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RESEARCH PAPER

Estimation of diffusion modelling of unhealthy nanoparticles by using natural and safe microparticles

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ABSTRACT

In this study, we evaluated aerosol transmission of two wild edible mushrooms. They were *Calvatia booniana* and *Terfezia claveryi* Chatin with the spore sizes of about 2 μm and 20 μm, respectively. First, we stained both types of spores and carefully recorded the morphological shape of the two microparticles, which were different in size and cytological characteristics under an optical microscope. We pumped the solution containing both large and small spores in tunnels of 3 x 3 x 3 cubic centimeters and 10 meters long. After half an hour we examined the presence and frequency of spore particles settling on the glass placed under the microscope. Based on the results, the larger micro particles with the diameter of 20 μm can diffuse about 60 to 70 cm, while small microparticles (2 μm) were spread about 200 cm. Since the COVID-19 is about 100 nano meters in size and assumes a direct ratio of size with the particle mass (m), using the classical kinetic energy formula (½ mv^2), we estimated its diffusion more than 8-9 meters in room air condition. Thus, the results indicate that it is highly important to know that the Coronavirus 2019 and similar viral agents spread through air more than 8-9 meters; therefore, appropriate control measures should be applied to prevent the diffusion of the SARS-CoV-2 and similar epidemics.

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INTRODUCTION

Although viral diseases have been associated with humans throughout history, COVID-19 is a unique viral disease which has affected all social, economic, cultural, and even spiritual aspects of human beings [1], originated in Wuhan, China. This virus quickly crossed geographical boundaries, causing epidemics in all countries, resulting in high human mortality and severe economic losses leading to a global economic recession in 2020. This disease is a highly transmittable and pathogenic viral infection caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which spread rapidly worldwide [2]. Fortunately, despite the global problems and limitations of this Coronavirus, human knowledge about its nature and biological behaviour as well as genetic and biochemical structure have increased, and this is due to extensive research by worldwide scholars [3, 4]. Although some scientific reports on COVID-19 transmission behaviour have been performed using real data on the virus particles, due to the need for very safe and protective infrastructure, it is not repetitive for the possibility of contamination of devices and the life-threatening environment risks for researchers. Therefore, the actual experimental studies using the virus itself are minimal and highly risky. In the presence of the COVID-19 outbreaks, we need to explain the determinants of the transmission dynamics

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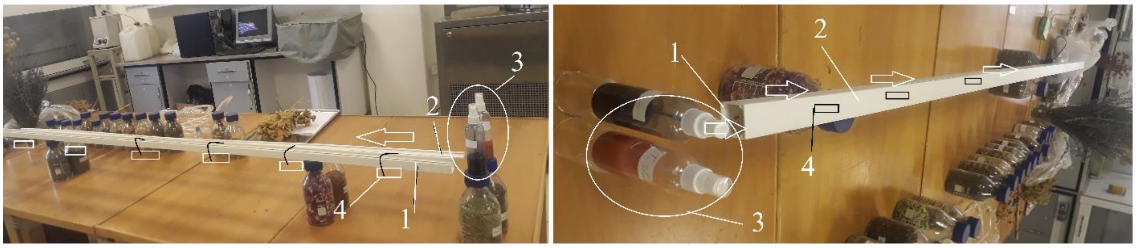

Fig. 1. The view of the experimental evaluation of mushrooms aerosol diffusion. 1: air flow tunnels, 2: cover of airflow tunnel, 3: Sprayers of microparticles, 4: Microscopically lams.

of this infectious disease for designing strategies to stop or reduce diffusion and empower health policy with economic, social, and environmental interventions. The manifold factors determining the diffusion of COVID-19 are analysed, such as the direct relationship between the spread of the disease and air pollution and the low wind speed as airflow [4]. Despite extensive studies on different drivers of this pandemic disease, less attention has been paid to the aerosol behaviour of COVID-19, while there are important reasons to suspect that it plays a critical role in the high transmissibility of this Coronavirus infection [5, 6]. Since the Coronavirus has dimensions of about 100 nanometres, the natural micrometre particles are the closest particles to this group, and the biological and ecological behaviour of these particles can be attributed to the Coronavirus. Thus, using and modelling safe and natural particle behaviour in the air is a key alternative. Some published research has confirmed the presence of indoor microbial materials around the world (7). The fungal spores are the cause of many adverse health outcomes, including asthma, rhinitis, allergies, hypersensitivity pneumonitis [8], and infectious diseases such as dermatomycoses and aspergillosis [9]. It has also been found that sub micrometer fungal fragments have stronger adverse effects than fungal spores because they can penetrate deeper into the respiratory tract and deposit into bronchi, bronchioles, and alveoli [10]. Fungal spore diffusion depends on several factors, including air velocity (air-flow rate over the surface), relative humidity, temperature, building materials, fungal species, ventilation, human activity, and the age of mold growth. Based on published reports, Kildesø et al. [11] found that the relationship between released fungal spore numbers and air velocity depends on fungal species. On the other hand, Pasanen et al. [12] found that spore diffusion depends on fungal genus, and Górny et al. [13] found that the release of fungal spores is affected by fungal species, air velocity over the surface, surface texture and vibration of the contaminated material [10]. Despite many studies on the pathogenic aspects of fungal spores, limited studies have been conducted on their beneficial applications, such as using calibration and validation of particle size analyzers [14].

We evaluated aerosol diffusion and spread behaviour of spores of two wild mushrooms. Based on our knowledge, this is the first study for modelling COVID-19 aerosol behaviour using safe and natural aerosol microparticles.

EXPERIMENTAL

Duct systems design

All experiments and tests were conducted at the Research Institute of Modern Biological Techniques, University of Zanjan, Iran. Three airflow tunnels in different dimensions and with a length of 10 meters were installed according to the duct systems, which had rails and covered doors (Fig.1). Some special microscopically thin glass plates (lam) were placed every half a meter inside the air tunnel to collect the settled particles.

Fungal materials and cytological studies

The two wild mushrooms spore were selected and performed for the experiment. The first was *Calvatia booniana* with about 1 to 2 µm in spore size, and the second was *Terfezia claveryi* Chatin with the spore size of 20 µm. First, the morphological shape of the two microparticles were carefully recorded Giemsa and Methylene blue. These two types of spores were different in size and cytological characteristics under an optical microscope. The scanning electron microscope (SEM) was used for a complete study of microparticle details (Fig. 3 and 4). The solutions containing spores of 20 and 2 microns

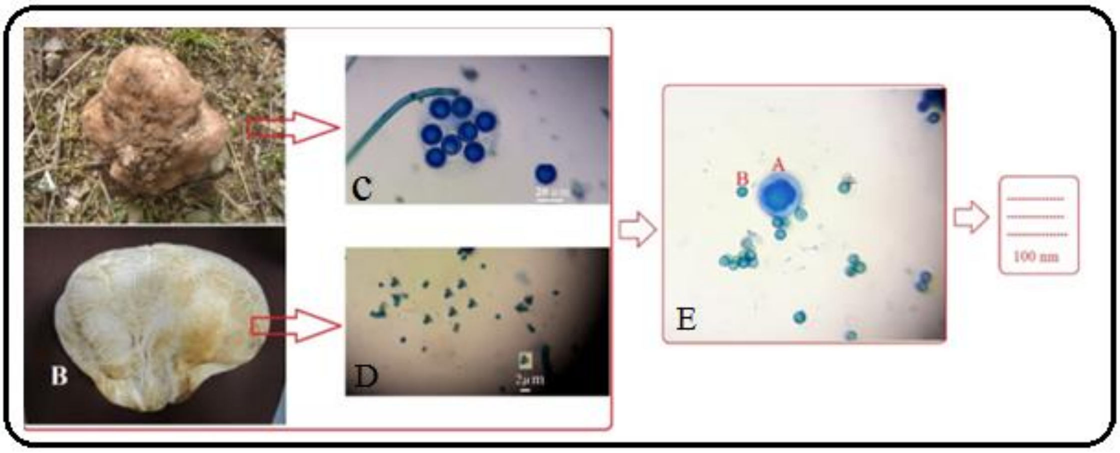

Fig. 2. Monitoring of two natural particles. A: *Terfezia claveryi* Chatin (20 µm) and B: *Calvatia booniana* (2 µm) aerosol particles to estimate COVID-19 diffusion. C: Microscopic photo of 8 spores with 20 µm diameter. D: Microscopic photo of some spores with 2 µm diameter. E: The comparative microscopic photo shows two large particle with 20 µm (A) and 2 µm (B)

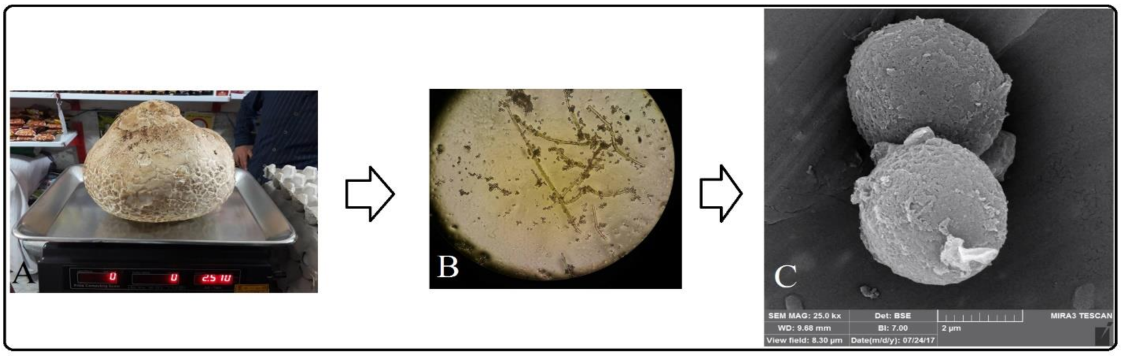

Fig. 3. The *Calvatia booniana* edible mushroom with 2.5 kg weight (A), light microscopic photo of its spores and SEM image of two micro particles (C)

were sprayed in tunnels measuring 3 x 3 x 3 centimeters and 10 meters long.

RESULTS AND DISCUSSION

The actual view of the experiment is shown in Fig.1. The contents of the mixture of two fungal spores are sprayed by the sprayers inside the tunnel and entered to the empty duct.

After half an hour, the presence and frequency of spore particles settling on the glass placed under the microscope were evaluated (Fig.2). Based on our preliminary results (Fig 3 and 4), the larger micro particles with a diameter of 20 μm (Fig. 4) can diffuse about 60 to 70 cm, but small microparticles (2 μm) (Fig. 3) were spread about 200 cm. Because the COVID-19 is about 100 nanometres in size and assumes a direct ratio of size with the particle mass (m), using the classical kinetic energy formula (½ mv^2), we estimated the diffusion and spread of COVID-19 more than 8 to 9 meters in room air condition (Fig. 5).

Spores of puffball fungus have been used as a reference standard of stable monodisperse aerosol for calibration of optical instruments [12, 13, 14]. The features mentioned above make the fungal spores a highly promising substance for calibration and validation of particle size analyzers [14]. Because the diffusion rate for the 2 nm particle in our research was observed to be about 2 m in practice and in laboratory conditions, the distance of 8 m for the diffusion of the 100 nm particle were calculated. The finding of this experiment can be of great interest in interpreting the causes of the rapid diffusion of the pandemic of coronavirus disease as well as affecting the management of non-pharmaceutical interventions based on physical distancing, workplace distancing, avoiding crowded places, etc. in reducing and preventing the diffusion of COVID-19 and other infections. In addition, results that firstly reported here indicate

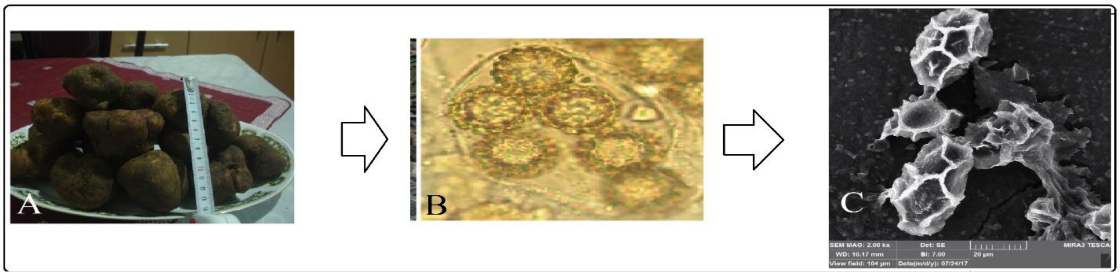

Fig. 4. Some *Terfezia claveryi* Chatin edible mushrooms (A), Light microscopic photo of 6 spores and SEM image of its related spores

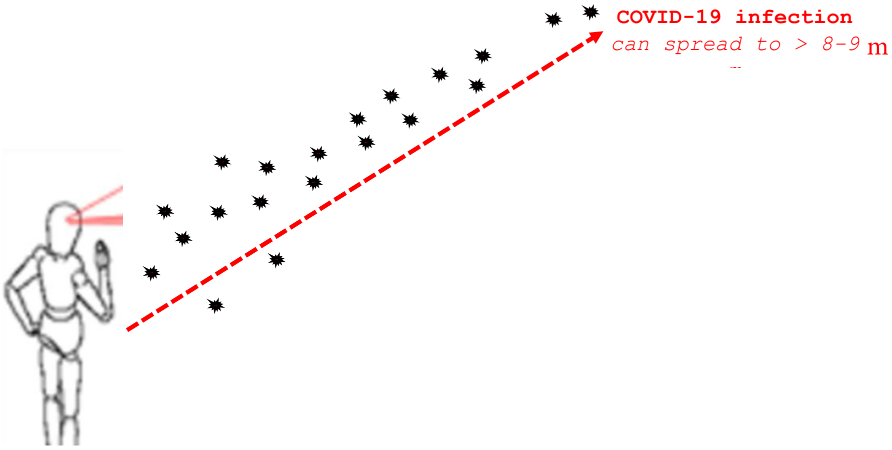

Fig. 5. Visual representation of COVID-19 diffusion based on estimation from the experiment

that COVID-19, as airborne disease, has a rapid diffusion over space [15].

CONCLUSSION

A strategy for preventing the current and possible future pandemics and epidemics, reducing deaths as well as economic damages is the one which applies, reiterates, and controls measures by social distancing and, in particular, devices that stop viral agents in indoor ambient. This is because COVID-19 infection is a threat to global public health and it is predicted that the world economic growth could contract by 2.2% or 3% of real GDP growth in 2020 [15]. Since the results of this research were obtained in laboratory conditions and in the limited dimensions of the duct, the authors are conducting experiments in larger dimensions such as rooms and in various temperature and humidity conditions, which will be reported later. Although approximately three years have passed since the corona epidemic, there is still no accurate information about the area, radius of distribution, and the way of spreading of this virus. Due to the high rate of mutation in the strains of this virus, the effectiveness of the manufactured vaccines is not complete and requires periodic repetition of vaccine injections. Periodic outbreaks and successive peaks of corona with new strains indicate the continued presence of this virus in human societies. Despite all the advances in vaccine production in the world, using a mask along with physical distancing is one of the most important preventive measures. The results of this research, which was conducted practically and in the laboratory setting, have considerations for the maximum physical distance guaranteed to avoid receiving suspended particles of the corona virus and other similar diseases.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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