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Economic and Environmental Health Challenges of COVID-19 Pandemic: A Sustainable Prevention and Control Measure Using Locally Made Ginger and Garlic Hand Sanitizer

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Abstract

Hand sanitizers are chemical preparation used as antiseptics in the prevention and control of diseases. The coronavirus disease is an infection caused by the SARS-CoV-2 virus which is susceptible to tropical temperature, disinfectants and antiseptics. During the COVID-19 pandemic, hand sanitizers were largely unavailable at some point due to the lockdown situation which crippled commercial and economic activities in Nigeria. In the light of the lockdown, there was a need to develop an indigenous hand sanitizer product with local, cheap and available materials without necessarily depending on importation. This study assessed the antibacterial properties of ginger and garlic blended with isopropyl alcohol as an effective hand sanitizer for the control and prevention of the spread of SARS-CoV-2 virus. Appropriate volumes of ginger and garlic juice with isopropyl alcohol were used to formulate the hand sanitizer. Antimicrobial activity of these hand sanitizers were determined using 10 clinical bacterial isolates which include: *Pseudomonas aeruginosa, Salmonella typhi, Escherichia coli, Vibro cholerae, Klebsiella* spp., *Staphylococcus* spp., *Streptococcus* spp., *Micrococcus* spp, *Streptobacillus* spp. and *Bacillus* spp. The analysis was conducted in triplicate using disc diffusion agar method. A tolerance assessment test was carried out on all the hand sanitizers on 300 individuals. All 10 bacterial isolates were sensitive to garlic 25 % and garlic 50 % hand sanitizer expect *Micrococcus* spp. *Bacillus* spp. was most sensitive with 13.4 mm zone diameter. The garlic hand sanitizers were more effective and most preferred to the ginger hand sanitizers. It was observed that the blending of isopropyl alcohol with ginger and garlic produced stronger antibacterial effect. The bacteria used in this study were mesophilic bacteria which thrive in the tropics, knowing the fact that SARS-CoV-2 virus cannot survive under high temperature in the tropics, these hand sanitizers having shown antibacterial effects on these mesosphilic bacteria could also be used in vitro for the control of SARS-CoV-2 virus and prevention of a future outbreak. Therefore, more research should be tailored towards discovering other African herbs with antibacterial/antiviral properties which could be used in the production of hand sanitizers for the prevention and control of future viral outbreaks.

Keywords: Ginger, Garlic, Isopropyl Alcohol, COVID-19 Pandemic

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1. Introduction

The wave of COVID-19 pandemic which started from Wuhan in China swept through almost every country in almost all the continent of the world. The word "lockdown" became a strategy proposed by the World Health Organization (WHO) to contain the spread of the virus [1-2]. This restriction of movement in many countries created economic downtime with very high reduction in commercial production, exportation and importation of goods and services. This trend impacted on the production and sale of hand sanitizers all over the world especially in countries that depend on importation for their hand sanitizers like Nigeria. The COVID-19 pandemic posed several environmental health challenges, many of which had both immediate and long-term implications [3]. There was an increased demand for clean water hand hygiene and sanitation needs surged, stressing water supply systems, especially in areas with limited access to clean water. Health risks from disinfectants were also a major concern because excessive and sometimes inappropriate use of chemical disinfectants posed risks to respiratory health and environmental contamination. Sanitation workers, healthcare personnel, and waste handlers were at high risk of infection due to insufficient protective equipment or training [1].

There were cases of mental and physical health strain as a result of long working hours, high risk of exposure, and poor working conditions affected well-being of environmental and health service workers [2-3].Most communities in Nigeria didn't have enough hand sanitizers to go round during the COVID-19 pandemic. At this point, individuals started formulating anything they could lay their hands on that could serve as relieve from the scourge of pandemic. With restrictions on movement, production and commercial activities which made hand sanitizers unavailable to individuals and communities, there was a need to formulate an indigenous hand sanitizer product made from affordable and available local materials such as ginger, garlic and isopropyl alcohol in order to bridge the unavailability of hand sanitizer gap created by the "lockdown" situation [3]. Ginger and garlic both celebrated not just for their culinary uses but also for their impressive nutritional and antibacterial properties [4-5]. When used together, ginger and garlic can complement each other's health benefits, potentially boosting overall antibacterial effectiveness and supporting digestive health. Ginger is rich in vitamins and minerals which include vitamin C, magnesium, and potassium.

It also contains antioxidants like gingerol which helps in combating oxidative stress and improves the overall immune function by reducing inflammation. The gingerol in ginger exhibits antibacterial effects against various pathogens. Garlic also is rich in vitamins C and B6, manganese, and selenium [6-7]. Garlic contains allicin which contributes to many of its health benefits, it has broad-spectrum antibacterial properties, it is effective against a wide range of bacteria, including antibiotic-resistant strains like MRSA and enhances the immune response, helping the body fight off infections [8].The availability and affordability of Isopropyl alcohol is key towards its high demand as a chemical of choice in the formulation of several hand sanitizer products. At 60-70% concentration, it is effective at reducing the number of microorganisms on the hand and is particularly useful when soap and water are not available [9-10]. It can kill a variety of bacteria and inactivate viruses, including those that cause the flu and cold, as well as some more resilient pathogens and it is also effective against fungi making it a versatile antiseptic.

It works by disrupting the cell membranes of bacteria, which leads to the breakdown of the bacteria and their eventual death [11].The effect of the combined antibacterial propertiesofginger and garlic, and isopropyl alcohol is expected to produce a much more bactericidal effect. Ginger and garlic evidently possess huge antibacterial properties capable of killing bacteria and viruses [12]. However, both ginger and garlic can cause irritation or allergic reactions in some people, especially when applied to the skin. Also, fresh ginger and garlic juice may not have a long shelf life and can spoil quickly. On the other hand, isopropyl alcohol is able to reduce skin irritation that maybe caused by ginger and garlic juice and as a preservative, it can preserve the juice by increasing the shelf life of the juice making it last longer and fit as a hand sanitizer [13]. The combination of both ginger and garlic blended with isopropyl alcohol doubles its antibacterial property and creates a very strong hand sanitizer that can be used in the prevention and control of SARS-CoV-2 virus. Therefore, this present study assessed the antibacterial properties of ginger and garlic blended with isopropyl alcohol as an effective hand sanitizer for the control and prevention of COVID-19 pandemic.

2. Materials and Methods

2.1. Material source and study location

Fresh ginger and garlic were purchased from Area M World Bank market, New Owerri, Imo State, Nigeria. One (1) litre of isopropyl alcohol was gotten from the Microbiology Labouratory at the Department of Microbiology, University of Agriculture and Environmental Sciences Umuagwo. Bacterial isolates were subcultured from isolated cultures in Medical Labouratory Depatment, Imo State general hospital New Owerri. The experiment was set up at the Microbiology Labouratory, University of Agriculture and Environmental Sciences Umuagwo, Owerri, Imo State, Nigeria.

2.2. Experiment set-up

The glass wears used for the laboratory analysis were washed with detergent properly and rinsed in distilled water before air drying. The following bacterial isolates *Pseudomonas aeruginosa, Salmonella typhi, Escherichia coli, Vibro cholerae, Klebsiella* spp*., Staphylococcus* spp., *Streptococcus* spp., *Micrococcus* spp, *Streptobacillus* spp. and *Bacillus* spp. were sub-cultured to reactivate them. Eight (800 g) of ginger and garlic each were carefully peeled, washed under a running tap and cut into tiny pieces using a sharp knife. The 800 g peeled ginger and garlic were placed in an electric blender (Vitamix Blender E310 Explorian), 100 ml of distilled water was added for easy blending and the mixture were blended into a smooth paste respectively. The pastes were then sieved using a big plastic sieve (Oriental riverkit 100 mesh) to remove the excess chaff. The fluid gotten were further sieved using a smaller sieve (Oriental riverkit 400 mesh) to remove extra chaffs and stirred using a glass rod to speed up the process [14].The hand sanitizers were formulated as follows; 25 % ginger hand sanitizer (25 ml ginger juice and 75 ml isopropyl alcohol), the 50 % ginger

hand sanitizer (50 ml ginger juice and 50 ml isopropyl alcohol), the 25 % garlic hand sanitizer (25 ml garlic juice and 75 ml isopropyl alcohol), the 50 % garlic hand sanitizer (50ml garlic juice and 50 ml isopropyl alcohol) and 50 % ginger/garlic hand sanitizer (25 ml ginger juice with 25 ml garlicjuice and 50 ml isopropyl alcohol). Individaul ginger and garlic hand sanitizers solution were further filtered using a membrane filter (Whatmam 13mm) to remove precipitates and provide sterility. After this was done, a very little quantity of alcohol added to check for evaporation, and then mixtures transferred into sterile well labeled spray bottles [15].

2.3. Determination of the Inhibitory and Bactericidal Potential of the Hand Sanitizer

For the determination of the inhibitory and bactericidal potential of the hand sanitizer, the hand sanitizer sensitivity disc was designed using a filter paper which was cut to a size of 0.7 cm diameter. The filter paper was impregnated in each with 0.01 ml of the individual sanitizers (25 % ginger, 50 % ginger, 25 % garlic, 50 % garlic and 50 % ginger/garlic hand sanitizer) for 30 minutes. The Mueller-Hinton Agar was prepared according to manufacturer's instruction and poured into 100 disposable Petri dishes. Each bacterial isolated was streaked on duplicate plates of the Mueller-Hinton Agar. Two filter papers impregnated with the individual hand sanitizers (25 % ginger, 50 % giner, 25 % garlic, 50 % garlic and 50 % ginger/garlic hand sanitizer) were placed on each of the duplicate *Pseudomonas aeruginosa* streaked plates. This was repeated for all the other nine isolates and incubated at 37 ℃ for 24 hours [14-16]. The zone of clearance was determined by measuring the diameter of the cleared zone around the disc with Wastcott Metric Ruler, 30 cm, M-108 and converted to mililitre.

2.4. Tolerance Assessment for the Individual Hand Sanitizers

Tolerance assessment for the 5 hand sanitizer products was carried out on 300 individuals in and out of the campus of the University of Agriculture and Environmental Sciences Umuagwo, Owerri, Imo State. The sampling captured both students and staff living within and outside the University environment. A questionnaire was developed for the assessment where every individual was expected to describe their level of tolerance of each hand sanitizer as they applied it on their hands by answering YES for (tolerance) or NO for (non-tolerance). Every individual response was captured in 5 columns under each hand sanitizer. Their response was based on if they liked the smell of the hand sanitizer and if they experienced any skin reaction [17-18].

2.5. Statistical analysis

The performance of the hand sanitizers were compared using the values from the individual bacterial zone diameter. These values were subjected to analysis of variance (ANOVA) using the SPSS software.

3. Results and discussion

The composition of each of the hand sanitizers is recorded in Table 1. The individual bacterial zone diameter which shows their level of sensitivity to individual hand sanitizers is captured in Table 2. *Vibrio cholera* had zone diameter value of 1.0 mm for 25 % ginger and 2.5 mm for 50 % ginger which shows that it was resistant to both hand sanitizers. *Micrococcus* spp. was also resistant to 25 % ginger, 50 % ginger and 50 % ginger/garlic hand sanitizer with 0.0 mm, 2.5 mm and 1.9 mm zone diameter respectively. Similarly *E coli,* and *S. aureus* had 2.0 mm and 3.9 mm zone diameter for 25 % ginger hand sanitizer. All 10 bacterial isolates were sensitive to garlic 25% and garlic 50% hand sanitizer, only *Micrococcus* spp. was resistant to ginger/garlic 50% hand sanitizer. All bacteria isolates with zone diameter ranging from 4 to 6 mm were considered moderately sensitive while those with zone diameter of 7 and above were considered to be sensitive to the hand sanitizers. Figures 3 to 7 shows a picture of the formulated hand sanitizers which include: 25 % ginger hand sanitizer, 50 % ginger hand sanitizer, 50 % ginger/garlic hand sanitizer, 25 % garlic hand sanitizer and 50 % garlic hand sanitizer.

Figure 2, shows the percentage tolerance assessment chart for the individual hand sanitizers. The hand sanitizers were sampled on 300 persons to evaluate the toxicity and preference of individual hand sanitizer. They were asked to fill the questioner provided based on their choice of hand sanitizer. From the 300 questioner received, it was observed that 87 persons (29 %) preferred 50 % garlic hand sanitizer, about 63 persons (21.66 %) preferred 50 % ginger hand sanitizer, about 51 persons (17. 66 %) chose 50 % ginger/garlic hand sanitizer, also about 48 persons (16.6 %) preferred 25 % ginger hand sanitizer while only 45 persons (15 %) chose garlic hand sanitizer. Figure 8, is a graphical representation of the different zone diameters recorded for each bacterial isolate in table 2. *Bacillus* spp. was sensitive to all the hand sanitizers followed by *Streptobacillus* spp., *Streptococcus* spp., *Klebsiella* spp. and *Pseudomonas* spp. on the other hand, *Micrococcus* spp. was resistant to three hand sanitizer: 25 % ginger hand sanitizer, 50 % ginger hand sanitizer and 50 % ginger/garlic hand sanitizer.

Similarly, *Vibrio cholera* was resistant to two hand sanitizers 25 % ginger hand sanitizer and 50 % ginger hand sanitizer. Figure 8, is a graphical representation of the different zone diameters recorded for each bacterial isolate in table 2. *Bacillus* spp. was sensitive to all the hand sanitizers followed by *Streptobacillus* spp., *Streptococcus* spp., *Klebsiella* spp. and *Pseudomonas* spp. on the other hand, *Micrococcus* spp. was resistant to three hand sanitizer: 25 % ginger hand sanitizer, 50 % ginger hand sanitizer and 50 % ginger/garlic hand sanitizer. Similarly, *Vibrio cholera* was resistant to two hand sanitizers 25 % ginger hand sanitizer and 50 % ginger hand sanitizer. In this research, the antibacterial property of ginger, garlic blended with isopropyl alcohol was assessed. The data from the tolerance test shows that garlic 50 % was most preferred followed by ginger 50 %. Garlic 25 % was less preferred amongst the hand sanitizers.

Figure 1: A: Ginger roots, B: Garlic Bulbs

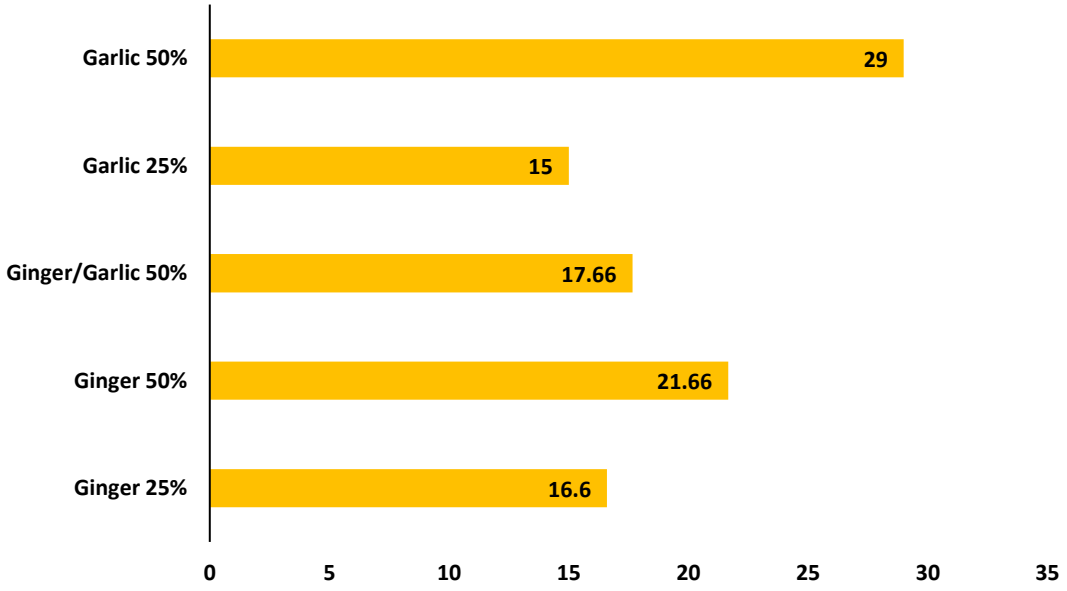

Figure 2: Percentage tolerance assessment chart for the individual hand sanitizers

Figure 3: Photo of 25 % ginger hand sanitizer

Figure 4: Photo of 50 % ginger hand sanitizer

Figure 5: Photo of 50 % ginger/garlic hand sanitizer

Figure 6: Photo of 25 % garlic hand sanitizer

Figure 7: Photo of 50 % ginger hand sanitizer

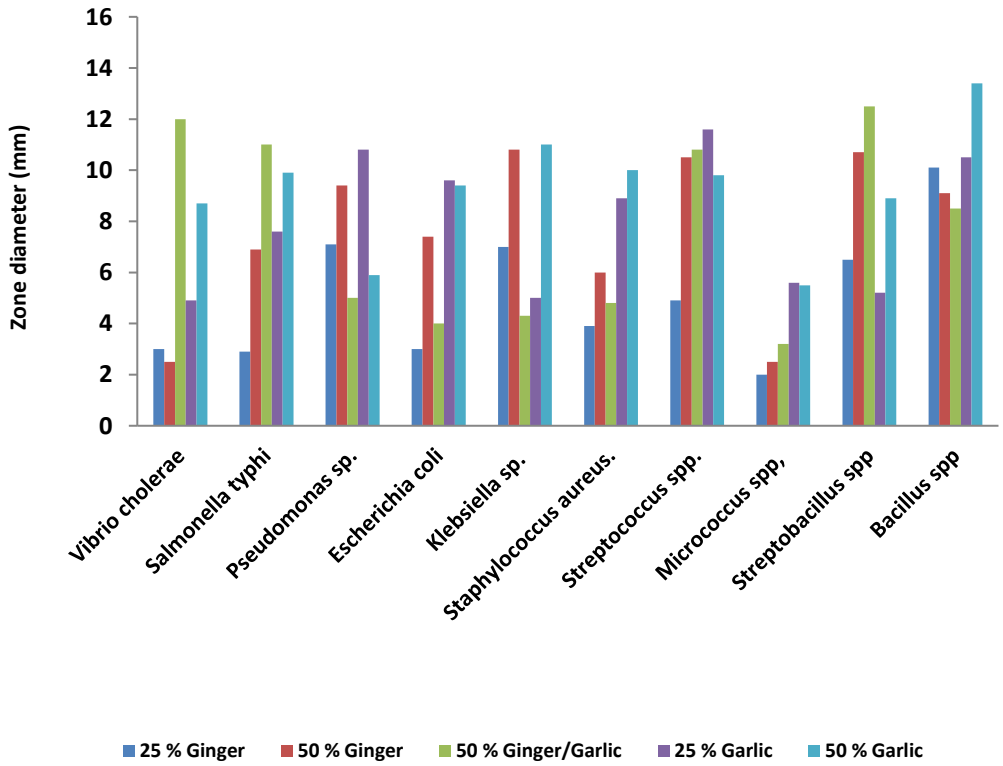

Figure 8: Sensitivity prevalence of the bacterial isolates to the hand sanitizer

Table 1: Composition of Lemon and Lime Hand Sanitizer Formulation

S/N	Hand sanitizers	Composition
1	25% Ginger	25ml Ginger Juice and 75ml Isopropyl Alcohol
2	25% Garlic	25ml Garlic Juice and 75ml Isopropyl Alcohol
3	50% Ginger/Garlic	25ml Ginger Juice, 25ml Garlic Juice and 50ml Isopropyl Alcohol
4	50% Ginger	50ml Ginger Juice and 50ml Isopropyl Alcohol
5	50% Garlic	50ml Garlic Juice and 50ml Isopropyl Alcohol

Table 2: Bacterial zone diameter (mm)

S/N	Bacterial isolates	25 % Ginger	50 % Ginger	50 % Ginger/Garlic	25 % Garlic	50 % Garlic
1	*Vibrio cholerae*	3.0	2.5	12.0	4.9	8.7
2	*Salmonellatyphi*	2.9	6.9	11.0	7.6	9.9
3	*Pseudomonas* sp.	7.1	9.4	5.0	10.8	5.9
4	*Escherichia coli*	3.0	7.4	4.0	9.6	9.4
5	*Klebsiella* sp.	7.0	10.8	4.3	5.0	11.0
6	*Staphylococcus* aureus.	3.9	6.0	4.8	8.9	10.0
7	*Streptococcus* spp.	4.9	10.5	10.8	11.6	9.8
8	*Micrococcus* spp,	2.0	2.5	3.2	5.6	5.5
9	*Streptobacillus* spp	6.5	10.7	12.5	5.2	8.9
10	*Bacillus* spp	10.1	9.1	8.5	10.5	13.4

Key: S= Sensitive (≥7 mm), R= Resistant (≤4 mm), MS= Moderately Sensitive (4-6 mm)

However, the result did not correspond with the antibacterial activity of the hand sanitizers, rather individual choice of hand sanitizers was strictly based on their personal reason (Figure 1). Several researches on hand sanitizer have shown a high prevalence of choice for alcohol base hand sanitizer over others [7-16-19]. All the 10 bacterial isolates were sensitive to garlic 25 % and garlic 50 % hand sanitizer except *Micrococcus* spp. which was resistant to 25 % ginger hand sanitizer, 50 % ginger hand sanitizer and 50 % ginger/garlic hand sanitizer. *Vibrio cholera* had zone diameter value of 1.0 mm for 25 % ginger and 2.5 mm for 50 % ginger which shows that it was resistant to both hand sanitizers. *Micrococcus* spp. was also resistant to 25 % ginger, 50 % ginger and 50 % ginger/garlic hand sanitizer with 0.0 mm, 2.5 mm and 1.9 mm zone diameter respectively. Similarly *E coli* and *S. aureus* had 2.0 mm and 3.9 mm zone diameter respectively for 25 % ginger hand sanitizer. Most of the bacterial isolates were sensitive to garlic 25% and garlic 50% hand sanitizer, only *Micrococcus* spp. was resistant to ginger/garlic 50 % hand sanitizer. All bacteria isolates with zone diameter ranging from 4 to 6 mm were moderately sensitive while those with zone diameter of 7 and above were considered to be sensitive to the hand sanitizers [20].

Figures 3 to 7 shows a picture of the formulated hand sanitizers which include: 25 % ginger hand sanitizer, 50 % ginger hand sanitizer, 50 % ginger/garlic hand sanitizer, 25 % garlic hand sanitizer and 50 % garlic hand sanitizer. The data from Table 2 shows that both garlic hand sanitizers were effectives against a wide range of bacterial isolates which was followed by the ginger/garlic 50 % hand sanitizer which corroborate with [21]. Considering ginger 25 % hand sanitizer, it was observed that the ginger hand sanitizer had a low bacterial sensitivity range at low concentration which improved with increased concentration looking at the data from ginger 50 % hand sanitizer [19-21]. It was obvious that the garlic hand sanitizers were more effective compared to the ginger hand sanitizers. However, there was no significant difference observed ($p \leq 0.05$) across means of zone diameter from the hand sanitizers. The findings from present research corroborate with *Udochukwu et al.* [19], who observed a similar trend with lemon and lime hand sanitizer which tested on 5 Gram negative bacterial isolates. Highest zone diameter of 13.4 mm observed with garlic 50 % hand sanitizer which was followed by 50 % ginger/garlic 12.5 mm and 25 % garlic with 12.0 mm zone diameter. These observations are also in line with previous studies by [8-16-22].

4. Conclusions

Ginger and garlic alcohol-based hand sanitizer is effective in the control and prevention of diseases. This study bridges the gap of unavailability of other commercially sold hand sanitizers during the lockdown situation of the COVID-19 pandemic. This research provides a guide on how we as a nation in Nigeria and other developing nations can handle future viral outbreak especially in the case of a re-emergence COVID-19 strain. It further urges the industry and policy makers to look inward towards the control and prevention of viral outbreak, to support local research institutions to formulate effective preventive and control measure using local herbs which are cheap, safe and available. Therefore, there is a need to further research on the antimicrobial properties of other African herbs which could serve as a tool in the prevention and control of future viral outbreaks and to sensitize the government and policy makers on the need to encourage local industries for the production of hand sanitizers over importation.

Competing Interest

The authors declare that they have no competing interests.

Authors' Contributions

This work was initiated and conceptualization by UU and EMO, Data collection and processing were carried out by IVC, N.M.O and IPO. Result computation and analysis were carried out by ACL, K.M.C, NCA, OTE and O.P.C. All authors have read and agreed to the published version of the manuscript.

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