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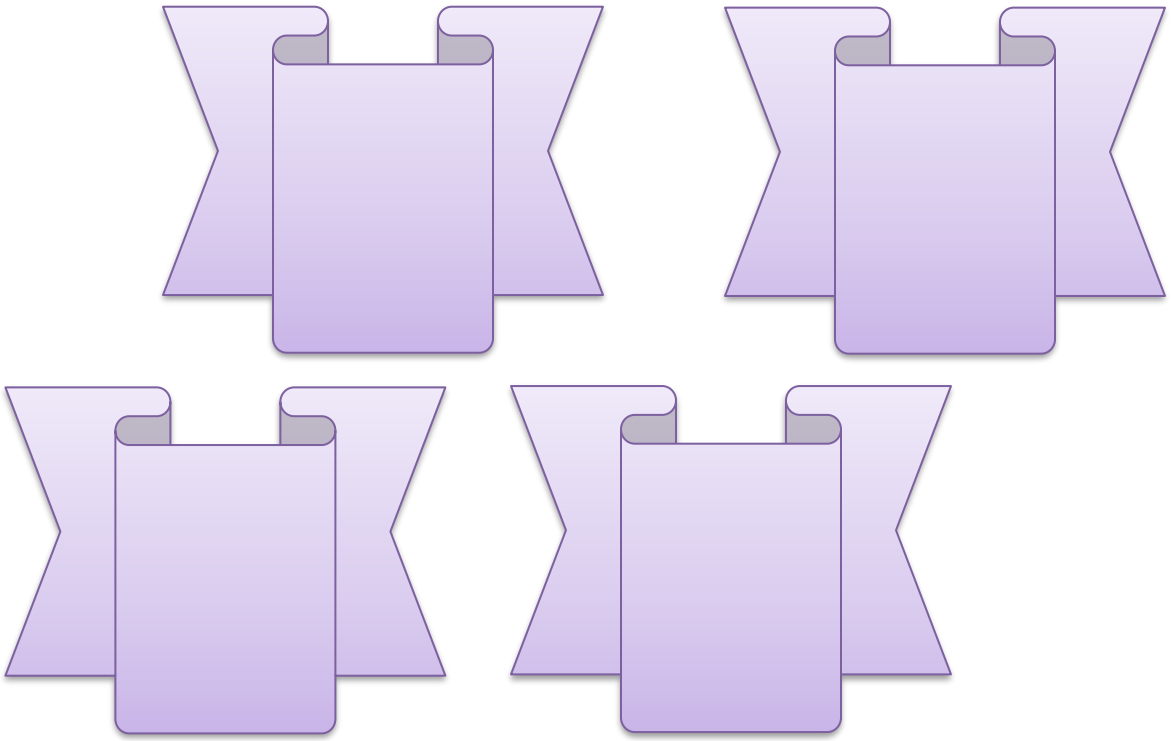

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Original Article

Live Attenuated and Sub-Unit Vaccines Exploitation Against Severe Acute Respiratory Syndrome Coronavirus 2 [SARS-COV2]

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ABSTRACT

Background: Severe acute respiratory syndrome coronavirus 2 [SARS-COV2] is a serious infection nowadays. Infection is typically limited to the mucosal cells of the respiratory tract. At least 50% of infections are asymptomatic. Immunity is brief and reinfection occurs.

Aim of the work: Live attenuated and sub-unit vaccines development against SARS-COV2

Patients and Methods: This was a screening experimental study. In our study, we designed sub-unit vaccine [A] for coherent and conserved Spike[S] protein and other coherent and conserved structural and non-structural proteins of the virus using bio-informatics applications software. Also, we prepared live attenuated vaccine of SARS-COV2 [B].

Results: Both vaccines [A and B] resulted in 97 and 96% efficacy, respectively during preclinical trials [animal testing] while showed 86 and 84% protection power during human clinical trials phases 1-2. They showed superior biological activity and fewer side effects than other standard vaccines such as Pfizer and Astrazenca vaccines. Their efficacy lasted from 2-3 months for vaccine A and 6-8 months for vaccine B.

Conclusion: Both vaccines in our study were effective as prophylaxis against viral infection with SARS-COV2 and mutant forms of this virus. Booster doses are required to enhance immunity for both types of vaccines.

Keywords: Vaccine; Severe acute respiratory syndrome; Pneumonia; Droplets.

INTRODUCTION

The severe acute respiratory syndrome coronavirus type 2 [SARS-COV2] is recently a very dangerous and fatal viral pathogen [1]. Because few medications are effective against viral infections, vaccinations are essential for preventing this viral illness [2]. It is possible to prevent viral illnesses by using vaccinations that promote active immunity or by administering ready antibodies that give passive protection [3].

Pneumonia that is lethal is one of the main causes of severe acute respiratory syndrome [4]. Fever, cough, shortness of breath, exhaustion, dyspnea, and a loss of taste and smell are the infection's other symptoms [5]. Cold and SARS [Severe acute respiratory syndrome] CONV1 and CONV2 are two illnesses caused by coronaviruses [6].

Coronavirus is One single-stranded, positively polarized fragment of RNA and an enveloped virus with a helical nucleocapsid [7]. Without virion polymerase. Two serotypes are present [8].

Droplets exhaled during transmission. Human infection may result from coronaviruses that infect animals [9]. Infection normally only affects the respiratory tract's mucosal cells. At least fifty percent of infections have no symptoms. Since immunity is transient, reinfection happens [10]. The main form of diagnosis is clinical. Tests are achieved using PCR and antibodies [11].

Nowadays, there are two types of vaccinations that provide active immunity; those that contain dead virus or live virus whose toxicity has been attenuated. Certain vaccinations, including the hepatitis B vaccine, are referred to as sub-unit vaccines because they include pure viral proteins [12]. Furthermore, mRNA vaccines against SARS-COV2 pandemic were created in 2021. The properties of mRNA and sub-unit vaccines mimic those of killed vaccinations since no viral replication occurs in these vaccines [13].

A phase 1 experiment involves a comprehensive assessment of the dose-response connection with the new vaccine's pharmacokinetics in a small sample of healthy human volunteers [e.g., 20–10]. In phase 1 investigations, the acute effects of the drug are examined at a wide range of doses, starting at one that has no observable impact and working up to one that either causes a major physiologic response or a very mild harmful effect [14].

In a phase 2 study, a medicine is assessed in a moderately sized group of human volunteers [100–200], all of whom have the target ailment. A placebo for a single-blind or double-blind design and a positive control medication are incorporated during this stage. The objective is to assess whether the medication has the necessary effectiveness, or whether it creates an appropriate therapeutic response, at levels that sick patients can tolerate. In-depth information is gathered on the pharmacokinetics and pharmacodynamics of the medication in this patient population [15].

A phase 3 study often entails numerous healthy human volunteers [typically 1000–6000 or more, across several facilities] and numerous doctors who are administering the vaccine in accordance with the suggested method for its eventual widespread usage [e.g., in outpatients]. Such studies commonly include placebo and positive controls in a double-blind crossover design. The objectives are to examine the new vaccine's range of beneficial effects in more detail under the circumstances of the proposed clinical use, to compare it to placebo [the negative control] and older treatments [the positive control], and to find any toxicities that may occur infrequently enough to be missed in phase 2 studies [16].

Phase 4 is the post-marketing monitoring phase of assessment, and it is believed that toxicities that emerge relatively quickly may be caught during this phase. Seldom will be identified and reported early enough to stop serious therapeutic catastrophes [17].

The goal of the current research was to develop sub-unit and live attenuated vaccines to combat SARS-COV2 infection and lessen the severity of its infectious illnesses, such as pneumonia.

PATIENTS AND METHODS

Ethical statement: All applicable national, institutional, and/or international guidelines for utilizing both people and animals were postdated for the current inquiry. The local government, the Ethical Committee for Human and Animal Handling at Cairo University [ECAHCU], and the Pharmacy Faculty, University of Cairo, Egypt all approved all procedures used in the

study, including those involving people and animals, with approval number P-3-2-2020 in accordance with the suggestions of the Weatherall report. Every effort was made to reduce the number of participants and the suffering of the animals utilized in the study.

Material: The chemical and biological components were bought from the pharmaceutical companies Algomhoria in Cairo, Egypt, and Alnasr in Abo zabal Alkhanka, Qalyubia, Egypt.

Table [1]: List of instruments

Instrument	Model and manufacturer
Autoclaves	Tomy, Japan
Aerobic incubator	Sanyo, Japan
Digital balance	Mettler Toledo, Switzerland
Oven	Binder, Germany
Deep freezer -70 °C	Artikel
Refrigerator 5	Whirpool
PH meter electrode	Mettler-toledo, UK
Deep freezer -20 °C	Whirlpool
Gyratory shaker	Corning gyratory shaker, Japan
190-1100 nm Ultraviolet-visible spectrophotometer	UV1600PC, China
Light[optical] microscope	Amscope 120X-1200X, China

Source of animal models: They were acquired and given the green light for legalization by the college of pharmacy's pharmacology and toxicology department at Cairo University in Egypt.

Inclusion criteria for animal models: Male adult mice who are fat and weigh 40–50 gm; susceptible to SARS-COV2 infection; transgenic mice.

Exclusion criteria: Young mice; female mice who are pregnant.

Place and date of the study: Between March 2020 and March 2023, this study was conducted at the Microbiology and Immunology Department of the Pharmacy Faculty at Cairo University in Egypt.

Type of study: Experimental screening research.

Sample collection: The blood samples were taken from 100 individuals who had pneumonia brought on by SARS COVID 19 in various parts of Egypt.

Methods

Preparation of SARS-COV2 sub-unit vaccine [A]: Using bioinformatics applications software through NCBI, it was possible to create a sub-unit vaccination for the coherent S protein and other coherent structural and non-structural proteins of the virus: SARS-COV2 has cohesive structural and non-structural protein genes that do not change; potential target vaccination candidates might take advantage of this fact.

Via the NCBI bioinformatic applications website, the gene for the coherent spinal protein in SARS-COV2, commonly known as the S-protein gene, was extracted. Moreover, other genes for coherent structural and non-structural proteins were extracted. Subsequently, using recombinant DNA technology, this gene was put into the *Saccharomyces cerevisiae* BJ1824 expression host for its expression in a manner similar to how the hepatitis B vaccine was created. The expression system vector was PYES2-DEST52, and the promoter was AUG1. The C-terminal was 6x histidine, the inducer was methanol. A protein carrier like diphtheria toxoid was added to activate and excite the acquired immunity, which then generated antibodies that were protective and neutralizing against S protein and diphtheria toxoid, preventing the illness from spreading to other people.

Design of primer for expression of SARS-COV2 spike protein:

Forward primer 5^- to 3^-:

TCGGCTGCATGCTTAGTGCA.

Tm= 59.01 °C, Ta= 54.01 °C.

Reverse primer 3^- to 5^- :

CAGTAAGAGGATTCTTCGAT

Tm= 60.84 °C, Ta= 55.84 °C.

Using *Saccharomyces cerevisiae* BJ1824 as the expression host, recombinant DNA

technology was used to complete the production of the SARS-COV2 spike protein. The expression system vector was PYES2-DEST52, the promoter was AUG1, the inducer was methanol, and the C-terminal was 6x histidine. Gene of spike protein of interest was cloned using PCR and then sub-cloned into PYES2-DEST52 utilizing Hind III and EcoRI restriction endonucleases II for the digestion of the plasmid, followed by ligation by ligase enzyme. Escherichia coli Top 10 [Invitrogen, USA] was used to identify and replicate the recombinant plasmid before it was converted into *Saccharomyces cerevisiae* BJ1824. YNBG selective medium [0.57% yeast nitrogen base without amino acids supplemented with appropriate nutrients and 2% galactose] was used for the growth of yeast transformants at 25 °C, followed by maintenance in YPG-rich media [2% bacterio-peptone, 1% yeast extract, and 2% galactose]. This was done in order to spike protein production using galactose as an inducer.

Clarification and purification of recombinant spike protein: At a speed of 4000 rpm, a centrifuge was operated for 3 minutes. Ammonium sulphate precipitation and nickel affinity chromatography purification were used to clarify the spike protein precursor from the culture's supernatant. After extraction by precipitation [salting out] of 100 ml of the supernatant with 53 ml of a 4.1 M ammonium sulphate saturated solution at 25 °C, recombinant fused spike protein with poly-histidine-tagged proteins could be quickly purified from the supernatant via Nickel columns using immobilized metal affinity chromatography [the metal-ligated was a nickel-metal ion; while the target bio-molecule was polyhistidine tag fusion protein]. Before being utilized in the final formulation, the preparations were sterilized by filtration via 0.22 micron sterile-grade filters [Whatman-1541-042 filter paper, acquired in the USA].

Formulation of SARS-COV2 spike protein sub-unit vaccine [A]: Those who got the intramuscular injection vaccination against the SARS-COV2 sub-unit were given a sterile suspension of the spike protein. Each 1 ml dose contained 60 mcg of the lipid dimethyl dioctadecyl ammonium bromide [DDAB], 0.3 g of Diphtheria toxoid, and 25 mcg of the spike protein for SARS-COV2. Each dosage also included 5.5 mg of sodium chloride and 0.620 mg of sodium dihydrogen phosphate dihydrate. In order to assess the immunogenicity in animal models, purified sub-unit vaccine of SARS-COV2was delivered intraperitoneally to trans-genic mice that had been implanted with human lung cells; whereas it was injected intramuscular in human clinical trials phases 1/2.

Preparation of SARS-COV2 live attenuated vaccine [B]: SARS-COV2 was grown in conditions that prevented it from proliferating, such as hepatocytes or renal cells, for a number of passages in order to cause mutations that rendered it weak and prevented it from causing the disease, but left it with the ability to infect mucosal epithelial cells of the digestive and respiratory tracts. This promoted robust cell-mediated immunity as well as robust humeral immunity, particularly neutralizing IgA antibodies that prevented virus attachment to mucosal epithelial cells of the respiratory and digestive tracts.

Formulation of live attenuated SARS-COV2 vaccine[B]: SARS-COV2 live attenuated vaccine in sterile suspension given orally to humans in stages 1 and 2 of clinical studies. Each 1 ml dosage included 65 mcg of live attenuated SARS-COV2, 55 mcg of the lipid dimethyl dioctadecyl ammonium bromide [DDAB], and 0.4 µg of Diphtheria toxoid. Each dosage also included 3.6 mg of sodium chloride and 0.530 mg of sodium dihydrogen phosphate dihydrate. Purified live attenuated vaccination of SARS-COV2 was delivered orally to transgenic mice that had human lung cell implants in order to investigate the immunogenicity in mice animal models weighing 45-50 gm.

In vitro evaluation of immunogenicity of both vaccines

Screening and bio-assay of the biological activity and toxicological effects of the vaccines: Transgenic mice were animals whose genes have been modified utilizing tissue culture and recombinant DNA technologies. A transgenic animal was one that possessed a gene that has been incorporated into the genome of a cell by human intervention [a trans-gene] [18]. One hundred transgenic mice were challenged with each kind of the two vaccinations [vaccine A was administered by intraperitoneal injection, while vaccine B was given by the normal oral route]. They received two dosages; 28 days were separated from each other. The first dosage was half the second booster dose. Each vaccination was administered in 0.5 ml of sterile suspension for the first dose and 1 ml for the second booster.

Protection tests: Were used to determine the potency of vaccines.

Active: Upon vaccination with the vaccine that was being evaluated, groups of transgenic mice were challenged with increasing quantities of Microorganisms [Infectious dosage varied from 2.14×10^6 PFU–7×10^6 PFU]. To gauge the effectiveness of the vaccination, the lowest number of germs [or LD50] required to cause 50% of animals' deaths was established and compared to LD50 in unvaccinated animals. The SARS-COV2 strains Alpha, Beta, Delta, and Omicron were used in preclinical animal research.

Passive: Regular mice were given progressively larger volumes of serum from vaccinated people before being exposed to the infectious pathogen. As a way to gauge the effectiveness of the vaccine, the greatest serum dilution that could still protect 50% of animals [i.e., ED 50%] was identified. Plaque forming units and tissue culture infectious dose [TCID 50] were the two primary techniques for determining the level of infection.

Human evaluation of vaccines via human clinical trials phases 1/2: SARS-COV2 strains employed during human clinical research were Alpha, Beta, Delta and Omicron. Three groups of human volunteers were included in the present investigation. Each group had 100 participants:

Group 1 [the negative control group] got the placebo intramuscularly for the assessment of the SARS-COV2 sub-unit vaccine, whereas Group 1+ [the negative control group] received the placebo orally for the evaluation of the SARS-COV2 live attenuated vaccine. Strains of SARS-COV2 included in the current investigation were Alpha, Beta, Delta and Omicron.

Group [2] [positive control group] were administrated the standard Pfizer mRNA vaccination of SARS-COV2 intramuscularly.

The test vaccinations were administered to Group 3 [the test group] [intramuscularly for sub-unit vaccine while another test group administrated the live attenuated vaccine of SARS-COV2 orally].

The 3 groups were challenged with graded levels of the infectious microorganisms after 2 weeks to allow emergence of protective neutral-izing antibodies. All groups received booster dosages after 28 days. During the course of three years, the test vaccine's level of protection was assessed. The identification of the protective neutralizing antibodies was done through enzyme linked immunosorbent [ELISA] test.

ELISA detection of neutralizing antibodies to spike protein: Antigen was fastened to the bottom of the well. Antibody that was bound to antigen was present in patient's serum. IgG from the patient was coupled to an enzyme-conjugated human IgG antibody [Horseradish per-oxidase enzyme]. A substrate for the enzyme was added, and as the enzyme interacted with it, the substrate changed color. Enzyme activity was calculated using the color reaction and the enzyme's substrate in a UV spectrophotometer that operates at 450 nm wavelength [19].

Flow cytometry for detection of CD+4 and CD+8 T lymphocytes: Exploiting an Invitrogen Attune Cytpix flow cytometer, SARS-COV2 spike protein vaccine-specific CD+4 and CD+8 T cells were identified and analyzed [obtained from the USA]. A monoclonal antibody was utilized in this experiment to tag the patient's cells. These antibodies were made against proteins that are unique to cells [e.g. CD4 protein when measuring the number of T helper cells]. Monoclonal antibodies were labelled using fluorescent dyes like rhodamine and fluorescein. Individual cells were exposed to the laser beam, which caused them to light. The fluorescence was assessed [FACS] using a tool known as a Fluorescence Activated Cell Sorter [20].

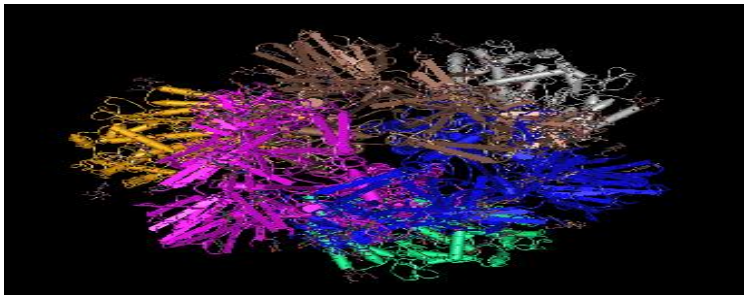


Figure [1]: 3D structure of spike protein of SASRS COVID 19. It is made of 1273 amino acids. It is a type 1 trans-membrane protein

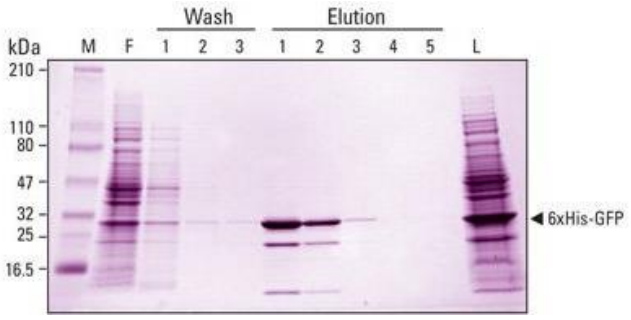


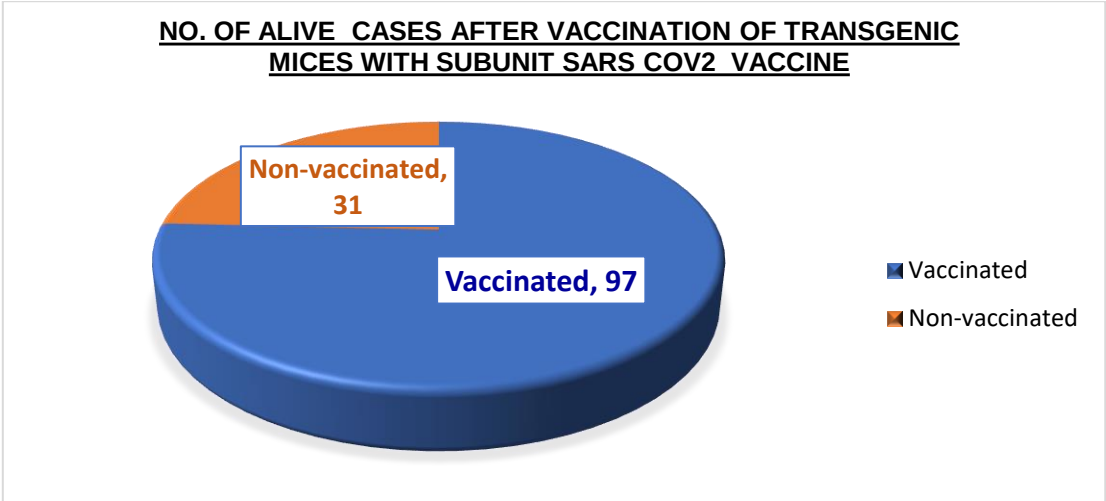
Figure [2]: The immobilized metal affinity chromatography on nickel affinity resins used to purify the recombinant SARS-COV2 spike protein. Recombinant proteins had a purity level of about 85%

Statistical Analysis

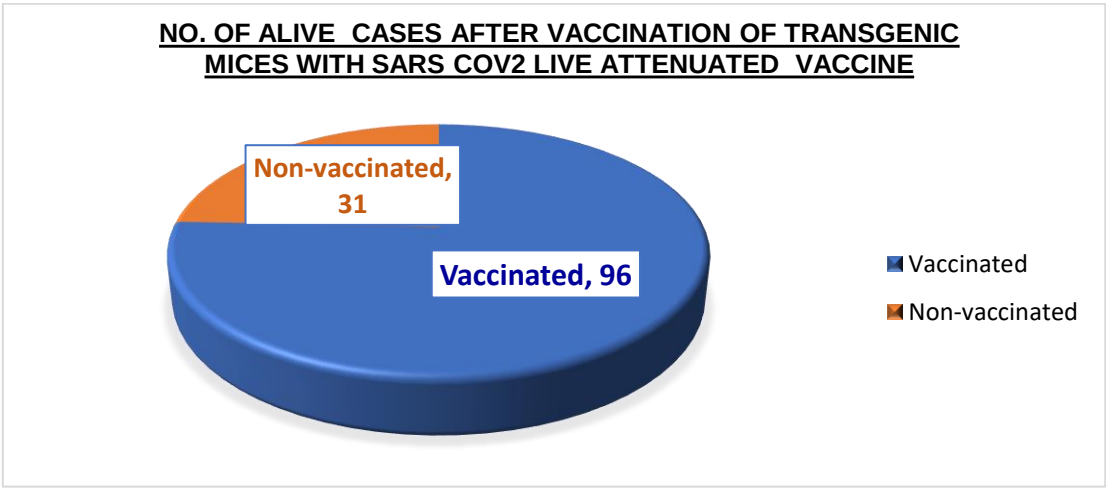
All samples were studied in triplets, and their results were presented using means and standard deviation. The means for doing statistical analysis, including statistical analysis based on Excel spreadsheet software, were one-way analysis of variance [p value 0.05]. F test was employed in the present investigation.

RESULTS

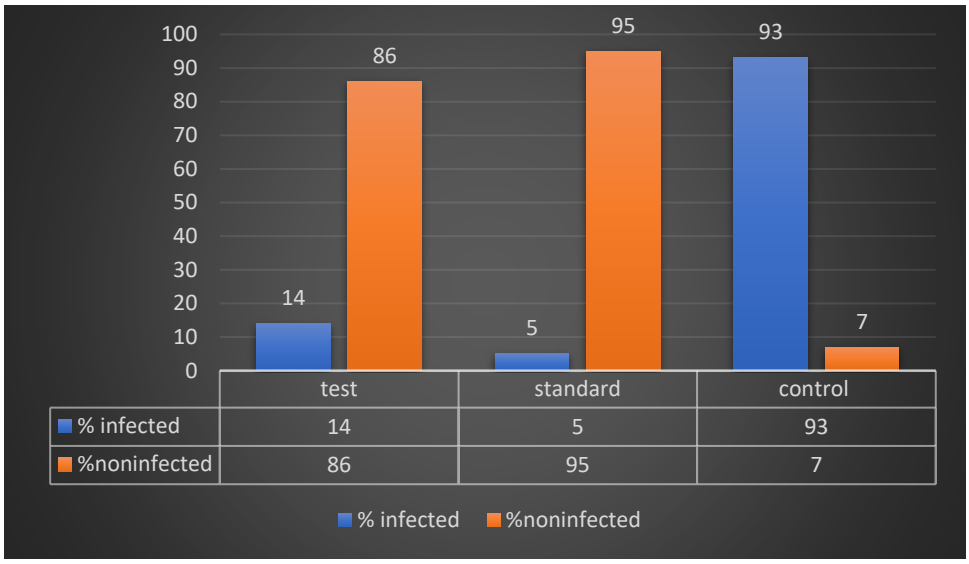
During preclinical studies [animal testing], both vaccines [A and B] demonstrated 97 and 96% effectiveness, respectively, while showing 86 and 84% protective power throughout human clinical trials stages 1-2. The ED50% of SARS-COV2 vaccine was discovered to be 25 mcg/ml for sub-unit vaccination whereas it was 30 mcg/ml for live attenuated vaccine of SARS-COV2. 7×10^6 PFU was the value of LD50% of SARS-COV2.



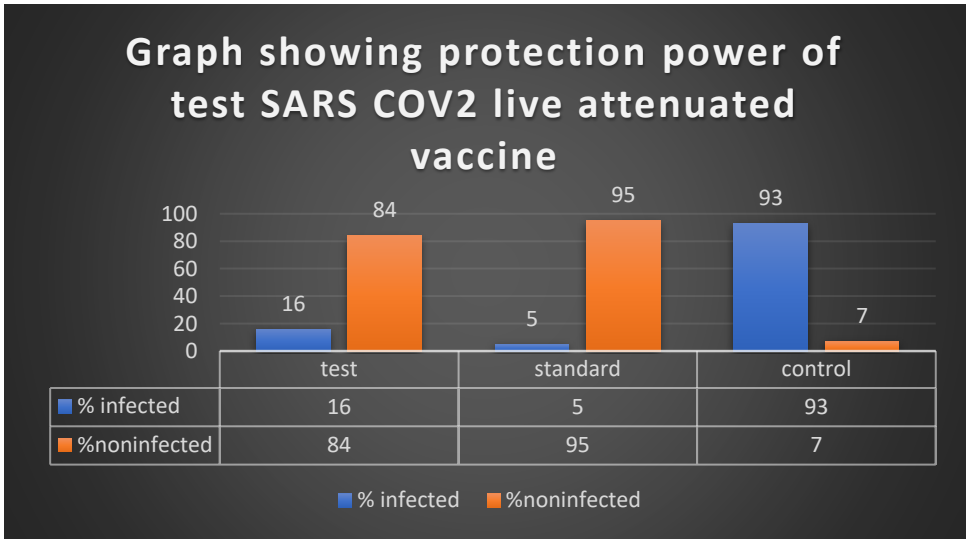
Graph [1]: It indicates that during animal testing, the current sub-unit vaccine's effectiveness against SARS-COV2 was 97%



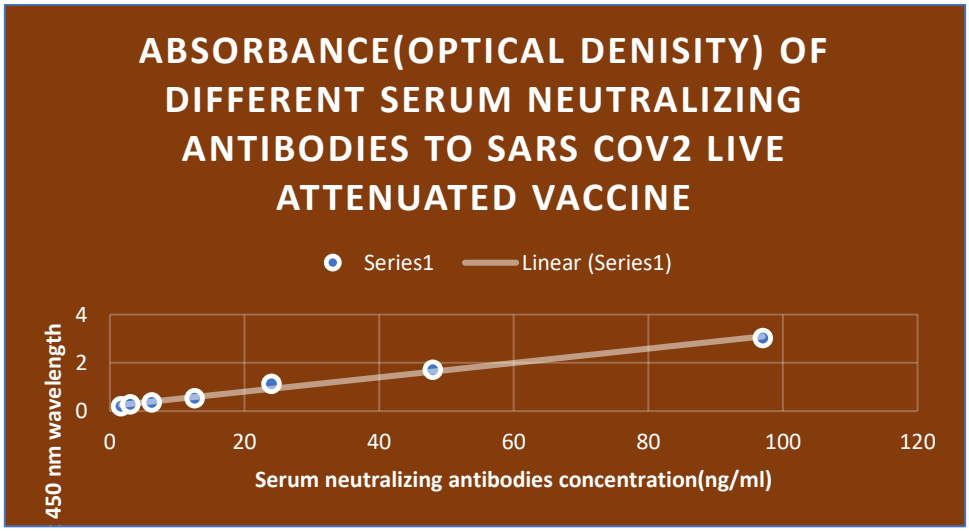
Graph [2]: It demonstrates that the protective power of live attenuated vaccination against SARS-COV2 was 96% during animal testing



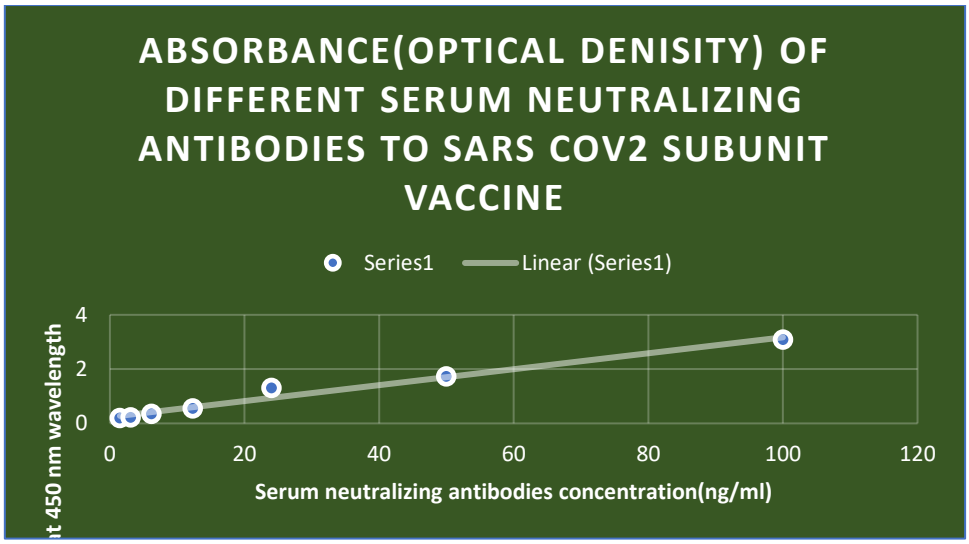
Graph [3]: It indicates that the SARS-COV2 sub-unit vaccine provided 86% protection in human clinical trials phases 1/2



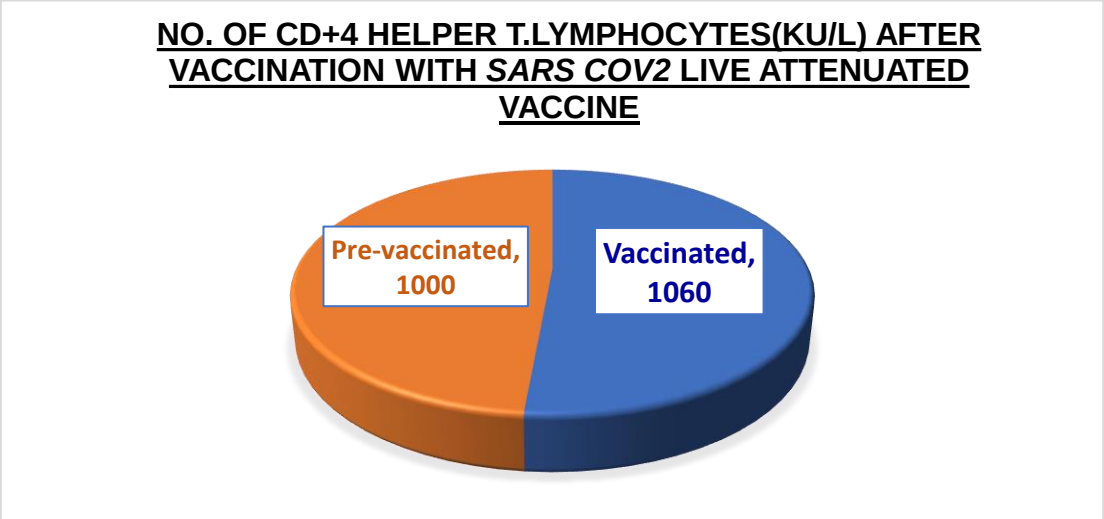
Graph [4]: During human clinical trials stages 1/2, the SARS-COV2 live attenuated vaccine provided 84% protection



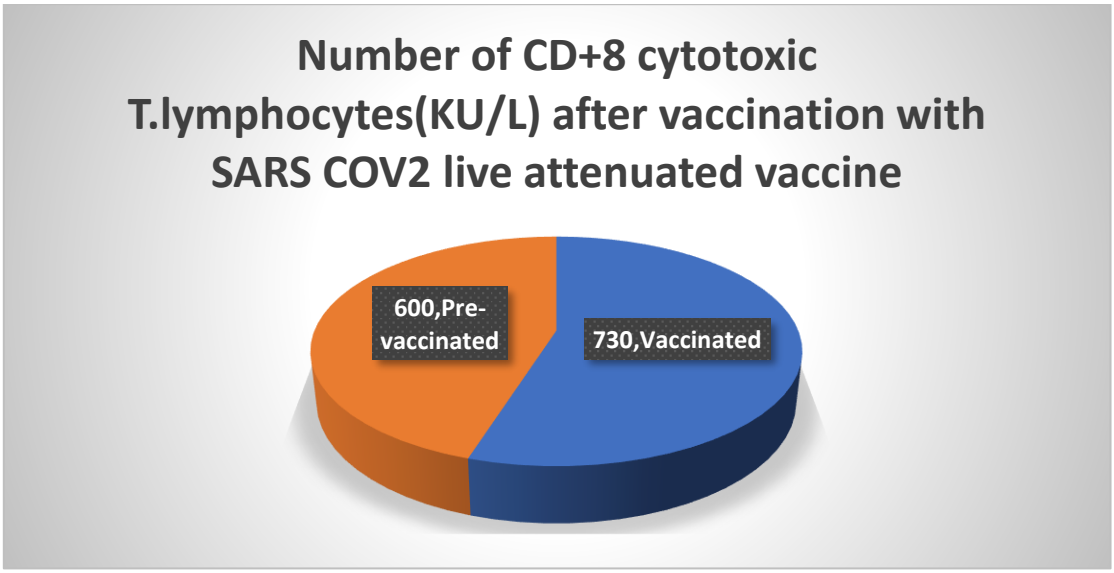
Graph [5]: It represents the ELISA absorbance of various serum concentrations of SARS-COV2 live attenuated vaccine neutralizing antibodies. There was a marked increase in neutralizing antibodies to SARS-COV2 surface glycoproteins such as spike[S] protein



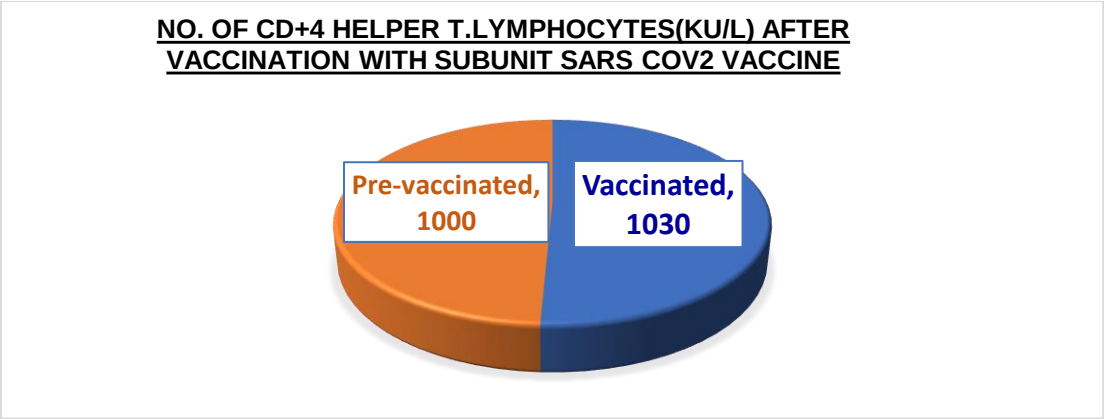
Graph [6]: It corresponds the absorbance of different serum concentrations of neutralizing antibodies to SARS-COV2 sub-unit vaccine via ELISA. There was a noticeable increment in neutralizing antibodies to SARS-COV2 surface spike[S] protein



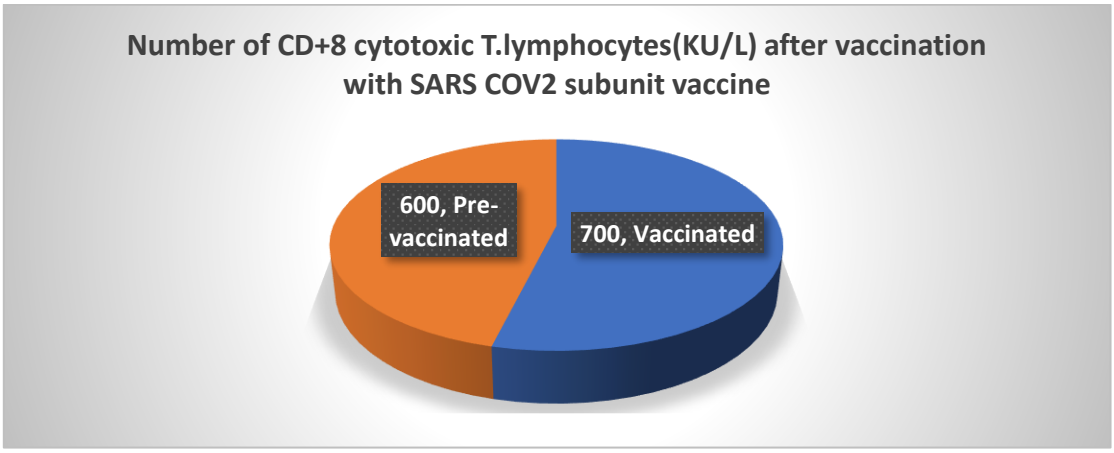
Graph [7]: It represents count of helper T-lymphocytes after immunization with SARS-COV2 live attenuated vaccine. The count of helper T. lymphocytes was increased moderately after vaccination



Graph [8]: It represents count of cytotoxic T-lymphocytes after immunization with SARS-COV2 live attenuated vaccine. The count of cytotoxic T-lymphocytes was increased markedly after vaccination



Graph [9]: It represents count of helper T. lymphocytes after immunization with SARS-COV2 sub-unit vaccine. The count of helper T. lymphocytes was increased mildly after vaccination



Graph [10]: It represents count of cytotoxic T. lymphocytes after immunization with SARS-COV2 sub-unit vaccine. The count of cytotoxic T. lymphocytes was increased fairly after vaccination

Table [2]: The absorbance of various serum neutralizing antibodies to SARS-COV2 live attenuated and sub-unit vaccines via ELISA

Live-attenuated vaccine		Sub-unit vaccine	
Concentration [ng/ml]	**Absorbance**	**Concentration [ng/ml]**	**Absorbance**
1.65	0.194	1.48	0.195
3.04	0.268	3.07	0.221
6.2	0.356	6.17	0.351
12.6	0.528	12.3	0.549
24	1.124	24	1.3
48	1.707	50	1.725
97	3.022	100	3.087

Table [3]: The count of lymphocytes after live attenuated and sub-unit SARS-COV2 vaccinations

	Live-attenuated vaccine		Sub-unit vaccine	
Description	Vaccinated	Pre-vaccinated	Vaccinated	Pre-vaccinated
CD+4 COUNT	1060	1000	1030	1000
CD+8 COUNT	730	600	700	600
Total	**1790**	**1600**	**1730**	**1600**

Table [4]: The count of alive and dead cases after live attenuated and sub-unit SARS-COV2 vaccination of transgenic mice

	Live-attenuated vaccine		Sub-unit vaccine	
Description	Vaccinated	Non-vaccinated	Vaccinated	Non-vaccinated
Alive	96	31	97	31
Dead	4	69	3	69
Total	**100**	**100**	**100**	**100**

DISCUSSION

New SARS-COV2 vaccines [A and B] were created for this investigation. A vaccine included the SARS-COV2 spike protein sub-unit vaccine, whereas B vaccine was a live attenuated SARS-COV2 vaccine including the Alpha, Beta, Delta, and Omicron stereotypes. The current mRNA SARS-COV2 vaccine produced by Pfizer pharmaceutical company achieved 95% efficacy in clinical trials phase 3, compared to about 70% for SARS-COV2 vaccines produced by Astrazenca and Johnson and Johnson pharmaceutical companies in clinical trials phases 1/2 of the study, which was also conducted in the USA [21].

In the current study, preclinical studies [animal testing] demonstrated that both vaccines [A and B] had effectiveness rates of 97 and 96%, respectively; however, phases 1 and 2 of human clinical trials revealed protection rates of 86 and 84%. They outperformed other common vaccinations including those made by Pfizer and Astrazeneca in terms of biological activity and adverse effects. For vaccination A and B, respectively, their effectiveness continued for 2-3 months and 6-8 months, respectively. 93 people were infected in the negative control group during human clinical trials, while 5 people were infected in the positive control group. However, in the current study, 14 and 16 candidates were infected in the test groups for sub-unit and live attenuated vaccines against SARS-COV2, respectively. The SARS-COV2 virus was discovered to have an LD50 of more than 80 mcg/ml.

The ED50% for the SARS-COV2 sub-unit vaccination was determined to be 25 mcg/ml; whereas the ED50% for the live attenuated SARS-COV2 vaccine was 60–65 mcg/ml. Compared to the live attenuated SARS-COV2 vaccine formulation, the SARS-COV2 sub-unit vaccine had a formulation of 25 mcg/ml as opposed to 65 mcg/ml. For individuals older than 16, both vaccinations were advised. The doses for the current sub-unit and live attenuated SARS-COV2 vaccines, respectively, were 25 and 65 mcg/ml when administered twice a year in October. In contrast to live attenuated vaccination, which was administered orally, sub-unit vaccine was administered via intramuscular route of injection. There was seen to be a 28-day gap between the first and second doses. Those with allergies to the test vaccinations' components were not supposed to use them; also, for those younger than 16 years of age. The only side effects were a little amount of discomfort at the injection site and a brief period of moderate fever, both of which were treated with inexpensive analgesics such paracetamol and ibuprofen. The efficacy of the existing sub-unit and live attenuated vaccines was 86 and 84%, respectively, compared to the efficacy of the current standard vaccinations, whereas the efficacy of the Moderna mRNA vaccines was roughly 94% with low secretory protective IgA antibodies [22].

In comparison to other available SARS-COV2 vaccines, the live attenuated vaccination in the current trial demonstrated greater IgA antibody titers. The effectiveness of the Russian, Johnson, and Astrazenca SARS-COV2 vaccines demonstrated close to 70% efficiency with low IgA antibodies, compared to the Chinese Sino-pharm killed vaccine's roughly 50% efficacy with little protective secretory IgA antibodies [23].

The vaccinations used in this trial did not cause any of the major adverse effects associated with previous vaccines from Russian, Johnson, and Astrazenca, including *Guillain-Barre* syndrome and atypical blood clots with low platelets [24]. The function of immunity in preventing infection: Vaccine A: It greatly boosted humeral immunity; while, just mildly stimulating cell-mediated immunity. The primary physical barrier against infection was humoral immunity. IgM and IgG1 antibodies against the virus' spike protein were the predominant neutralizing antibodies in blood. Since the SARS-COV2 virus was not acquired through a normal infection process, little IgA antibodies against the spike protein were generated. The SARS-COV2 virus infection was resistant to this vaccine's sporadic activation of cell-mediated immunity.

Benefits: A virulent state could not be restored. Cons: The sub-unit vaccine had a shorter half-life [2–3 months] than the live attenuated vaccine and was not execrable by the body. As a result, it could not be transmitted to contacts who were not immune, which prevented the establishment of herd immunity against the SARS-COV2 virus. Vaccination B: The humeral and cell mediated immune systems were both substantially activated. The primary system of the body's defense against infection was cell-mediated immunity. To destroy the viral infected cells, cytotoxic CD8+ T lymphocytes were predominant. The SARS-COV2 virus was

successfully warded off by the vaccine's powerful humeral response.

Due to the constant reproduction of the virus contained in the vaccine in the host, neutralizing secretory IgA antibodies were generated against the virus' spike protein in mucosal secretions in the respiratory and gastrointestinal systems. Furthermore, neutralizing IgM and IgG2 antibodies were produced in the blood and lymph against the viral infection. Since it substantially promoted both humoral and cell-mediated immunity against the viral infection of SARS-COV2, vaccine B was superior to vaccine A and had a longer duration of effect [25].

Benefits of vaccination B include the possibility of vaccine virus excretion and transmission to contacts who are not immune, which aids in the establishment of herd immunity against this viral illness; longer duration of effect than the dead vaccination. Cons: Immuno-compromized patients may revert to virulence [26]. While, the current vaccinations are free of these side effects, the virus-like particles vaccines produced by Astrazenca and Johnson-Johnson pharmaceutical businesses were found to seldom induce thrombotic problems [27]. The SARS-COV2 vaccine made from virus-like particles in insect cells using recombinant DNA technology had a moderate yield and productivity but a high immunogenicity [28]. The current vaccinations showed increased output and productivity; however, because the sub-unit vaccine was created using recombinant DNA technology within yeast cells, it had a lesser immunogenicity than the virus-like particles SARS-COV2 vaccine [29]. As host cells for the machinery expressing the target protein, yeast cells showed less post-transnational and post-transcriptional changes than insect cells [30].

Conclusion: In experiments designed to simulate an outbreak, both vaccines were effective in shielding against SARS-COV2 and its mutant variant forms. Giving any of these to anyone under the age of 16 is not well-advised.

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