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Antiviral Effect of Commercial Juices and Beverages

JACK KONOWALCHUK* AND JOAN I. SPEIRS

Bureau of Microbial Hazards, Health Protection Branch, Health and Welfare Canada, Ottawa, Ontario, Canada K1A OL2

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Nineteen commercial juices or beverages were tested for inactivation of poliovirus type 1. Grape and apple juices and tea were particularly antiviral. Although antiviral in aqueous solution, ascorbic acid was ineffective after addition to juices.

Recent studies have shown the effectiveness of fruit extracts and infusions as in vitro inactivators of several enteric viruses (2). Grapes and grape products were potent antiviral agents, and this was attributed to phenolic compounds; several commercially available phenolic compounds of plant origin were effective (3). More recently, we tested purified grape tannin kindly supplied by J. Masquelier (Bordeaux, France) and found that this was antiviral against several enteric viruses (unpublished data). In the present study, a number of commercially available juices and beverages were examined for antiviral effects. Poliovirus type 1 (Sabin) was chosen as the representative enteric virus.

Juices and beverages were purchased from local stores; when indicated, the pH was adjusted to 7.0 with 1 N NaOH; dilutions were made in water. A virus inoculum of about 8,000 plaque-forming units in 0.05 ml of water was added to single, duplicate, or triplicate screw-capped bottles containing 2 ml of water (virus control) or 2 ml of juice or diluted juice, at the natural pH or at pH 7.0. Suspensions were incubated at ambient temperature (about 22°C) for 2 h. Virus was assayed by diluting each suspension 1:100 in medium 199 containing 10% fetal bovine serum; triplicate 2.5-ml portions were added to HEp-2 monolayers as described previously (3). Plaque counts for each sample (counts on three monolayers) were averaged. The counts obtained for duplicate or triplicate samples were averaged and expressed as percentages of the values obtained for the controls. The percent error (standard deviation divided by the mean and multiplied by 100) of the assay system varied from 2 to 25%, with a mean of 9%. Differences of 25% (the maximum experimental error) were considered significant.

The antiviral activity of 19 commercial juices and beverages, listed in order of effectiveness either at the natural pH or pH 7.0, is shown in Tables 1 and 2. Grape juice, apple juice, and tea were the most potent inactivators of poliovirus type 1; pineapple, tomato, grapefruit, orange, and vegetable juices, as well as orange drink and coffee, were ineffective. (Previously, Green [1] showed that extracts of tea inhibited influenza virus multiplication in embryonated eggs.) The response with cranberry and prune drinks was

TABLE 1. *Percent survival of poliovirus type 1 in juices or beverages after incubation at ambient temperature for 2 h*

Product	Natural pH	% Survival after incubation at:	
		Natural pH	pH 7.0
Grape juice	3.3	<1[a]	<1
Apple juice	3.5	<1	<1
Tea	5.5	<1	<1
Cranberry drink	2.6	21 (19-23)[b]	<1
Prune drink	3.6	95 (92-97)	<1
Lemon juice	2.4	2 (1-2)	98 (95-100)
Ginger ale	2.9	100 (97-102)	4 (3-5)
Cola	2.3	6 (5-6)	8 (7-9)
Cocoa	6.6	8 (6-10)	—[c]
Apple drink	3.3	52 (50-54)	28 (24-32)
Milk, skim	6.2	50 (48-52)	—
Milk, 2% fat	6.4	58 (56-59)	—
Pineapple juice	3.4	87 (84-90)	90 (87-93)
Tomato juice	4.0	95 (91-100)	89 (87-91)
Coffee	4.7	90 (87-93)	92 (88-95)
Grapefruit juice	3.2	90 (88-92)	104 (100-106)
Orange juice	3.5	99 (96-102)	92 (88-96)
Orange drink	2.8	102 (100-103)	98 (96-99)
Vegetable juice	4.1	104 (100-106)	98 (95-101)

[a] No plaques in three samples.
[b] Average of three samples; range is given within parentheses.
[c] —, Not done.

TABLE 2. *Titration of antiviral activity in five products after incubation at ambient temperature for 2 h*

Product	Reciprocal of the dilution at which there is approximately a 50% reduction in the number of plaques at:	
	Natural pH	pH 7.0
Grape juice	1,024	1,024
Apple juice	16	64
Tea	16	64
Cranberry drink	4	64
Prune drink	0	4

TABLE 3. *Percent survival of poliovirus in ascorbic acid in water and juices after incubation at ambient temperature for 2 h*

Product	pH	% Survival with additional ascorbic acid (mg/100 ml):			
		0	35	100	1000
Water	2.5	97 (95–99)[a]	10 (8–12)	26 (24–28)	26 (25–27)
Water	7.0	100 (97–102)	<1[b]	<1	<1
Apple drink	3.3	52 (49–54)	60 (57–62)	46 (43–49)	48 (46–50)
Apple drink	7.0	28 (27–29)	30 (29–31)	28 (27–29)	26 (23–28)
Orange juice	3.5	101 (97–103)	97 (94–100)	95 (93–97)	104 (101–106)
Orange juice	7.0	92 (90–94)	102 (100–104)	89 (85–92)	94 (85–99)
Tomato juice	4.0	83 (80–85)	85 (83–87)	90 (88–92)	—[c]
Tomato juice	7.0	103 (100–105)	91 (89–93)	95 (92–98)	—

[a] Average of two samples; range is given within parentheses.
[b] No plaques in two samples.
[c] —, Not done.

greater at pH 7.0 than at the natural pH; this phenomenon was noted previously with poliovirus type 1 in strawberry extract (2).

The antiviral activity of ascorbic acid in water was reported previously (2). It was unexpected, therefore, to find that juices such as orange, grapefruit, and pineapple, which contained relatively high levels (≥35 mg/100 ml) of ascorbic acid either naturally or after fortification, lacked antiviral activity. However, the addition of up to 1,000 mg of ascorbic acid per 100 ml did not result in an antiviral response (Table 3). It appears that ascorbic acid may react with ingredients in the beverages and thus loses its antiviral activity.

The antiviral activity of grape juice is apparently due to polyphenols, including tannin (3). We surmise that the antiviral activity of apple juice and tea may likewise be due to tannins and related compounds (1, 4) which form noninfectious complexes with viruses. The importance of these foods as natural antiviral agents seems to depend on the stability of these complexes during passage through the digestion system. Current work with monkeys may supply the answer to this problem.

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