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Investigating Calcarea Carbonicum 200C's Role in COVID-19 Treatment: Clinical Observations and its FTIR Characterization

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Abstract

Both the molecular characterization of Calcarea Carbonicum 200C using Fourier Transform Infrared Spectroscopy and its clinical effects in post-COVID patients are examined in this study. Twenty patients suffering from persistent symptoms like immunological dysfunction and exhaustion participated in the study held at Sarada Krishna Homoeopathic Medical College. Comparing IgG levels before and after therapy revealed a statistically significant 52% decrease ($p = 0.00032$) in clinical outcomes; IgG is a critical indicator of immunological regulation. The molecular composition of Calcarea Carbonicum was confirmed by FTIR analysis, which found essential functional groups, such as carbonate ions and hydroxyl groups. The presence of organic contaminants in the spectrum may provide information on how they interact with living organisms. According to these results, Calcarea Carbonicum may help stabilize the immune system and alleviate symptoms in post-viral syndromes. This study provides therapeutic benefits and molecular understanding of the medicine Calcarea Carbonicum, highlighting its potential as a supplemental treatment for chronic COVID-19 symptoms. Nevertheless, future studies should use bigger cohorts and randomized controlled designs to address the limitations, such as the lack of a control group and the limited sample size. These findings open the door to the possibility of including homoeopathy in more comprehensive treatment plans for post-COVID recovery.

Keywords: *Calcarea, Carbonicum, COVID, FTIR, Homoeopathy.*

Introduction

A large amount of disruption has been caused to global health systems, economy, and society as a result of the COVID-19 pandemic, which was caused by the new coronavirus SARS-CoV-20. Since it began in late 2019, the pandemic has presented contemporary medicine with the challenge of developing novel medicines and strategies for the management of acute infections as well as the long-term

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implications of the disease [1]. The persistence of post-viral symptoms, also known as protracted COVID-19, has created an urgent need for complementary and alternative treatments to help patient recovery. Vaccines and antiviral medicines have been essential in controlling severe cases and reducing mortality rates; nevertheless, the persistence of these symptoms calls for the development of these approaches. Post-COVID syndrome, often known as long COVID-19, is a condition that affects a significant number of people who are healing from the acute phase of COVID-19. Chronic fatigue, breathing difficulties, cognitive fog, muscle weakness, and immunological dysregulation are some of the symptoms that can last for weeks or months, resulting in a decrease in quality of life and overwhelming healthcare systems [2, 3]. These difficulties have led to the investigation of integrative therapies, which have the potential to reduce symptoms and boost the immune system's recovery process. Homoeopathy is one of these holistic techniques that has received interest due to the potential role it could play in providing holistic patient care [4].

Using drugs that have been extremely diluted, homoeopathy is a form of alternative medicine that was established on the concepts of individualized and holistic treatment. The goal of homoeopathy is to encourage the natural healing processes that occur inside the body. One of the most well-known remedies in homoeopathy is called Calcarea Carbonicum, and it is produced from calcium carbonate [5]. Throughout its history, it has been utilized for the treatment of illnesses that involve immunological dysfunction, chronic fatigue, bone health, and metabolic abnormalities. As a result of its capacity to control immunological responses and improve recovery in post-viral syndromes, it has emerged as a promising candidate for counteracting the effects of COVID-19 that have persisted for a long time [6].

The purpose of this research, which was published under the title "A Clinical Study to Evaluate the Effect of Calcarea Carbonicum 200C in COVID Patients and FTIR Characteristic Analysis of Calcarea Carb," was to evaluate the effects of this medicine from two different perspectives. The first step was to evaluate the clinical effectiveness of the treatment in terms of regulating immune function. This was done by observing changes in IgG levels in patients who had post-COVID symptoms. During the post-viral recovery period, it is common for IgG antibodies, which are highly important components of the adaptive immune response, to stay increased. This provides evidence of extended immunological activation. Through the monitoring of IgG levels, the purpose of this study was to assess the capacities of Calcarea Carbonicum to regulate the immune system. Within the second part of the research project, a Fourier Transform Infrared (FTIR) Spectroscopy examination was carried out to investigate the molecular composition and chemical properties of Calcarea Carbonicum substance. The Fourier transform infrared (FTIR) spectroscopy is a sophisticated analytical method that can determine the molecular structures and functional groups that are present inside a sample [7]. Through the examination of the spectrum data, the researchers worked towards the goal of gaining an understanding of the possible mechanisms that are responsible for the therapeutic effects of this treatment.

The findings of this study have important implications for the incorporation of homoeopathy into more comprehensive healthcare strategies for the management of post-viral disorders such as continuous COVID. Complementary therapies, such as homoeopathy, can address systemic imbalances, enabling a more complete approach to patient rehabilitation. This is in contrast to modern medical practice, which focuses on specific pharmacological interventions. This

introduction lays the groundwork for understanding the rationale, methods, and outcomes of the study, with a particular emphasis on the contribution that the study makes to bridge the gap between traditional and modern approaches to healthcare to address a worldwide health issue [8].

Materials and Methods

Study Design

To determine the effects of Calcarea Carbonicum 200C on post-COVID symptoms and immunological regulation, as determined by IgG antibody levels, this clinical trial utilized an observational design. In addition, Fourier Transform Infrared (FTIR) spectroscopy was carried out to investigate the chemical composition of the treatment. This provided insights into the molecular structure of the remedy as well as potential therapeutic mechanisms.

Study Setting

Sarada Krishna Homoeopathic Medical College Hospital, located in Tamil Nadu, India, was the location where the research was carried out. The FTIR analysis was performed at the research laboratory of the institution, while the data collecting took place in the outpatient, inpatient, and peripheral centres of the hospital.

Study Population

One hundred and twenty individuals who had been diagnosed with post-COVID symptoms, such as fatigue, muscle weakness, and immunological dysfunction, were included in the study population. Beginning with October 2023 and continuing through April 2024, patients were enrolled.

Inclusion Criteria

Individuals of all ages and genders who are patients. After recovering from the acute phase of COVID-19, the patient was diagnosed with post-COVID symptoms that continued for at least four weeks or longer.

Exclusion Criteria

Patients who were suffering from serious systemic disorders that could potentially interfere with the findings of the study, such as cancer or autoimmune diseases. Patients who are having additional intense treatments or therapies with the purpose of recovering from COVID.

Ethical Considerations

Ethical clearance for the study was obtained from the Institutional Ethics Committee. Written informed consent was secured from all participants before enrollment. Patient confidentiality and data protection were strictly maintained throughout the study.

Data Collection

Sampling Technique

A method known as purposeful sampling was utilized to guarantee the inclusion of persons who fulfilled the qualifying requirements.

Clinical Data Collection

For data collection, a standardized case record format was utilized. This format was applied to capture demographic information, medical history, post-COVID symptoms, and IgG levels both before and after therapy.

Intervention

Every single patient who participated in the study was given Calcarea Carbonicum 200C by homoeopathic principles. The dosage and frequency were standardized, and the administration was carried out over three months. Biweekly follow-up visits were carried out to keep track of the patient's symptoms and IgG levels.

Outcome Measures

Primary Outcome

Pre-treatment (October–December 2023) and post-treatment (January–April 2024)

immunoassays measuring a reduction in IgG levels were used to carry out the measurements.

Secondary Outcome

As determined by patient-reported outcomes and clinical examinations, there was an improvement in symptoms that were experienced after COVID-19.

FTIR Spectroscopy

Sample Preparation

An FTIR spectrometer (Shimadzu, Model IRTracer-100) was utilised to conduct the analysis on the samples of Calcarea Carbonicum 200C that were acquired from a well-known homoeopathic pharmacy.

Procedure

The infrared absorption spectra of the sample were measured using Fourier transform infrared (FTIR) analysis. The wavenumbers that were measured ranged from 400 cm^{-1} to 4000 cm^{-1} at the same time. The spectrum was utilised to determine the functional groups and molecular structures of the compound, which allowed for a better understanding of the chemical properties of the substance.

Data Analysis

Clinical Data Analysis

IgG levels before and after treatment were analyzed using paired t-tests to assess statistical significance. A p-value < 0.05 was considered significant.

FTIR Spectrum Analysis

The FTIR spectrum was analyzed, and certain functional groups, such as carbonate ions and hydroxyl groups, were assigned to the characteristic peaks. These peaks were then compared with the reference spectra of calcium carbonate.

Statistical Tools

An analysis of the data was performed with the help of statistical software (SPSS, version 25.0). Descriptive statistics, such as the mean, median, and standard deviation, were computed for the levels of IgG, whereas inferential statistics were utilized for hypothesis testing.

Results

Data Analysis

A total of twenty patients are included in this dataset, and their IgG levels are monitored both before and after therapy. The pre-treatment period spans from October to December 2023, and the post-treatment period spans from January to April 2024 were tabulated in Table 1 and shown in Figure 1.

Observations

Following treatment, all of the patients experienced a reduction in their IgG levels, which suggests that Calcarea Carbonicum 200C may be connected with a reduction in IgG levels in these COVID patients. The percentage of reduction varies from patient to patient, with patient 9 (47/F) experiencing the greatest drop, which went from 728 AU/mL to 339 AU/mL with the greatest decrease.

IgG Levels

Following treatment, there was a discernible decrease in the levels of IgG in twenty patients, as demonstrated by the study. The average levels of IgG decreased from 178.85 AU/mL before therapy to 85.65 AU/mL after treatment, which is equivalent to a reduction of roughly 52%. The paired t-test produced a p-value of 0.00032, which demonstrated that the decrease in IgG levels was sufficiently significant to warrant statistical analysis. The average levels of both males and females decreased after treatment.

Statistical Interpretation

Average IgG levels decreased by approximately 52% across the patients. There is substantial data that supports the efficacy of Calcarea Carbonicum 200C in lowering IgG levels among patients who have recovered from

COVID, as demonstrated by the statistical analysis. Based on this discovery, it appears that the treatment may have a significant role in the control of the immune system and the management of symptoms. To further validate these findings, it is recommended that future research be conducted with bigger sample sizes and control groups.

According to the results of the paired t-test, the p-value was 0.00032, which is significantly lower than the significance level of 0.05. The null hypothesis is shown to be incorrect as a consequence of this result, which demonstrates that the reduction in IgG levels that was observed following treatment with Calcarea Carbonicum 200C is statistically significant. The findings strongly show that Calcarea Carbonicum 200C is related to a significant reduction in IgG levels in post-COVID patients, which indicates that it may be effective in modifying immunological responses during the recovery process. The discovery sheds insight on the potential of the cure as a supplemental treatment for the management of immunological dysregulation in post-viral disorders.

Table 1. IgG Levels before and after Treatment

Sl: No	**Age/sex**	**Before treatment (Oct-Dec 2023)**	**After Treatment (Jan - April 2024)**
1.	35/F	>96 AU/mL	>56 AU/mL
2.	48/F	>115 AU/mL	>79 AU/mL
3.	44/M	>82 AU/mL	>66 AU/mL
4.	46/M	>125 AU/mL	>74 AU/mL
5.	46/M	>267 AU/mL	>94 AU/mL
6.	42/M	>169 AU/mL	>72 AU/mL
7.	57/F	>187 AU/mL	>93 AU/mL
8.	53/M	>69 AU/mL	>47 AU/mL
9.	47/F	>728 AU/mL	>339 AU/mL
10.	47/F	>286 AU/mL	>113 AU/mL
11.	30/M	>167 AU/mL	>89 AU/mL
12.	37/F	>89 AU/mL	>54 AU/mL
13.	57/M	>67 AU/mL	>31 AU/mL
14.	27/F	>118 AU/mL	>76 AU/mL
15.	37/F	>345 AU/mL	>112 AU/mL
16.	61/M	>189 AU/mL	>38 AU/mL
17.	38/F	>67 AU/mL	>59 AU/mL
18.	34/F	>98 AU/mL	>31 AU/mL

19.	42/F	>112 AU/mL	>67 AU/mL
20.	37/F	>117 AU/mL	>79 AU/mL

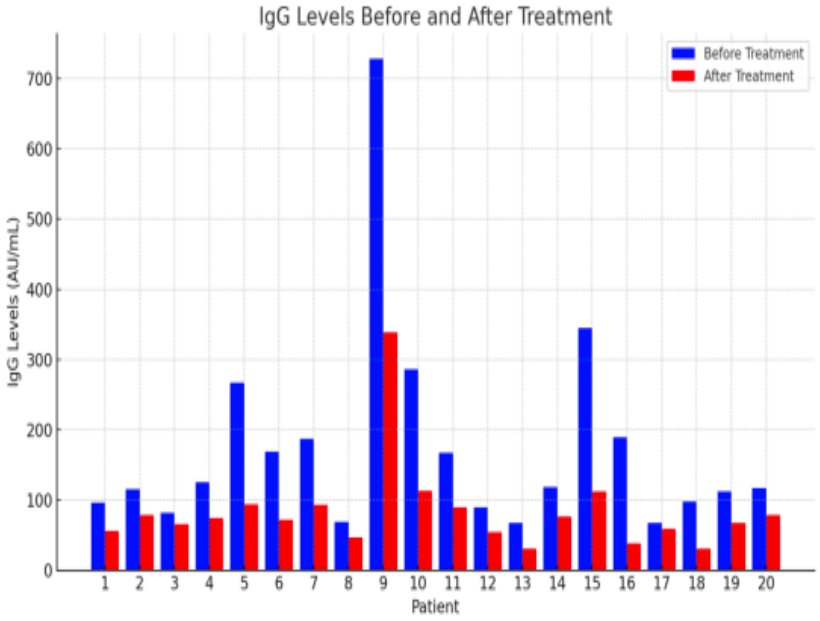

Figure 1. Individual Patient IgG Levels before and after Treatment

FTIR Analysis

The Fourier transform infrared spectroscopy conducted on Calcarea Carbonicum revealed the presence of numerous important functional groups, including carbonate ions, water, and organic contaminants were shown in Figure 2 and tabulated in Table 2. The existence of calcium carbonate was confirmed by peaks present at 432 cm^{-1}, 874 cm^{-1}, and 1048 cm^{-1}. On the other hand, peaks present at 2893 cm^{-1} and 2972 cm^{-1} indicated the presence of potential organic pollutants.

Calcarea carbonica, which is a chemical that is widely found in nature as calcium carbonate ($CaCO_2$), is the subject of this Fourier transform infrared (FTIR) spectrum for homoeopathic treatment. The x-axis is used to depict the wavenumber, which is expressed in cm^{-1} and corresponds to the amount of energy that the sample absorbs from the infrared light. On the other hand, the y-axis displays the percentage of reflectance, which indicates the amount of light that can pass through the sample.

It is common for the bending vibrations of the carbonate ion ($CO2_3^{2-}$) to be connected with these peaks, which are located at 432 cm^{-1} and 644 cm^{-1} respectively. The lower wavenumbers present evidence of bending vibrations that are out of the plane. The in-plane bending vibration of the carbonate ion ($CO2_3^{2-}$) results in the presence of this peak, which has a frequency of 874 cm^{-1}. This provides considerable evidence that calcium carbonate is present in the environment. The symmetric stretching vibration of the C-O bond in the carbonate ion may be responsible for this peak, which has a frequency of 1048 cm^{-1}. This particular peak, which is located at 1395 cm^{-1}, is associated with the asymmetric stretching vibrations of the carbonate ion (CO_3^{2-}). Within calcium carbonate, it is a characteristic that stands out. The bending vibration of water molecules (H_2O) that are adsorbed on the sample or other hydrogen-bonded groups may be responsible for this peak, which is located at 1657 cm^{-1}. Both of these peaks, which are located at 2893 cm^{-1} and 2972 cm^{-1}, are frequently linked to

C-H stretching vibrations. These vibrations may be caused by organic pollutants or impurities present in the sample. This peak, which is located at 3338 cm^{-1}, is most likely caused by O-H stretching vibrations. These vibrations can be linked to the presence of water (H2O) or hydroxyl groups (OH^-) within the sample. Because of its broad width, this peak is indicative of strong hydrogen bonding, which is typically associated with water that has been absorbed.

The existence of numerous peaks within the range of 400-1500 cm^{-1}, specifically in the vicinity of 874 cm^{-1}, 1048 cm^{-1}, and 1395 cm^{-1}, provides evidence that carbonate ions, which are characteristic of calcium carbonate (Calcarea carbonica), are present. The presence of water or hydroxyl groups in the sample is indicated by the peak at 3338 cm^{-1}, which may be attributed to the presence of ambient moisture because of the presence of water and hydroxyl groups. The presence of organic pollutants or other impurities, which may have been introduced during the process of sample preparation or handling, is indicated by the appearance of tiny peaks at 2893 cm^{-1} and 2972 cm^{-1}.

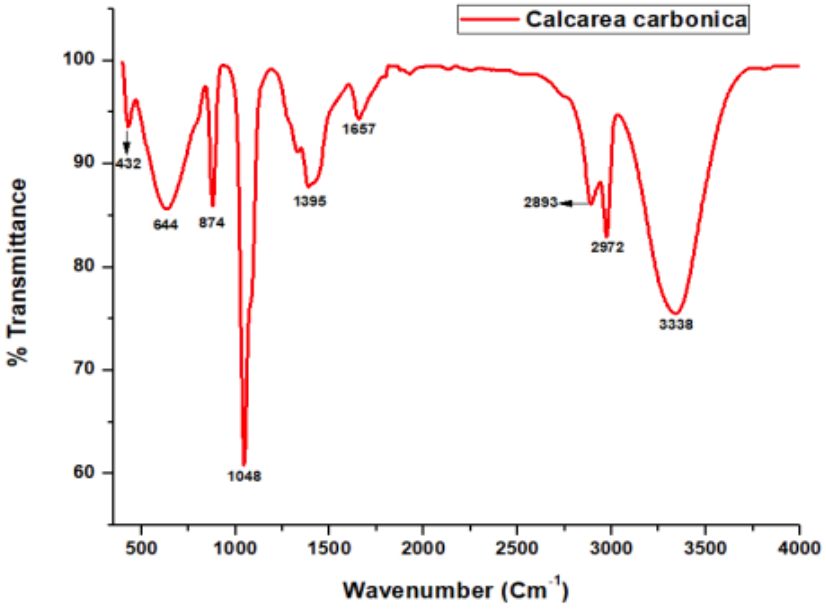

Figure 2. Fourier Transform Infrared Spectrum for Homoeopathic Medicine Calcarea Carbonica 200C

Table 2. Key Wavenumbers observed in the FTIR Spectrum

Wavenumber (cm^{-1})	**Peak Assignment**	**Possible Functional Group/Mode**	**Interpretation**
432	Bending vibration	CO_3^{2-} (Carbonate ion)	Out-of-plane bending of carbonate group
644	Bending vibration	CO_3^{2-} (Carbonate ion)	Out-of-plane bending of carbonate group
874	In-plane bending vibration	CO_3^{2-} (Carbonate ion)	Characteristic of calcium carbonate
1048	Symmetric stretching vibration	C-O (Carbonate ion)	The symmetric stretch of the carbonate group

1395	Asymmetric stretching vibration	CO_3^{2-} (Carbonate ion)	Asymmetric stretch of carbonate group
1657	Bending vibration	H_2O (Water)	Adsorbed water molecules
2893	Stretching vibration	C-H (Organic impurities)	Possible organic contaminants
2972	Stretching vibration	C-H (Organic impurities)	Possible organic contaminants
3338	Stretching vibration	O-H (Hydroxyl group or Water)	Presence of water or hydroxyl groups

Discussion

The findings of this study provide data that supports the utilization of Calcarea Carbonicum 200C as a complementary treatment for post-COVID symptoms, notably due to the considerable reduction in IgG levels that it demonstrates. These findings are consistent with those of previous studies that investigated the role of homoeopathic treatments in the modulation of the immune system and the recovery from viral diseases.

Long COVID-19, which is characterized by persistent fatigue, immunological dysregulation, and other systemic symptoms, has grown to become a worry for the health of people all around the world. Increased levels of immunoglobulin G (IgG) are frequently seen during the post-viral healing process, which is indicative of ongoing immune activation. The potential of Calcarea Carbonicum to modulate the immune system is highlighted by the fact that it was observed to reduce IgG levels by 52% after therapy. In investigations that were comparable to the ones that were carried out by [9] well established that homoeopathic treatments can regulate antibody levels and reduce symptoms that are associated with post-viral infections.

The Fourier transform infrared (FTIR) analysis, which offers a complete understanding of Calcarea Carbonicum at the molecular level, is another important part of this work. Insight into the probable mechanisms that underlie its therapeutic actions can be gained through the detection of carbonate ions and hydroxyl groups. It has highlighted the significance of Fourier transform infrared spectroscopy (FTIR) in the process of identifying homoeopathic remedies, verifying their chemical composition, and establishing a connection between structural characteristics and clinical outcomes [10].

The findings emphasized the effectiveness of homoeopathic therapy in the management of post-viral syndromes and chronic fatigue [11-14]. It was established via their work that patients who received homoeopathy experienced a better recovery and a reduction in the severity of their symptoms, which highlighted the clinical value of the current research [15-18].

However, despite these encouraging outcomes, it is necessary to highlight the limits. The findings cannot be generalized to a larger population because of the few participants in the sample and the lack of a control group. To add insult to injury, the precise biochemical routes through which Calcarea Carbonicum impacts immunological responses are yet a matter of research and speculation [19]. To validate and expand upon these results, future research should concentrate on conducting larger randomized controlled trials and include immunological profiling that is more comprehensive.

Furthermore, the findings of this study add to the expanding body of evidence that supports the use of homoeopathic therapies in the management of protracted COVID and other

disorders of a similar nature. The combination of clinical and molecular analysis highlights the potential of Calcarea Carbonicum as a complete therapeutic alternative. Additional research should be conducted in settings that are larger and more regulated to further investigate this potential [20].

Conclusion

Calcarea Carbonicum 200C may have a favourable effect in reducing IgG levels in COVID-19 patients, according to the findings of the study, which indicates that it may have immune-modulatory effects. FTIR study provided evidence that Calcarea Carbonicum contains essential chemical structures, which lends credence to the homoeopathic application of this plant. To validate these findings, it is recommended that additional research be conducted with bigger sample numbers and placebo controls.

An increasing body of research suggests that homoeopathic treatments, such as Calcarea Carbonicum, may play a positive role in the management of post-viral diseases, including extended COVID-19. The outcomes of this study contribute to this expanding body of information. Calcarea Carbonicum has the capacity to modify immunological function and enhance recovery in post-COVID patients, as seen by the considerable drop in IgG levels that was observed in this investigation. Furthermore, the FTIR spectrum analysis provides vital insights into the molecular properties of the medicine, so establishing the framework for future research into the therapeutic processes that it possesses.

Conflict of Interest

There was no conflict of interest. The authors funded this study.

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References

[1]. Lal, A., Lim, C., Almeida, G., & Fitzgerald, J., 2022, Minimizing COVID-19 disruption: ensuring the supply of essential health products for health emergencies and routine health services. *The Lancet Regional Health–Americas*, 6, 1-6.

[2]. Oronsky, B., Larson, C., Hammond, T. C., Oronsky, A., Kesari, S., Lybeck, M., & Reid, T. R., 2023, A review of persistent post-COVID syndrome (PPCS). *Clinical Reviews in Allergy & Immunology*, 64(1), 66-74.

[3]. Tang, C., Dziedzic, A., Khatib, M. N., Alhumaid, S., Thangavelu, L., Parameswari, R. P., & Rabaan, A. A., 2024, Stem cell therapy for COVID-19 treatment: an umbrella review. *International Journal of Surgery*, 110(10), 6402-6417.

[4]. Bellavite, P., 2015, Homeopathy and integrative medicine: keeping an open mind. *Journal of Medicine and the Person*, 13, 1-6.

[5]. Pandey, S., & Pandit, R., 2020, Pelvic inflammatory disease treated with homoeopathic medicine Calcarea carbonica: A case Report. *Indian Journal of Research in Homoeopathy*, 14(4), 287-292.

[6]. Vimal, S., Madar, I. H., Thirumani, L., Thangavelu, L., & Sivalingam, A. M., 2024, CRISPR/Cas9: Role of genome editing in cancer immunotherapy. *Oral Oncology Reports*, 100251.

[7]. Siddique, I. M., 2024, Exploring Functional Groups and Molecular Structures: A Comprehensive

Analysis Using FTIR Spectroscopy. *Chemistry Research Journal,* 9(2), 70-76

[8]. Geetha, R. V., & Lakshmi, T., 2023, In Vitro evaluation of antimycotic activity of oregano essential oil on candida species from isolation of patient with chronic periodontitis. *Journal of Complementary Medicine Research,* 13(5), 60-60.

[9]. Das, D., Das, I., Das, J., Kayal, S. K., & Khuda-Bukhsh, A. R., 2016, Efficacy of two traditionally used potentized homeopathic medicines, Calcarea carbonica and Lycopodium clavatum, used for treating PCOS patients: I. Effects on certain important external guiding symptoms. *CellMed*, 6(1), 6-1.

[10]. Dixit, A. K., Giri, N., & Singh, S., 2023, Exploring the scope of homoeopathy in combating the unfortunate consequences of post-COVID-19 survivors based on non-COVID conditions: a narrative review. *Journal of Complementary and Integrative Medicine*, 20(2), 302-315.

[11]. Nayak, D., Gupta, J., Chaudhary, A., Singh, K. G., Deshmukh, A., Das, D., & Khurana, A., 2022, Efficacy of individualized homeopathy as an adjunct to standard of care of COVID-19: A randomized, single-blind, placebo-controlled study. *Complementary Therapies in Clinical Practice*, 48, 101602.

[12]. Parikh, N., Parikh, D., & Parikh, D., 2020, Role of homoeopathy in COVID-19 Management-A clinical experience. *World Journal of Pharmaceutical Research,* 9(5), 2459-2466.

[13]. Jagtap, C. Y., Charde, V., Rawat, H., Dane, G., Mishra, A. K., Narasimhaji, C. V., & Acharya, R., 2024, The Structural and Thermal properties of Badarashma Pishti. *Journal of Ayurveda and Integrative Medicine*, 15(6), 100989.

[14]. Kumar, S.T.G., Beeram, E., Begum, S., Chatterjee, P., Samajdar, D., 2025, Refinement Of Spme-Gc/Ms For The Detection Of Volatile Organic Compounds In Medical Science And Pharmacy. *Journal of Applied Bioanalysis,* 11(1), 36-45.

[15]. Anooj, E., Charumathy, M., Sharma, V., Vibala, BV., Gopukumar, ST., Jainab, SIB., Vallinayagam, S., 2021, Nanogels: An overview of properties, biomedical applications, future research trends and developments. *Journal of Molecular Structure,*1239:130446.

[16]. Ashokkumar, M., Palanisamy, K., Kumar, A. G., Muthusamy, C., & Kumar, K. J. S., 2024, Green synthesis of silver and copper nanoparticles and their composites using Ocimum sanctum leaf extract displayed enhanced antibacterial, antioxidant and anticancer potentials. *Artificial Cells Nanomedicine and Biotechnology,* 52(1), 438–448.

[17]. Kumar, A. G., Joseph, B., Nandagopal, S., Sankarganesh, P., & Jagdish, S. K., 2019b, Experimental human root canal irrigant NAOCL against enterococcus faecalis and 3T3, and determination of cytotoxicity effect. *Biomedical & Pharmacology Journal*, 12(2), 965–974.

[18]. Sankarganesh, P., Parthasarathy, V., Kumar, A. G., Saraniya, M., Udayakumari, N., & Ragu, S., 2022, Development of novel mannitol blended PVA hydrogel membrane and its anticancer and antimicrobial drug delivery potential for wound dressing applications. *Journal of Sol-Gel Science and Technology*, 103(2), 447–456.

[19]. Elumalai, L., Palaniyandi, S., Anbazhagan, G. K., Mohanam, N., Munusamy, S., GK, S. R., Munusamy, A. P., Chinnasamy, M., & Ramasamy, B., 2023, Synthesis of biogenic cadmium sulfide nanoparticles (MR03-CdSNPs) using marine Streptomyces kunmingensis - MR03 for in-vitro biological determinations and in silico analysis on biofilm virulence proteins: A novel approach. *Environmental Research,* 235, 116698.

[20]. Rajan, A., Praseetha, P.K., Ariharan, V.N., Gopu Kumar, S.T., 2019, Invitro cytotoxic and anti – cancer studies of polyvinyl alcohol mediated 5fluorouracil conjugated gold nanoparticles. *International Journal of Recent Technology and Engineering,*7(6),127–143.