differences of affinity for the different types of radicals. The slightly greater yield of hydrogen peroxide observed by irradiating a carboxypeptidase solution as compared with that obtained from irradiated pure water, could, therefore, have arisen secondarily through the disturbing effect of the small amount of β -ray energy accompanying the α -radiation. As mentioned earlier in the text, however, the difference is not statistically significant.

In conclusion we can say that the experiments reported here confirm the view suggested in the earlier publication (Dale *et al.* 1949) that the production of H_2O_2 by α -radiation takes place in the core of the track and that the small amount of inactivation of carboxypeptidase by α -radiation is due to the very low energy electrons or δ -rays which branch off as spurs from the α -track.

SUMMARY

The yield of hydrogen peroxide produced by the action of α -rays from radon on water and on a 0.1% solution of the enzyme carboxypeptidase have been compared and no significant difference found. This result confirms the view suggested in an earlier publication that the production of hydrogen peroxide by α -radiation takes place in the core of the track and that the small amount of inactivation of carboxypeptidase by α -radiation is due to the δ -rays which branch off as spurs from the α -track.

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