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THE ROLE OF VITAMIN C AS AN ANTIOXIDANT

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Ascorbic acid (vitamin C) was found to act as a radical scavenger and suppress the oxidation of methyl linoleate in homogeneous alcohol solution in the presence of radical initiator. Furthermore, vitamin C showed a synergistic effect when used with vitamin E.

The oxidation of oil, food, and plastics brings about their deterioration. Above all, the non-enzymatic oxidation of lipids in biological systems has received much attention recently in relation to its pathological effects and aging. A number of protective mechanisms which retard such oxidation have been identified in living organisms. One of these involves vitamin E which is a lipid-soluble antioxidant capable of scavenging active oxygen species such as peroxyl radicals, superoxide anion and singlet oxygen. It has been suggested that vitamin C can also play a role as an antioxidant,[1] but this has not been clearly established experimentally in a well-controlled system. We wish to present evidence which shows that vitamin C can indeed inhibit lipid autoxidation and that it has a synergistic effect when used with vitamin E.

Methyl linoleate was chosen as a substrate. The autoxidation proceeds by a free radical chain and, under mild conditions, it gives a quantitative yield of four isomeric conjugated diene hydroperoxides.[2,3] The autoxidation of 0.605 M methyl linoleate in methanol and t-butyl alcohol (3:1, v/v) was studied at 37°C. 2,2'-Azobis-(2,4-dimethylpentanenitrile) (AMVN) (0.01M) was added in order to obtain a constant rate of chain initiation. The rate of oxidation was measured by monitoring the oxygen concentration in the solution with a Clark type Pt-electrode. A constant rate of oxygen uptake was observed without any induction period. However, when vitamin C was added to the solution, the oxidation was suppressed and a distinct inhibition period was observed as shown in Fig. 1. The inhibition period was proportional to the amount of vitamin C added.

These results show that in homogeneous solution vitamin C scavenges the chain carrying peroxyl radicals and suppresses the oxidation. When all the added vitamin C was consumed, the inhibition period was over and the rapid oxidation took place. It should be noted that the rate of oxidation after the inhibition period was the same as that in the absence of vitamin C.

Figure1 also shows the effect observed when vitamin C was used with vitamin E. Vitamin E scavenges the peroxyl radical quite rapidly and suppresses the oxidation.[4-6] It is noteworthy that vitamin E gave a slower rate of oxidation during the inhibition period than vitamin C, presumably because of a higher rate of trapping the peroxyl radical. When both vitamin C and vitamin E were used, the inhibition period was lengthened to the sum of the inhibition period observed when either vitamin C or vitamin E was used alone. However, through the inhibition period, the rate of oxidation was the same as that observed when vitamin E was used alone.

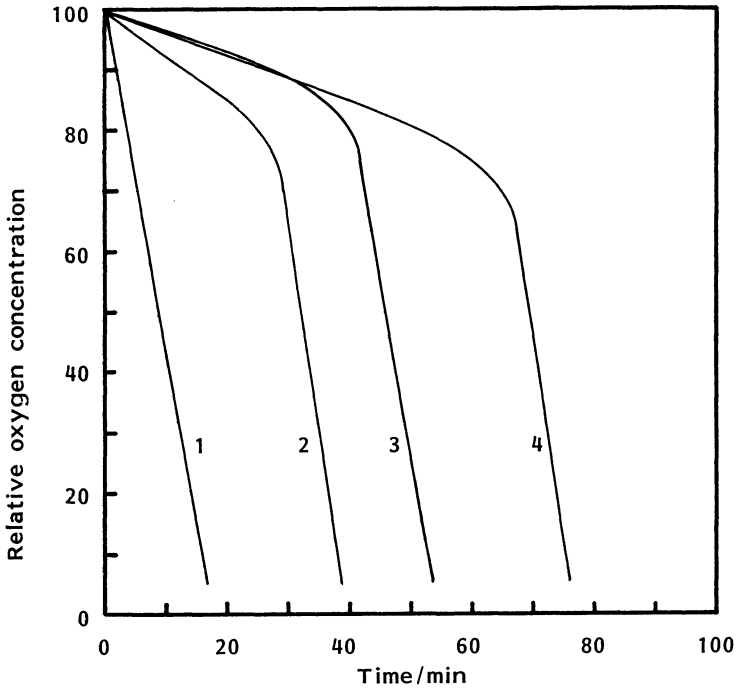

Fig. 1 Inhibition of oxidation of methyl linoleate in t-butyl alcohol/methanol (3/1) by vitamin C and vitamin E, 37°C, [AMVN] = 0.01 M.

Curve	1	2	3	4
[vit C]/μM	0	54.8	0	54.8
[vit E]/μM	0	0	30.4	30.4
$t_{inhibition}$/min	0	28.5	40.3	65.6

This phenomenon has been observed with other mixtures of chain breaking antioxidants.[7] Our results support the previous findings[8,9] that vitamin C can regenerate vitamin E by donating hydrogen atom to the vitamin E radical.

Lipid peroxyl radical must be trapped preferentially by vitamin E and the vitamin E radical thus formed must react with vitamin C to regenerate vitamin E. Thus the combination of vitamin C and vitamin E is an effective antioxidant.

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