Virucidal effect of acetic acid and vinegar on SARS-CoV-2

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Short Report

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Abstract

Given the potential infectivity of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) on surfaces for hours to days, it is important to find safe and effective disinfecting agents to help prevent the spread and transmission of this new virus responsible for the COVID-19 pandemic. Toward this end, in this study, the virucidal effect of acetic acid and vinegar, as safe foods, on SARS-CoV-2 was evaluated. Both 4% and 6% acetic acid aqueous solutions effectively inactivated the virus after 5-min incubation with a reduction over 4 log, resulting in a viral titre below the detection limit. In addition, white distilled vinegar (5% and 6% acetic acid concentrations) inactivated SARS-CoV-2 after 1-min incubation with reduction of over 4 log and a viral titre below the detection limit. These preliminary findings provide valuable information on the inactivation of SARS-CoV2, offering insight for effective infection control.

Introduction

The outbreak of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) represents a significant and urgent threat to global health. Transmission of SARS-CoV-2 from infected to non-infected individuals is considered to occur directly through respiratory droplets and droplet nuclei/aerosols, and indirectly through contaminated environmental surfaces [1]. SARS-CoV-2 isolated from contaminated surfaces has been reported to remain infectious for hours to days [2, 3]. Therefore, it is very important to test substances for a virucidal effect against SARS-CoV-2 attached to surfaces as a means to safely prevent the spread of infection in homes, workplaces, and medical treatment facilities.

Fortunately, enveloped viruses such as SARS-CoV-2 can be easily inactivated by bactericidal activators such as ethanol and detergents, including soaps and conventional hand washing agents [4, 5]. However, these agents are not always safe for ingestion; therefore, verification of the inactivation effect of a product that is already deemed to be safe for human consumption against SARS-CoV-2 would be meaningful to prevent the spread of infection.

Vinegar, as a highly safe food, was proven to effectively inactivate SARS-CoV that spread in 2003 [6]. However, there is no information available as to whether vinegar has similar inactivating ability against SARS-CoV-2. Therefore, in this study, we evaluated the potential virucidal effect of acetic acid and vinegar at different concentrations against SARS-CoV-2 *in vitro*.

Methods

SARS-CoV-2 (Hu/DP/Kng/19-020 strain) stock with an infectious titre of 2×10^6 50% tissue culture infective dose ($TCID_{50}$)/ml was incubated with aqueous solutions of 4% and 6% acetic acid (Kanto Chemical Co., Inc. Japan) at a ratio of 1:9 for 10 s, 1 min, and 5 min, respectively. The reaction was stopped by diluting the mixture 100 times with Dulbecco's modified Eagle medium. Using this solution and VeroE6-TMPRSS2 cells, the $TCID_{50}$ was calculated by the Behrens-Karber method to determine the virus infectious titre.

Grain vinegar (GV; 4% acetic acid concentration; Mizkan Co., Ltd. Japan) and white distilled vinegar (WDV; 6% acetic acid concentration; Mizkan Co., Ltd. Japan) were tested in contact with SARS-CoV-2 for 1 min as described above. To provide more practical insight for SARS-CoV-2 inactivation, we extended the virus contact time of GV (4% acetic acid concentration) and tested WDV with a lower acetic acid concentration of 5%. We further tested whether WDV containing a higher concentration of acetic acid (6%) could inactivate SARS-CoV-2 within a shorter time period (10 s).

Results

As shown in Table 1, a high virucidal effect was observed with both the 4% and 6% aqueous acetic acid solutions in contact with the virus for 5 min, with a reduction of more than 4 log, resulting in a titre below the detection limit. However, a less remarkable virucidal effect was observed in contact with both the 4% and 6% aqueous acetic acid solutions for 10 s and 1 min (less than 2 log reduction). WDV showed a high virucidal effect with over 4 log reduction and below the detection limit. However, a weaker virucidal effect was observed for GV, resulting in less than 1 log reduction.

As shown in Table 2, a strong virucidal effect was observed for WDV with 5% acetic acid in 1 min (more than 4 log reduction and below the detection limit). However, a less remarkable virucidal effect was still observed in GV (4% acetic acid concentration) despite the longer contact time of 60 min and for WDV with 6% acetic acid under 10-s contact with SARS-CoV-2 (1.75 log reduction for both).

Discussion

It is somewhat surprising that despite the remarkable inactivation effect of 4% acetic acid aqueous solution in contact with SARS-CoV2 for 5 min, GV with a 4% acetic acid concentration did not show a strong effect over the same contact time. In addition, 4% acetic acid aqueous solution was also more effective than GV with a contact time of 1 min. This suggests that some impurities contained in GV such as amino acids or sugars may protect SARS-CoV-2 from inactivation. By contrast, WDV with a 6% acetic acid concentration had a stronger inactivating effect in contact with the virus for 10 s and 1 min compared to that of the 6% acetic acid aqueous solution. This suggests that WDV may contain additional substances that can enhance the virucidal effect against SARS-CoV-2. Future research should therefore focus on identifying these potential virucidal substances in WDV, which can be used to help prevent the spread of infection.

Overall, we have shown that acetic acid aqueous solution and WDV, which is readily available, have a virucidal effect against SARS-CoV-2. It should be noted that although this study presents vinegar as a virucidal agent to inactivate SARS-CoV-2 that is present on a surface, we do not recommend consuming vinegar as a means of prevention or treatment.

The limitations of this study include that we only tested a limited type of vinegar and one strain of the virus, a control group could not be established for all test conditions, and we did not perform multiple

trials, and therefore could not conduct statistical analysis. Despite these limitations, our preliminary results strongly suggest that vinegar can be a safe and effective method of surface disinfection to help prevent the spread of SARS-CoV-2 worldwide.

Declarations

Acknowledgment

The SARS-CoV-2 strain (Hu/DP/Kng/19-020 strain) was provided by the Kanagawa Prefectural Institute of Public Health.

Data Availability Statement: The datasets during and/or analysed during the current study available from the corresponding author on reasonable request.

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Conflict of Interest: None

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Tables

Table 1. Inactivation of SARS-CoV-2 under different acetic acid and vinegar conditions.

	Acetic acid concentration in contact with the virus (w/w%)	pH in contact with the virus	Contact time	Virus infectious titre ($TCID_{50}$/ml)
PBS	–	–	1 min	1.1×10^6
70% ethyl alcohol	–	–	1 min	$\leq 6.3 \times 10^2$
4% acetic acid solution	3.6	2.68	10 sec	2.0×10^5
			1 min	3.6×10^4
			5 min	$\leq 6.3 \times 10^2$
GV (containing 4% acetic acid)	3.6	2.72	1 min	3.6×10^5
6% acetic acid solution	5.4	2.46	10 sec	1.1×10^5
			1 min	1.1×10^4
			5 min	$\leq 6.3 \times 10^2$
WDV (containing 6% acetic acid)	5.4	2.67	1 min	$\leq 6.3 \times 10^2$

PBS; phosphate-buffered saline, GV; grain vinegar, WDV; white distilled vinegar

Table 2. Inactivation of SARS-CoV-2 by vinegars.

	Acetic acid concentration in contact with virus %w/w	pH in contact with virus	Contact time	Virus infectious titre ($TCID_{50}$/ml)
PBS	–	–	1 min	1.1×10^6
70% ethyl alcohol	–	–	1 min	$\leq 6.3 \times 10^2$
GV (containing 4% acetic acid)	3.6	2.72	5 min	3.6×10^5
			30 min	2.0×10^5
			60 min	2.0×10^4
WDV (containing 5% acetic acid)	4.5	2.70	10 sec	6.3×10^4
			1 min	$\leq 6.3 \times 10^2$
WDV (containing 6% acetic acid)	5.4	2.67	10 sec	2.0×10^4

PBS, phosphate-buffered saline; GV, grain vinegar; WDV, white distilled vinegar