Possible Potential of Tamra Bhasma (Calcined Copper) in COVID-19 Management

Aleena Gauri¹, Pramod Yadav², Pradeep K Prajapati³

ABSTRACT

The complete genome sequence of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) is 82% similar to SARS-CoV-1. The emerging coronaviruses, including SARS-CoV-1 and Middle East respiratory syndrome coronavirus (MERS-CoV), have caused the recent pandemics of respiratory infectious diseases. Ayurveda makes use of metals and minerals in the form of Bhasma (calx) to treat various ailments. Ancient seers recommend Tamra Bhasma (calcined copper) and its formulations in various conditions including Kasa (cough), Shwasa (respiratory distress), Jwara (fever), Pinasa (chronic rhinitis/sinusitis), and as a Rasayana (rejuvenator). Rasa Bhasmas are claimed as biologically produced nanoparticles. The world is in need of an effective prophylactic and therapeutic agent for the prevention and control of coronavirus disease-2019 (COVID-19). This review article aims at suggesting Tamra Bhasma as a possible intervention in COVID-19. Calcined copper has been reported as sulphide and/or oxide of copper in major phases and some other trace elements. Safety aspects of calcined copper have been established previously. Copper was recognized in 2008 by the United States Environmental Protection Agency as the first metallic antimicrobial agent. Various studies show antimicrobial effect of copper, copper alloys, and various cupric and cuprous compounds against different viruses. Based on the evidences found in classical texts and preexisting antiviral studies, a lead can be made to employ calcined copper for its preclinical and clinical efficacy evaluation against the novel coronavirus SARS-CoV-2.

Keywords: Ayurveda, Calcined copper, Coronavirus, COVID-19, SARS-CoV-2, Tamra Bhasma.


BACKGROUND

Coronavirus disease-2019 (COVID-19) caused by a novel zoonotic coronavirus (severe acute respiratory syndrome coronavirus-2, i.e., SARS-CoV-2) was originated and identified in the city of Wuhan, China. It came into light in the wake of a sudden outbreak of pneumonia of unknown etiology.¹ SARS-CoV-2 belongs to the family Coronoviridae and genus Betacoronavirus.² It is spreading worldwide via human-to-human transmission and is a global health emergency in the form of a pandemic. According to the WHO, as on August 8, 2020, there were 19,187,943 confirmed COVID-19 cases and 716,075 confirmed deaths worldwide.³

Ayurveda, the ancient medical science, has played a beneficial role in the treatment of a variety of acute and chronic ailments since ages. Since SARS-CoV-2 is a novel coronavirus with high mortality rate and no definitive cure, potential of Ayurvedic drugs since ages. Since SARS-CoV-2 is a novel coronavirus with high mortality rate and no definitive cure, potential of Ayurvedic drugs has been explored. Use of metals and minerals in the form of Rasa Bhasmas shows Shigravyapta¹⁰ (fast assimilation) and is effective in comparatively smaller doses. Bhasma, an Ayurvedic herbmetallic compound, is basically metal converted into a specifically desired chemical compound by following a systematic and elaborate stepwise procedure known as Bhasmikarana (incineration). When metals undergo proper processing, they become least toxic, highly absorbable, therapeutically safe, and effective.⁶

Tamra (copper) and its alloys, Pittala (brass—80% Cu, 20% Zn) and Kamsya (brass—80% Cu, 10% Zn, 10% Sn), have been separately mentioned in the classical texts for their therapeutic efficiency. Extensive therapeutic use of some other copper-containing compounds like Swarna Makshik (chalcopyrite) and Tuttha (copper sulfate) is also evident in the classics. The ancient seers of Ayurveda have recommended Tamra Bhasma (calcined copper) in Kasa (cough), Shwasa (respiratory distress), Jwara (fever),⁷ and Pinasa (chronic rhinitis/sinusitis).⁸ Copper was recognized in 2008 by the United States Environmental Protection Agency (EPA) as the first metallic antimicrobial agent.⁹

Bhasmas have a special place in Ayurvedic medical practice. This concept of ancient seers is popularly compared to the modern-era nanomedicines because of the similarity in their particle size and ability to reach at micro levels. Bhasma is basically an incinerated metallic ash, which is nowadays claimed to be biologically produced nanoparticles.¹⁰ Tamra Bhasma has been chemically reported to be copper oxide and/or sulphide in major phases along with the presence of other trace elements.¹¹ Copper nanoparticles have been proven to act as an antiviral agent in many studies and hence can potentially act on SARS-CoV-2 as well. The main objective of this review article is to explore the potential of calcined copper in addressing the pandemic COVID-19 based on various scientific evidences.
Materials and Methods
Official websites of the World Health Organization (WHO) and Ministry of AYUSH, Government of India, were searched for relevant information. Official journals of various organizations including JAIM, AYU, and NISCAIR journals like JIPR were thoroughly searched for pertinent information. PubMed was searched for collection of significant information regarding the topic with keywords like COVID-19, coronavirus, Tamra Bhasma, copper, antiviral, and SARS-CoV-2. The Ayurveda research database of Institute for Post Graduate Teaching and Research in Ayurveda (IPGT and RA), Jamnagar, Gujarat, was searched for related information.

COVID-19: Current Scenario
The genetic sequence of the novel coronavirus SARS-CoV-2, seventh member of the family coronaviruses, shows 82% homologous similarity with severe acute respiratory syndrome coronavirus (SARS-CoV), outbreak of which occurred in 2003. The emerging coronaviruses (CoVs), including SARS-CoV and Middle East respiratory syndrome coronavirus (MERS-CoV), have caused the recent pandemics of respiratory infectious diseases with high mortality. When it comes to clinical diagnosis, the CT imaging findings reported for COVID-19 are similar to those reported with SARS and MERS. Most of the coronaviruses share a similar viral structure and a similar infection pathway suggesting that similar research strategies can be applicable for SARS-CoV-2.12

Many researchers are striving to develop a vaccine against this novel coronavirus but there are many limitations like lack of proper animal models for efficacy evaluation, recombination of DNA vaccines with other viruses, and elimination of the vaccine by preexisting immunity.13

Potential Role of Tamra Bhasma
Efficacy of Tamra (copper) has been appreciated in various classical texts of Rasa Shastra (Indian iatrochemistry) as well as the three foundational treatises of Ayurveda, i.e., the Brihatrayi (Charaka, Sushruta, and Vagbhata). Importance of Tamra can also be justified by the fact that two of the eight Maharasa (category of compounds that are of utmost importance after mercury), i.e., Swarna Makshika (chalcopyrite) and Tuttha (copper sulfate), contain copper in a hefty amount.14 Tuttha is also known as Tamra-garbha14 due to the fact that copper can be easily extracted from it. Tamra Bhasma (calcined copper) has been used as a potent medicine for internal as well as external use since ages. Systematic Bhasmikarana (incineration) of Tamra involves processes, namely Shodhana (purification), Marana (incineration), and Amrutikarana (special procedure to remove the remaining unacceptable qualities). During these processes, Tamra is subjected to a lot of chemical and physical changes. Processing a metal with herbal drugs and organic liquid media like Tila Taila (sesame oil), Takra (buttermilk), Gomutra (cow’s urine), Amla (fermented preparation), and Kulattha Kwatha (decocction of Dolichos biflorus L) results in elimination of the toxic nature of the metal, reduction in particle size, and increase in its qualities. The use of plant extracts possibly caps the reactive metallic nanoparticles, thus making the Bhasma biocompatible, bioassimilable, absorbable, effective, and safe for internal use.15

The most common symptoms of COVID-19 are fever (Jwara), tiredness or myalgia (Anmarga), and dry cough (~Vaatika Kasa). Some patients may have nasal congestion, runny nose, sore throat, or diarrhea (Atisara).16 Sushruta has mentioned Tamra for mitigation of Kapha and Vata Doshas,17 vitiation of which is found when symptoms of COVID-19 are looked upon. Acharya Charaka has mentioned similar symptoms in Samnipatika Jwara.18 Based on the symptoms and mode of transmission (human-to-human spread), COVID-19 can be considered as Jwara caused due to Sansarga (contact transmission).

Tamra Bhasma is rarely used singly and most often used as a compound formulation prepared along with various herbo-mineral substances. Tamra Bhasma is quoted for its following actions—Kasa Shvasavihdhanam (decreases the intensity of cough and respiratory distress), Jwararham (provides relief from fever), Gadaicaram (pacifies the effect of accumulated poisons), Aayushyam (increases lifespan),19 effective in Peenasa (chronic rhinitis/sinusitis). Tamra Bhasma is also quoted in diseases related to gastrointestinal tract.7

Jwararaha and Shwasa-Kasahara Effect of Tamra Bhasma
Many Tamra-containing formulations and approximate percentage of Tamra in each of them have been studied and conveyed earlier.19 Most of the formulations are exclusively mentioned under Jwara-Rogadhi (indicated in fever) while some are indicated in Kasa-Shwasa as well (Table 1).

A prescription of Tamra Bhasma has specially been mentioned in the text for Kasa-Shwasa; i.e., intake of half Ratti (~62.5 mg) of calcined copper along with powdered Bharangi [Clerodendrum serratum (L.) MOON], powdered Vibhitaka [Terminalia bellirica (Gaertn.) Roxb.], and honey as adjuvant provides relief in Kasa-Shwasa.20

Clinical studies of Tamra Bhasma and Somanath Tamra Bhasma and their effect on Kapha Kasa and Shwasa showed promising results. Although the studies were limited to only a few number of cases, positive results with a decrease in the intensity of signs and symptoms were reported.11

Effect of Tamra Bhasma on Gastrointestinal Tract
Therapeutic efficacy of Tamra Bhasma mixed with suitable herbal powders and adjuvants has been validated in cases of Grahan (disorders of intestine).21

Tamra Bhasma as Rasayana
Tamra Bhama has been claimed as a Rasayana (rejuvenator/immunomodulator) individually and as a part of various Rasayana formulations like Brahma Rasayana-2 and22 Apara Indrokt Rasayana.23

Safety Aspects of Tamra Bhasma
Previously conducted studies reported that Tamra Bhasma prepared from Shuddhita Tamra was safe even fivefold to therapeutically equivalent doses.24 Tamra Bhasma prepared from Ashodhita Tamra is toxic even in the dose of therapeutic equivalent dose and highly toxic at TED × 5 and TED × 10 doses on subchronic administration for 45 days as revealed by hematological, biochemical, and histopathological parameters. These observations revealed the role of Shodhana and importance of dose in expression of toxicity of the medicinal preparations.24

In a more recent study, it was revealed that samples of Tamra Bhasma with and without Amrutikarana did not produce any sign and symptoms of toxicity at therapeutic dose level (5.5 mg/kg) and therapeutic equivalent dose (TED) × 5 (27.5 mg/kg) while at higher dose of TED × 10 (55 mg/kg) Tamra Bhasma has mild toxicity in liver, kidney, heart, and thymus on repeated administration for 28 days in...
Correlation between Calcined Copper and Copper Nanoparticles

Since the development of nanotechnology in the recent years, a comparison is often made between ancient Ayurvedic Bhasmas and the modern-era nanomedicines due to similarity in their particle size and physicochemical properties. Vigorous scientific studies need to be done so as to prove whether they can be used interchangeably or not. The process of manufacturing ancient Bhasmas involves procedures like Bhavana (levigation), which basically contributes in particle size reduction. The concept of Laghutva (light weight) and Varitara (floating of a small quantity of Bhasma on the surface) are other traditional methods used in the ancient practice of Ayurveda for the preparation of these formulations.

### Table 1: Some commonly available Tamra-containing formulations indicated in Jwara, Kasa, and Shwasa

<table>
<thead>
<tr>
<th>S. no</th>
<th>Pathological condition</th>
<th>Name of formulation (reference from classics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jwara</td>
<td>Swacchanda Bhairav Rasa (B.R.5/490-491)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gadmodari Rasa (B.R.5/559)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ratnagiri Rasa (B.R.5/562-567)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chandeshwar Rasa (B.R.5/569-572)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anand Bhairevi Vatika (B.R.5/620-622)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mrutsanjeevan Rasa (B.R.5/632-36)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sannipat Bhaireva Rasa—II (B.R.5/734-742)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kalagni Bhaireva Rasa (B.R.5/772-779)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shleshma Kalanala Rasa (B.R.5/864-868)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kalanala Rasa (B.R.5/869-874)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vidyaadhara Rasa (B.R.5/894-895)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rasaraj Rasa (B.R.5/913-917)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sheetari Rasa (B.R.5/922-924)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sheetabhanji Rasa (B.R.5/926-929)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jwarrankusha Rasa—I (B.R.5/933-935)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bruhat Jwarrankusha Rasa (B.R.5/949-955)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mahajwarrankush Rasa (B.R.5/956-959)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chintamani Rasa—II (B.R.5/1001-1003)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chintamani Rasa—II (B.R.5/1004-1008)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bruhat Chintamani Rasa (B.R.5/1009-1014)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Triprari Rasa (B.R.5/1033-1035)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Meghnada Rasa (B.R.5/1036-1039)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jwari Rasa (B.R.5/1048-1050)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jwarantaka Rasa (B.R.5/1055-1056)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vaatpittantaka Rasa (B.R.5/1057-1059)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shree Jayamangala Rasa (B.R.5/1061-1069)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chandrakeela Rasa (B.R.5/1102-1108)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vishayjwarrantaka Lauha—II (B.R.5/1115-1154)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bruhat Vishayjwarrantaka Lauha (B.R.5/1155-1161)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shree Jayamangala Rasa (B.R.5/1061-1069)</td>
</tr>
<tr>
<td>2</td>
<td>Jwara, Kasa</td>
<td>Bruhat Kasturi Bhaireva Rasa (B.R.5/819-823)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bruhat Sarvajwarahara Lauha—II (B.R.5/1180-1192)</td>
</tr>
<tr>
<td>3</td>
<td>Jwara, Kasa, Shwasa</td>
<td>Poanya Vatika (B.R.5/650-667)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jwariabhra (B.R.5/1135-1139)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chintamani Rasa—II (B.R.5/691-695)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chudamani Rasa (B.R.5/981-986)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lakshmiyilasa Rasa (B.R.5/130-137)</td>
</tr>
<tr>
<td>4</td>
<td>Hikka, Shwasa</td>
<td>Mukhtadichurna (Ch.Chi. 17/125-128)</td>
</tr>
<tr>
<td>5</td>
<td>Kasa</td>
<td>Panchamruta Rasa (B.R.5/158-159)</td>
</tr>
<tr>
<td>6</td>
<td>Kasa, Shwasa</td>
<td>Purnachandra Rasa (B.R.73/78-88)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pittakasanta Rasa (B.R.15/52-53)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bruhat Rasendra Gutika (B.R.15/91-97)</td>
</tr>
<tr>
<td>7</td>
<td>Kasa, Peenasa</td>
<td>Mahalaxmivilasa Rasa (B.R.73/89-101)</td>
</tr>
</tbody>
</table>

B.R., Bhaisajya Ratnavali; Ch.Chi., Charaka Samhita, Chikitsa Sthana

rats. The processed sample, i.e., sample with Amrutikarana, showed less magnitude of toxicity.  

25
of cold and still water) in relation to the desired characteristics of Bhasmas indicates the essentiality of reduced particle size.\(^4\) The green synthesis method to prepare nanoparticles can be considered equivalent to preparation of Bhasmas because both the methods require herbal products for their execution. Green synthesis makes metallic nanoparticles least reactive ensuring their biocompatibility.\(^5\)

Green synthesis has gained extensive attention as an eco-friendly and a cost-effective protocol for synthesizing a wide range of materials/nanomaterials including metal/metal oxide nanomaterials.\(^6\) The physiochemicals such as carbohydrates, flavonoids, saponins, proteins, amino acids, and terpenoids present in the plant extracts play a key role in the synthesis of nanoparticles.\(^7\) The science of converting metals into compounds appropriate for internal consumption and external use is an age-old process widely accepted by the ancient seers of Ayurveda. The copper nanoparticles that are being synthesized in today’s time can easily be correlated to the ancient Bhasmas based on their chemical formula and particle size. Several researchers have reported the chemical composition of Tamra Bhasmas in their analytical studies. Initial studies reported the nature of Tamra Bhasma as copper sulphide.\(^8\) In more recent studies, the X-ray diffraction (XRD) pattern of Tamra Bhasma revealed the presence of CuS, Cu$_2$S, and Cu$_2$S$_2$.\(^9\) In 2005, Tamra Bhasma was identified as copper oxide (CuO) and copper manganese in minor phases.\(^10\) In a more recent study conducted in 2011, inductively coupled plasma atomic emission spectroscopy (ICP-AES) of calcined copper revealed presence of 56.42% copper and 23.06% sulfur with some traces of manganese, lead, arsenic, and zinc. Phase identification by XRD revealed copper sulfate hydroxide [Cu$_4$SO$_4$(OH)$_6$] and copper sulfide (CuS) in two samples of Bhasma made out of Shodhita (processed) and Ashodhita (unprocessed) copper, respectively.\(^11\) Since sulphur is an accompaniment to the metal in the Bhasma preparation, copper is converted to its sulphide form in major. Some sulphides may get converted into oxide while being heated for multiple times (Puta), because metallic sulphides when heated in air get converted to oxide of the metal and sulphur dioxide. Therefore, some oxides of copper are also found in Tamra Bhasma.\(^12\) It can therefore be concluded on the basis of the studies that have been conducted on calcined copper that it is analytically either nanoparticulate sulphide and/or oxide of copper.

**Copper Nanoparticles and their Antiviral Effect**

Effective use of copper in different forms have been reported against a variety of viruses; copper, copper alloys, copper nanoparticles, and copper surfaces are being studied since a very long time for their antimicrobial effect on various pathogens.

Copper nanoparticles have been proven to exert antiviral activity on influenza A virus by degradation of viral proteins.\(^13\) In another study, the antimicrobial activities of the different cupric and cuprous compounds like cupric oxide (CuO), cuprous oxide (Cu$_2$O), copper sulphide (Cu$_2$S), copper monosulphide (CuS), cuprous chloride (CuCl), cuprous iodide (CuI), and copper dichloride (CuCl$_2$) against bacteriophage Q8, a small-sized virus that possesses single-stranded RNA, as a model of human influenza virus, was evaluated. On evaluation, it was reported that the reductions in the titers of bacteriophage Q8 of cuprous compounds were much higher than those of cupric compounds. Ionic states of the copper compounds cause a large difference in antiviral activity regardless if the compounds are oxides, sulphides, or halides.\(^14\)

In another study, copper’s neutralization of infectious bronchitis virus, poliovirus, human immunodeficiency virus type I (HIV1), and other enveloped or nonenveloped single- or double-stranded DNA and RNA viruses has been reported.\(^15\) Nanosized copper iodide particles have been proven to show inactivation activity against H1N1 influenza A virus suggesting that it may be useful for protecting against viral attacks and maybe suitable for application on filters, face masks, protective clothing, and kitchen clothes.\(^16\)

One of the studies reported that copper sulphide nanoparticles exhibit variable virucidal efficacy against human norovirus (HuNoV).\(^17\) The mechanism of copper-mediated inactivation of herpes simplex virus (HSV) is that the cupric ions oxidatively damage the biomolecules. This might be useful in the development of therapeutic antiviral agents.\(^18\)

Copper oxide-containing filters reduced infection titers of a panel of viruses spiked into culture media suggesting the possibility of using copper oxide-containing devices to deactivate a wide spectrum of viruses found in filterable suspensions.\(^19\) Cu$_2$O can be fabricated in a variety of materials using powders and coating pigments. It has a great potential in reducing the risk of infection. Copper oxide impregnation in respiratory protective face mask confers biocidal properties against human and avian influenza virus. Use of copper oxide-containing protective masks have shown reduction in the spread of respiratory viruses, especially when used by individuals in enclosed spaces or in close contact with a person having influenza-like symptoms. No infectious viral particle was recovered from these masks after 30 minutes unlike from the control masks.\(^20\)

Antiviral activity of copper nanoparticles (CuNPs) against hepatitis C virus (HCV) showed CuNPs inhibit HCV infection by targeting the binding of infectious HCV particles to hepatic cells and the virus entry into the cells.\(^21\)

Another antimicrobial study of hydrothermally synthesized rhombohedral-like CuFeO$_2$ crystals revealed that the antivirus property exhibited by crystals on bacteriophage Q8 was attributed to Cu+ species present in the compound.\(^22\)

Another study reported copper(0)-induced neutralization of viruses, namely bronchitis virus, human immunodeficiency virus type I (HIV-1), poliovirus, and other enveloped or nonenveloped single- or double-stranded DNA and RNA viruses.\(^23\)

**Potential Role of Copper Surfaces: Modern and Ancient Aspect**

Respiratory droplet transmission is the main route of transmission of SARS-CoV-2 but it can also be transmitted via surface contact.\(^24\) The novel coronavirus has been studied for stability in aerosol and on various surfaces like stainless steel, copper, cardboard, and plastic. While SARS-CoV-2 virus remained viable with reduced titers even after 3 hours in aerosols, after 72 hours on plastic, and after 48 hours on stainless steel, no viable SARS-CoV-2 was measured after 4 hours on the copper surface. Similarly, on cardboard it was not viable after 24 hours.\(^25\)

A study suggests the phenomena of “contact killing,” which states that viruses die on metallic copper surfaces.\(^26\) The antimicrobial effect of copper and copper alloy surfaces is well established in various studies. A study reported that metal alloys containing copper can destroy human norovirus. Copper surfaces destroy both the virus genome and its capsid or protein shell.\(^27\) Another study revealed that surfaces made of copper have been
shown to reduce the chances of surface transmission of virus. Inactivation of viruses, namely murine norovirus (MNV-1), monkeypox, and vaccinia viruses, by gene copy number reduction on copper alloy surfaces (70–89%) has been reported. In another study, human coronavirus 229E has been reported to show rapid inactivation on a range of copper alloys and copper/zinc brasses were very effective at lower copper concentration. In case of alloy, copper ions were responsible for the inactivation, which was enhanced by reactive oxygen species (ROS) generation. Inactivation of coronavirus results in fragmentation of the viral genome, ensuring that inactivation is irreversible. The study suggested that both Cu(I) and Cu(II) ionic species of copper are required directly and/or indirectly for virus inactivation and that Cu(II) may be more significant in the longer term. Rapid inactivation, irreversible destruction of viral RNA, and massive structural damage were observed suggesting effective control of respiratory coronavirus transmission.

Apart from the use of Tamra Bhasma, Ayurveda also suggests using Tamra and its alloys for various other purposes. Modern science proves antimicrobial activity of copper and its alloys, which may be the reason why seers had advocated the use of vessels and containers made of copper. Acharya Sushruta has clearly mentioned that water stored in vessels made of copper48 or some other materials like bronze, gold, and precious stones should be used for drinking as it becomes free from all toxic effects and provides relief in Kasa, Shwas, and Pratishayya.49 Copper vessels and bronze containers have been mentioned for a variety of purposes like preparation and storage of medicines, making equipment for Panchkarma procedures like Basti Netra,50 and tongue scraper.51

**Review Results**

Based on the properties exhibited by Tamra Bhasma and its efficiency mentioned in the text to address conditions like cough, fever, respiratory distress, and abdominal disorders, it can be useful when conducting further studies. The modern equivalent of Tamra Bhasma, i.e., copper nanoparticle, has undergone a lot of antimicrobial studies resulting in appreciable findings. Positive findings in human coronavirus 229E, influenza A virus, infectious bronchitis virus, poliovirus, HIV1, H1N1 influenza A, HuNoV, HCV, and other enveloped or nonenveloped single- or double-stranded DNA and RNA viruses have been reported. Viruses belonging to the same family have similar structures and genome, which suggests that similar approach can be made for their control and prevention.

From the antiviral studies reviewed in this article, it is clear that calcined copper can work against viruses by causing high protein adsorption and denaturation and can potentially exhibit virus inhibitory activities. Scientists and researchers can take a lead to conduct studies on the use of calcined copper in the novel coronavirus SARS-CoV-2.

**Discussion**

The world is currently facing desperate times in the form of a pandemic and is in need of an urgent prophylactic and therapeutic measure to efficiently combat COVID-19. While many researchers and scientists are struggling to find its cure, ancient science of Ayurveda can also be searched for its potential. Ayurveda can play a significant role in boosting the immune system of human beings and reducing the susceptibility of catching infections in general.

Role of various Rasayana (rejuvenators) drugs including Agastyar Hareetaki and immunomodulating drugs like Guduchi (Tinospora cordifolia) (Willd) Hook.F. and Thoms., Haridra (Curcuma longa L.), Tuli (Ocimum tenuiflorum (L.) Merrill), and Adraka (Zingiber officinale Rosc.) have been suggested by the Ministry of AYUSH as self-care measures in the time of this pandemic. However, the clinical evaluation of such measures in the novel virus needs to be justified through proper trials and observational studies.

The studies reviewed in the present article suggest that copper nanoparticles in its various forms can be incorporated for protection against the virus. Least viability time of the novel coronavirus was observed on copper, which forms a lead for copper to be used abundantly so as to have a safer environment. Copper surfaces can be used on high-touch surfaces like door knobs, hand rails, etc., to prevent environmental transmission of the virus. A study suggested that incorporation of copper alloy surfaces in conjunction with effective cleaning regimens and good clinical practice could help to control transmission of respiratory coronaviruses, including MERS and SARS.

Some studies have shown affinity of the novel coronavirus with the epithelial lining of the small intestines due to the presence of ACE2 receptor protein, thereby causing symptoms related to GIT. New coronavirus was detected in the feces of confirmed patients in Wuhan and even the first case in the United States showed existence of the virus in the digestive tract, suggesting the possibility of fecal-oral transmission as well. Ancient seers have mentioned the use of Tamra Bhasma for providing relief in diseases of abdomen (Udaraamayaghnam) and it is claimed to show improvement in the emaciation of intestines (Aantarshoshankrucchadi).

A wide range of copper nanoparticle applicability can be envisioned through various antimicrobial studies. Recent mechanistic studies support a role for copper in the innate immune response against infections. A group of scientists have hypothesized that copper supplementation can help fight COVID-19, especially in older people where marginal or severe deficiency of Cu is a strong possibility. A study reported significant antiviral potency of copper oxide nanoparticles (CuO NPs) against herpes simplex virus type I (HSV-1) and it suggested the use of CuO NPs in topical formulations for the treatment of orolabial or genital herpetic lesions. This provides a lead that copper nanoparticles can be wisely incorporated in topical applications like antimicrobial creams, lotions, sprays, and powders. CuO NPs have been applied intensively in biomedical areas, textile industry, as a material of food packaging, and in the making of medical devices. Experiments have suggested the possibility of using copper nanoparticles in water purification, air filtration, and air quality management. Recently, Australia-based metal 3-D printing company SPEE3D has successfully developed and tested a rapid and affordable 3-D printed antimicrobial copper, which can kill the COVID-19 virus on metal surfaces. It breaks down the cell wall and destroys the genome of the virus and other microorganisms. Tests have shown that 96% of the viruses were killed in only 2 hours and 99.2% of the viruses were killed in 5 hours. The fact that viruses get inactivated on coming in contact with copper surfaces due to the action of copper ions can be correlated to the efficiency of calcined copper, which basically contains copper in its ionic state as mentioned earlier in the chemical composition of Tamra Bhasma.
CONCLUSION AND CLINICAL SIGNIFICANCE

As evident from the review, calcined copper has been used since ages as an effective medicine in various disorders. All the evidences from the classics prove that calcined copper has potential antipyretic and antimicrobial properties and it can potentially act on respiratory and gastrointestinal disorders. Contemporary studies also suggest the use of copper in its different forms as an effective antiviral agent. Therefore, calcined copper can be considered as a potential agent for subjecting to trials against the SARS-CoV-2. SARS-CoV-2 is a novel virus and therefore calcined copper will have to undergo thorough preclinical and clinical trials for its efficacy and dose evaluation in COVID-19 patients.

ACKNOWLEDGMENTS

The authors extend special gratitude to Dr Galib R., Associate Professor, Department of Rasa Shastra and Bhaishajya Kalpana, All India Institute of Ayurveda, for his valuable literary and experiential contribution in framing the manuscript and for providing immense motivation throughout.

The author is also grateful to Dr Rahul Kumar Burolia, Department of Samhita and Siddhant, and Dr Ganesh Tambe, Department of Rasa Shastra and Bhaishajya Kalpana, for providing literary help.

REFERENCES

हिन्दी सारांश

ताम्र भ्रंस - COVID-19 के प्रबंध में एक संभव व्यवधान

अलीना गौरी, प्रमोद यादव, प्रदीप कुमार प्रजापति

सीवियर एक्स्ट्रेसिपेटरी सिंड्रोम कोरोना वायरस-2 (SARS-CoV-2) का पुष्प जीनोम क्रम SARS-CoV-1 के 82% समान पाया गया है। SARS-CoV-1 और मिडिल इस्ट रेसिपिरेटरी सिंड्रोम कोरोना वायरस (MERS-CoV) सहित उभरते हुये कोरोना वायरस वर्तमान समय में श्वसन संबंधी महामारियों में कारणभूमि रहे हैं। आयुर्वेद में विभिन्न चिकित्सा हेतु भ्रंस के रूप में धातुओं और खनिजों का प्रयोग किया जाता है। आचार्य ने ताम्र भ्रंस का वर्णन कास (खॉसी), श्वास (श्वसन संकट), ज्वर (बुखरा), पीनस (क्रोनिक राइनाइटिस/ सायनोसाइटिस) और रसायन कल्प के रूप में किया है। रस भ्रंस प्राकृतिक रूप से निर्मित तैलो-कण मानी जाती हैं। कोरोना वायरस 2019 (COVID-19) की इस वैश्विक महामारी के दौरान और नियंत्रण हेतु एक प्रभावी औषधि की आवश्यकता है। इस लेख का उद्देश्य COVID-19 में ताम्र भ्रंस की उपयोगिता सिद्ध करना है। ताम्र भ्रंस के विश्लेषण में उसे ताम्र का सल्फाइड और/या ओक्साइड पाया गया है। ताम्र भ्रंस के आह्निक प्रयोग से शरीर पर दुष्परिणाम नहीं पाये गए हैं। कोपर को 2008 में यूनाइटेड स्टेट्स प्रोटेक्शन एजेंसी द्वारा पहले धातु प्रोफाइलिंग एजेंट के रूप में मान्यता दी गई है। कई शोध कार्यों में विभिन्न वायरस के प्रतिबंध हेतु ताम्र, ताम्र के मिश्र धातु और ताम्र के विभिन्न योगिताओं के एंटी-माइक्रोबियल प्रभाव को सिद्ध किया गया है। शास्त्रीय ग्रंथों में पाए गए प्रमाणों और स्थायित्व एंटी-वायरल शोध कार्यों के आधार पर ताम्र भ्रंस को SARS-CoV-2 के लिए उपयुक्त समझते हुये और अधिक चिकित्सीय मूल्यांकन की आवश्यकता है।