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Study of Antibacterial effects on Indian Currency

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Abstract:

The Indian rupee is the official mode of currency in India. With time, science and technology got advanced and our society is slowly making its way to a cashless mode of transaction. But as India is still an emerging country a large part of our society still depends on the transaction through cash. During the times of pandemics, we came to understand that everything that we touch is not safe from microbial contamination. The Indian currency is also not an exception. The Indian currency is the modern-day medium of harmful bacterial as well as other microbial contaminations resulting in diseases in human bodies. Therefore, the need came to make the currency disinfectant to give our people a healthier lifestyle.

The main focus of the study is to develop a solution that when applied to the currency notes will kill the persisting bacteria or microbes present in the notes. So various natural edible products were used in order to prepare the solution which is highly effective against the presence of harmful bacteria such as E. coli and S. aureus. The antibacterial activity of these natural ingredients is not unknown to us so extracts from those products were mixed together to form a solution which was made the Indian currency notes antibacterial for 20min approx. The solution was persisting on the outer surface of currency notes, therefore, making it antibacterial for a given duration of time i.e., no bacterial growth was seen during the time period of 20 minutes, therefore, making it safe for the usage of human hands.

Keywords: Indian currency; Antibacterial property of Indian currency; Surface coating on currency, Antibacterial solution.

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Introduction:

India is an evolving country both in terms of digitalization and overall development. Among the different forms of digitalization, the cashless economy is of great concern all over the world. India is also moving towards the cashless economy to transform India into a digitally driven society and knowledge economy. Recent COVID pandemic has necessitated and boosted the cashless transactions in our society. But usually, India has been a cash driven economy here the currency notes are being circulated millions of times among innumerable number of people per day.

The huge circulation of notes increases the risk of contamination of harmful diseases and especially in these tough times of pandemic where everything is advised to be contactless to avoid the deadliest effects of CORONA virus, the cash-based mode of transaction is one such thing where contact must be

made in-order to complete the transaction therefore raising a probability of contamination by currency.

A study of microbial identification was carried out on 24 currency notes out of which all were contaminated with bacteria. The results showed that the currency notes that were collected from the open market as well as from the hospitals were contaminated with pathogenic microorganisms. The S. aureus contamination was found more in the notes collected from the hospitals than in the open market [1].

In order to prevent the contamination of harmful microbial contaminations through currency notes countries like Australia and New Zealand has introduced washable notes so that the lifespan of the currencies is not compromised while washing the notes [2]. But it is not possible in our country like India as the main composition of Indian currency includes 100% cotton with certain portion of silk for security thread purposes. Washing it is in not an option. Also, ultraviolet light can be used to disinfect the notes while being handed out in the banks [2]. But the longevity of the UV Rays is very less, and UV rays are just passed to check the security thread of the note therefore making it partially antibacterial but the major drawback is that its making it antibacterial for a very short span of time. [Source: Reserve Bank of India]. This present study differs from all the previous works mainly because of one significant point and that is to make the entire currency note antibacterial for a certain period time, an idea upon which no study has been done yet.

The process of disinfecting the notes involves the creation of a coating on currency notes which will prevent the growth of microorganisms for a certain period of time. The coating will persist on the upper layer of the note preventing the growth of microorganisms especially bacteria therefore preventing contamination through notes. Lime peel extract (citric acid) is used for its powerful antibacterial properties to prepare the solution along with alcohol for maximum effectiveness against E-Coli among others [3-7]. Vinegar was added it was composed of 0.1% concentration of acetic acid along with chloride to get antibacterial effect 100% on E - Cobe, S.aureas and around hundred percent antibacterial activity against E coli. It can be used as a natural substitute for antimicrobial drugs [8-14]. Ginger was also added because of its components zingiberene and Alpha curcumene. Antibacterial activity was tested against harmful microbes such as S aureus and E coli. The results showed that some electrophoretic bacteria cell proteins bands disappeared with increase in GEO concentration. The metabolic activity of bacteria was also decreased [15-18].

Materials and methods:

The aim of the research is to prepare a disinfectant solution which will make the Indian currency notes antibacterial for a certain period. The raw materials used for the preparation of the desired disinfectant solution includes lemon extract that contains citric acid which is proved to be of great use to make products antibacterial in nature. The solution also consists of industrial vinegar for acetic acid and ginger for its antibacterial qualities and for its strong aroma. Iso propyl alcohol was also incorporated in trace amount so that when added to the solution it doesn't persist on the surface of the notes and dry up quickly and for its antibacterial nature. Methylene blue was used for identifying E. coli that presents on the surface of the currency notes. Zeoline has been included as it contains sodium hypochlorite which when applied on silk activates the natural antibiotic properties of this natural fibre. Lastly, traces of alcohol were added so that the prepared solution doesn't make the currency notes wet for longer period of time and also because of its antibacterial properties. The nature of the solution is that of a colourless liquid with a strong aroma and the pH of 4-5 approximately which when sprayed on currency creates an antibacterial coating

2.1.1 *Extraction of Lemon Juice*

Lime extract is an essential part of the disinfectant solution that has been made. The lime juice was extracted from fresh lemon slices. The juices were squeezed into a glass petri dish and to remove any kind of pulp that may have been mixed with the juice, the lime juice was passed through the filter paper to get the actual fresh lime extract and it was stored in a clean air-tight container for further use.

2.1.2 *Extraction of Ginger Juice*

Ginger juice was extracted from raw and fresh ginger. The raw ginger was cut into pieces and was shredded into much smaller pieces with a help of a clean and sterilised shredder. The shredded pieces are then taken in a clean petri dish and with the help of a filter paper the juices are extracted from those pieces and kept in an air-tight container for further use.

2.1.3 *Preparation of Currency Disinfectant Solution*

The disinfectant solution was prepared by mixing of all the natural and chemical components in measured proportions. The lime extract and the ginger extract that was prepared from fresh lime and ginger respectively were kept in a petri dish and

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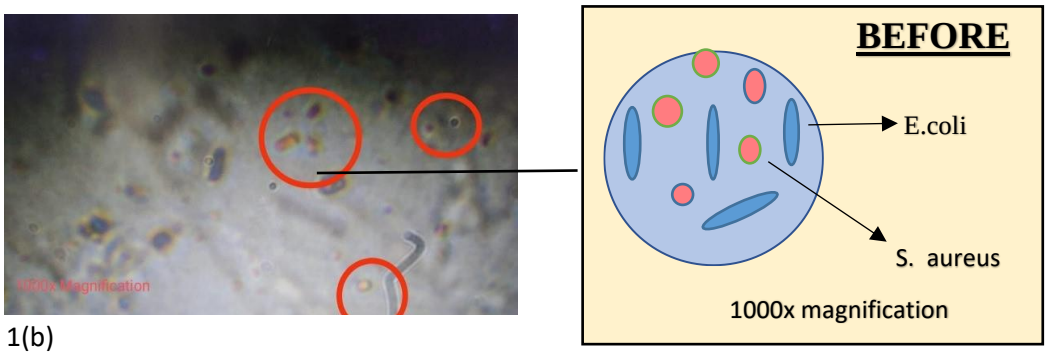
1(a)



1(b)

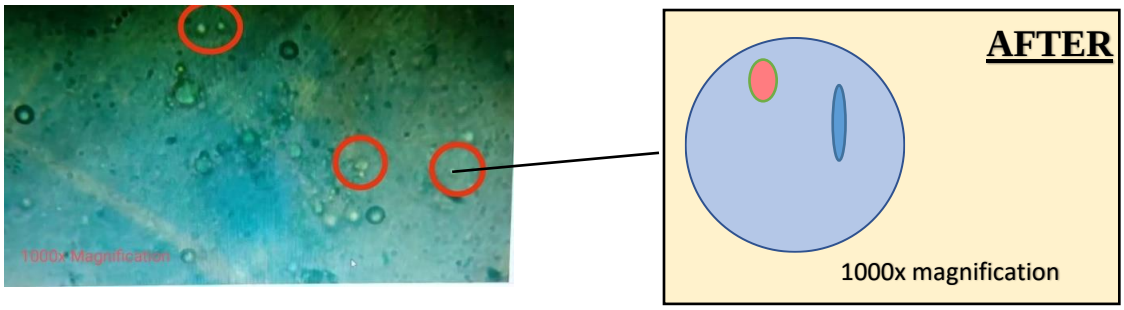


Fig. 1 Microscopic image of the: (a) culture collected from the surface of the note without the addition of solution (presence of microbes) and (b)culture collected from the surface of the note after application of solution at time (t) = 16 minutes (absence of microbes)

measured proportions were taken with the help of a syringe. Measured proportion of vinegar and iso-propyl alcohol were mixed together and were kept in an air tight test tube. For the chlorination purpose Zeoline and water were combined to get the desired results. All of these ingredients were mixed together thoroughly to get our required solution.

2.2 *Characterization Techniques*

Microscope (Make: NEBOLAB INDIA) used to identify and the study the various microbes present in the currency notes as well as the effect of the antibacterial solution on those microbes. The specific objective lens used for this purpose were of magnification 100/1.25OIL 160/0.17, 40/0.65 160/0.17, 10/0.25 160- and the eyepiece used were of zoom WF10x/20 and WF15x/15. Methylene blue (LOBA CHEMIE PVT.LTD) was used in order to identify the gram-negative bacteria i.e., E. coli.

2.3 *Culture Preparation*

The culture was prepared from notes that have been already used multiple times in-order to get the best results. A note was taken and few drops of normal water was given on the surface of the currency notes. A clean ear bud was taken and samples were scraped from the outer surface of the currency notes and were put in the slide. The sample was then mixed with measured proportions of methylene blue solution and was covered with a slide cap and then put to test under the microscope. Different magnifications of the microscope were taken into account in identifying the bacteria present in the sample.

Results and Discussions:

The solution, prepared using all the natural and chemical components showed a range of results when it was applied on the microbial culture as well as on the surface of the currency notes. The results were a definite proof that the application of the solution would make the Indian currency notes antibacterial in nature for a certain period of time.

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On application of solution on the surface of the currency notes an instant and notifiable changes have been observed. When placed under the microscope the colony of living cells of E. coli and S. aureus which are marked in red circles including other microbes (see Fig. 1(a)). When the solution first comes in contact with the culture, the colony of microbes got separated and scattered from each other. With increase in time the antibacterial property also increases and after a certain period of time the growth of microbes get stopped and the living cells die making the culture free of microbes as shown in Fig. 1(b). Therefore, making the Indian currency notes antibacterial in nature.

2(a) 2(b) 2(c)

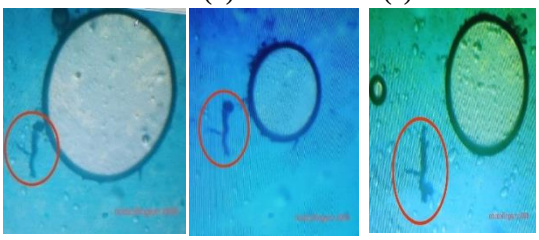


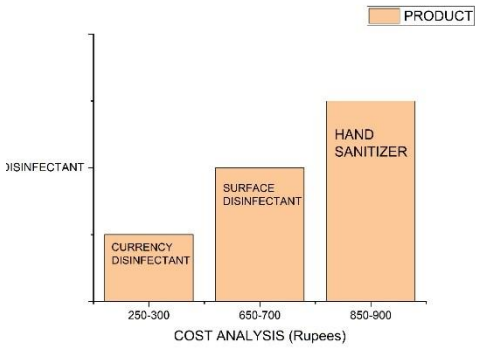
Fig. 2 Microscopic image of the: (a) colony of E.coli bacteria marked in red being attached to a cell before the application of the prepared solution but in (b) after applying the solution into the culture the bacterial colony slowly started to lose its bactericidal properties and started to get separated from the cell and finally in (c) the colony of E. coli is fully separated from the cell as the bacteria present in the colony died due to lack of oxygen and low pH level of the solution applied.

The application of the solution shows a gradual process of the colony of bacteria getting separated from the cell shown in fig. 2(a)-(c). This fragmentation occurs due to the lack of oxygen as the applied solution creates a persisting layer on the surface of notes and also the low pH of the solution which kills the microbes and makes the currency bacteria free.

Table 1: Changes observed in the bacterial nature/growth with change in time

Change in Time	Changes Observed
1. 0 seconds	All bactericidal cells were detected to be alive
2. 2 minutes	The applied solution started acting on the microbial cells and getting spread out throughout the surface of the note
3. 4 minutes	The colony of the microbes started to get separated from each other due to the action of the applied solution on them
4. 6 minutes	The random movement of bacteria stopped and the solution has created a resistance layer on the surface of the notes to prevent further growth
5. 8 minutes	The living cells of the microbes started to die and also the growth of new microbes is stopped
6. 10 minutes	The layer of the applied solution persists on the outer surface of the currency notes to prevent any microbial contamination
7. 12 minutes	The solution continues to barrier the currency notes from any bacterial growth and most of the living bacterial cells died
8. 14 minutes	The culture shows negligible movement of microbes but no new growth of microbes including E. coli and S. aureus can be observed
9. 16 minutes	The culture is now bacteria-free and the studied note can now be declared as an antibacterial currency note

Fig.3: Cost analysis among currency disinfectant, sanitizer and surface disinfectant



The graph shown in Fig. 3 depicts the cost analysis among several antibacterial solutions available in the market. The comparison has been done solely based on the raw materials used to prepare the solutions. The ingredients used as raw materials and their cost analysis has been shown below:

1. Hand sanitizer – comprises of 90-95% of alcohol along with 5% of water. Cost of water is minimal and 1Litre of isopropyl

alcohol costs around 600 Indian rupees. Therefore, the costs of a hand sanitizer range about 850-900 Indian rupees [19].

2. Surface disinfectant– comprises of equivalent proportions of the mixtures of isopropyl alcohol, sodium hypochlorite and hydrogen peroxide. The costs of individual ingredients sum up to be around 650-700 Indian rupees per litre [20].
3. Currency disinfectant – comprises of 50-55% of natural ingredients, 30-35% of sodium hypochlorite (Zeoline) and the rest with isopropyl alcohol. The cost of the raw materials ranges to 250-300 Indian rupees.

The above cost analysis of the several types of antibacterial solutions indicates that the currency disinfectant can be claimed as the most cost effective among the antibacterial solutions due to the cost reduction in all the natural raw materials and their easy availability in the market.

Table 2: Comparison between the properties of currency disinfectant and sanitizer/disinfectant

Currency Disinfectant	**Sanitizer/surface disinfectant**
1. pH – 4.5 to 5	pH – 6.5 to 7
2. Colourless in nature	Colourless/coloured in nature
3. Odour – Limy Fresh	Odour - Alcoholic
4. No Side Effects on Human skin	May show Side Effects
5. Showslittle antibacterial activity on human skin	Shows up to 99 percent of antibacterial activity on human skin
6. Shows more than 95 percent antibacterial activity on currency note	Not tested on currency notes
7. Has a longevity of time period more than 15 minutes	Not tested on currency notes
8. Composed of All Natural Ingredients	Composed of both Natural as well as Chemical components.
9. When applied, cleans all the layers of the currency note	When applied, it damages the currency note.

Table. 2 shows the difference between the currency disinfectant with any other standard surface disinfectant or hand sanitizer.

The main objective behind this table is to show the improved qualities this currency disinfectant is showing when applied on the solution.

Conclusions:

The study shows the result that there is the presence of many contaminating microbes most of which can be destroyed with the studied solution. Moreover, the solution also persisted on the layer, therefore, making the note antibacterial itself for the given period of time. Thus, this can be concluded that when the solution is applied, the note can be safe from bacterial contamination for quite a period of time. Further studies can help with more distinguishable improvements in the near future.

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