Communication

Effect of Vitamins Other than Vitamin C
on Viruses: Virus-Inactivating
Activity of Vitamin K₅

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We have to date systematically studied the inactivation *in vitro* of viruses by vitamin C (ascorbic acid), using a wide variety of bacterial viruses (phages) as a model system (1-5). The study has led to the conclusion that the virus-inactivating activity *in vitro* of vitamin C is a generally observable phenomenon in all kinds of viruses (6). In contrast, very little has been studied of the effect on viruses of vitamins other than vitamin C.

We have made a systematic study of the effect on viruses of a number of water-soluble vitamins and their related substances, and found that vitamin K₅ (4-amino-2-methyl-1-naphthol) has an inactivating activity on a wide variety of phages.

Phages used are listed in Table 1. These 21 phages present a wide variety from the viewpoint of nucleic acid type, morphology, host bacteria, serological grouping and certain other characteristics. Vitamins and their related substances examined are listed in Table 2.

The 20 vitamins and related substances other than vitamin K₅ exerted no significant inactivating effect on any of the phages tested.

In contrast, vitamin K₅ exerted an inactivating effect on all of the phages tested, although the phages exhibited differential sensitivities to the inactivation by vitamin K₅. Table 3 shows the inactivation rates of the 21 phages in certain concentrations of vitamin K₅. At 1×10^{-3} M, full inactivation of 11 phages (J1, T1, λ , M2, T3, ϕ X174, MS2, GA, Q β , SP and ϕ 6) was achieved and of 6 phages (T1, λ , MS2, GA, Q β and ϕ 6) at 3×10^{-4} M. Sensitivities of the phages to vitamin K₅ were arranged, from the highest to the lowest, in the following order: GA, ϕ 6, Q β , MS2,

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Table 1. List of bacterial viruses (phages) used.

Phage	Nucleic acid	Morphology	Host
J1 ϕ 219 T1, T5, λ	Double-stranded DNA		<i>Lactobacillus casei</i> <i>Lactobacillus plantarum</i> <i>Escherichia coli</i>
J2, NHc ϕ 16 T2, T4 SP10, SP01, M2			<i>Lactobacillus casei</i> <i>Lactobacillus plantarum</i> <i>Escherichia coli</i> <i>Bacillus subtilis</i>
T3			<i>Escherichia coli</i>
ϕ X174	Single-stranded DNA		<i>Escherichia coli</i>
δ A			<i>Escherichia coli</i>
MS2, GA, Q β , SP	Single-stranded RNA		<i>Escherichia coli</i>
ϕ 6	Double-stranded RNA		<i>Pseudomonas phaseolicola</i>

Table 2. Vitamins and their related substances examined.

Trivial name	Vitamin name	Trivial name	Vitamin name
Thiamine	B ₁	<i>p</i> -Aminobenzoic acid	B _x
Riboflavin	B ₂	Choline	
Nicotinamide	B ₃	Lipoic acid	
Nicotinic acid		Inositol	
<i>d</i> -Pantothenic acid	B ₅	<i>d</i> -Biotin	H
Pyridoxine	B ₆	4-Amino-2-methyl-1-naphthol	K ₅
Cyanocobalamin	B ₁₂	Anthranilic acid	L ₁
Orotic acid	B ₁₃	Hesperidin	P
Pangamic acid	B ₁₅	Rutin	
Folic acid	B _C	Cabagin	U
Carnitine	B _T		

SP, T1, λ , J1, ϕ X174, M2, T3, δ A, ϕ 219, SP10, SP01, ϕ 16, J2, NHc, T5, T2, T4.

These results indicate that vitamin K₅ has a potential virus-inactivating activity. In other words, the virus-inactivating activity could be a new biological activity of vitamin K₅.

Table 3. Inactivating activity of vitamin K₅ on a wide variety of phages. Phages ($1 \sim 4 \times 10^7$ PFU/ml) were incubated with vitamin K₅ in 0.02 M Tris-HCl buffer (pH 7.4) for 30 min at 37°C. Survival of the control without the vitamin was represented as 100%.

Phage	Survival (%)		
	Concn. (M) of K ₅		
	1×10^{-3}	3×10^{-4}	1×10^{-4}
J1	0	1	20
ϕ 219	4	15	65
T1	0	0	15
T5	30	45	75
λ	0	0	20
J2	20	30	55
NHc	25	40	80
ϕ 16	15	25	55
T2	45	60	80
T4	60	75	100
SP10	5	15	65
SP01	5	15	70
M2	0	4	40
T3	0	5	45
ϕ X174	0	3	40
δ A	1	4	55
MS2	0	0	7
GA	0	0	2
Q β	0	0	4
SP	0	0	10
ϕ 6 ^a	0	0	3

^a Phage ϕ 6 was incubated for 20 min at 25°C because of its relative instability at 37°C.

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