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Potentiality of Mushrooms as Edible Vaccines

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Abstract

Vaccines have long been used globally as preventive and therapeutic agents against various diseases. Global necessity of cos-effective, edible and functional food based vaccine development has led the vaccine scientists search for multiple agents that would act either directly as vaccine or as vaccine adjuvant. In this article, the potentiality of edible and medicinal mushrooms or mushroom bio-components' as vaccine adjuvants or as direct edible vaccines have critically been reviewed. Outcomes of the present article would be of immense importance to the immunologists, vaccine scientists and health-care professionals and policy makers worldwide.

Keywords: Adjuvant; Acquired Immunity; Cytokine Storm; COVID-19; Immunomodulation; Innate Immunity; Vaccine

Abbreviations

SARS COV-2: Severe Acute Respiratory Syndrome Coronavirus-2; TCM: Traditional Chinese Medicine; WHO: World Health Organization; PSG: Polysaccharides of Ganoderma; FIPs: Fungal Immunomodulatory Proteins; DNA: Deoxyribo nucleic Acid; HBV: Hepatitis B Virus.

Introduction

Vaccine is a medicinal preparation containing either the attenuated or killed microbe or its part that exert antigenicity to the host and develops acquired immunity of the host [1]. Since 1920s, vaccines of different types had been applied against different diseases globally [2,3]. Recent coronavirus diseases 2019 (COVID-19) has up surged the production and utilization of vaccine against severe acute respiratory syndrome coronavirus-2 (SARS COV-2) [3]. Health care professionals, researchers and scientists throughout the globe had tried their best to present the humanity with an easy and accessible to all vaccine against SARS COV-2. Ultimately, the humanity has been gifted with a COVID vaccine and thus hype towards vaccine development and utilization has skyrocketed all over the world. Actually, since the invention of vaccine, strategies had been applied to enhance the efficacy of vaccine. In this aspect, utilization of adjuvants or helping agents for vaccines' enhanced potentiality is a milestone in the era of vaccination.

Globally, aluminum salts or alums have mostly been utilized as the adjuvants towards different forms of injectable and edible vaccines [3,4]. World health organization (WHO) has allowed alums or aluminum salts rather than any other substances as the most potent adjuvants [5]. However, search for alternative adjuvant sources has nor remained standstill, rather, usage of alternative or traditional medicinal items as vaccine adjuvants has received considerable attention [6]. In this regard, traditional Chinese medicine (TCM) and relevant bio-components seem promising [6,7].

Potentiality of Mushrooms as Vaccines or Vaccine Adjuvants

Among others, the bio-components of the macrofungi Ganoderma lucidum seem pertinent as the adjuvant of different vaccines currently utilized worldwide [8-10].

Ganoderma lucidum, also known as ling zhi (in Chinese) or reishi (in Japanese) is a medicinal mushroom [11]. Its usage in medicine dates back to hoary past [11]. Polysaccharides of Ganoderma (PSG) had been found promising as adjuvants of different vaccines [12-19]. Different bio-components of Ganoderma especially tri-terpenoids also beacon excellent as vaccine adjuvants [12-19]. Besides, fungal immunomodulatory proteins (FIPs) also seem promising as adjuvants towards vaccines [12-15,20-22]. A protein called ling zhi-8, derived from G. lucidum had been reported to have potent adjuvancity towards DNA vaccine against cancer [12-15,20-22]. Adjuvancity of G. lucidum polysaccharides, proteins and tri-terpenoids had been linked with their immunomodulatory effects [23-27].

Beta-D-glucans (β-D glucan) are polysaccharides of β-1-3 glycosidic linkages that provide multiple physiological effects among which immunomodulatory effects are most noteworthy [28-35]. Beta-D-glucans have been found to be excellent adjuvants towards vaccines [28-35]. Lentinan, dervided from another species of edible mushroom, Lentinula edodes, has also been regarded as a potent adjuvant to vaccine [36-43]. Polysaccharide from shiitake mushroom (L. edodes) enhances immune responses against inactivated influenza vaccine in mice [44]. Similar observation has been noticed for human subjects in case of maiitake mushrooms (Grifola frondosa) [45].

Still today, DNA based vaccines have been used against hepatitis B virus (HBV) and relevant patho-physiologies [44,45]. Experimental evidence suggest that oyster mushroom (Pleurotus ostreatus)-derived lectin, when added as adjuvant to the HBV DNA vaccines, the immunogenic potency increases several fold [44,45]. Mechanistically, lectins of oyster mushroom (Pleurotus ostreatus) aid in vanquishing HBV tolerance through toll like receptor 6 signaling cascade that generates anti-HBV antibodies and helper T cells [47,48]. Fruiting bodies of enoki mushroom (Flammulina velutipes) have been genetically engineered to express the trans-gene of HBV and to produce HBV oral vaccine [44,45]. Antibody titer of these vaccinated pigs show successful outcome of this mushroom based approach [44,45]. Immunomodulatory effects of some edible musrooms such as button (Agaricus blazei Murill), lion's mane (Hericium erinaceus), and maitake (Grifola frondosa) provide extensive evidence of their potentiality in their usage as edible vaccines [46]. Bio-informatics based molecular docking studies show that bio-components (β-D-glucan, galactomannan, betulinic acid) of chaga mushroom (Inonotus obliquus) strong binding affinity with the spike proteins of the SARS-COV-2 virus [47,48]. Thus, this mushroom also could be a basis of vaccine development (Table 1).

S. No	Name of Mushroom	Figure of Mushroom
1	Oyster mushroom (*Pleurotus ostreatus*)	
2	Reishi mushroom *(Ganoderma lucidum)*	
3	Shiitake mushroom (*Lentinula edodes*)	

4	Maitake mushroom (*Grifola frondosa*)	
5	Enoki mushroom (*Flammulina velutipes*)	
6	Button mushroom (*Agaricus bisporus*)	
7	Lion's mane mushroom (*Hericium erinaceus*)	
9	Chaga mushroom *(Inonotus obliquus)*	

Table 1: Figures of Mushrooms.

Conclusion

Different bio-components present in both edible and medicinal mushrooms spur excellent sources to be of vaccine agents or vaccine adjuvants. Extensive studies and clinical trials of the positive outcomes of mushroom based vaccines and vaccine adjuvants could pave a new vista in fighting the humanity against different diseases. In this aspect, special attention of the funding authorities, research regulatory bodies, health-care professionals and researchers throughout the globe should come forward.

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