Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(4), 1622-1630 | ISSN:2251-6727

Scientific Exploration of Nanoparticles in "Gowri Chinthamani Chenthuram" and its Quality Control Studies

[1]S.Sriram, [2]C.Savariraj Sahayam , [3]P.Rajalakshmi [*] , [4]P.Brindha
Centre for Advanced Research in Indian Systems of Medicine,
School of Chemical and Biotechnology,
SASTRA Deemed University, Thanjavur, Tamil Nadu, India

(Received: 14 April 2024 Revised: 1 May 2024 Accepted: 18 June 2024)

KEYWORDS
Gowri Chinthamani Chenthuram, quality control studies, EDAX, FTIR, XRD and SEM.

ABSTRACT:

Introduction: "*Gowri Chinthamani Chenthuram"* is mercury based metallic medicine of *Siddha* system of medicine. It is administered to treat all types of pains such as acute pain, chronic pain, neuropathic pain, nociceptive pain, radicular pain, and its therapeutic dose level is 130 mg along with honey and *thirikadugu choornam.*

Objectives: In the present work, three batches of the *Chenthuram* were procured from the same manufacturer and were subjected to quality control studies, surface characterisation studies (XRD and SEM) and elemental analysis performed using EDAX. FTIR spectroscopy was also performed to detect major functional groups present in the formulation.

Results and Discussion: Data of quality control studies revealed that the moisture content of the three samples were about 2% to 3%, the total ash level was nearly 20% and acid insoluble ash in negligible amount. These values pointeds out that the preparation was free from moisture and unwanted chemical molecules. EDAX results indicated that mercury was present in high concentration (67.09%), followed by sulphur (23.86%) and borax (9.06%). In FTIR spectroscopic studies, totally 4 peaks were found which included one single bond region and three fingerprint regions. Three batches of SEM image size ranged from 95 to 140 nm. The powder X-ray diffraction pattern of GCC revealed the existence of crystalline phase and can be indexed to the pure cubic phase of Beta-HgS. The surface area of GCC was observed to be smooth, may be due to the contribution of processes involved in manufacturing.

Conclusions: The "**nano features"** of GCC, a mercury based *Siddha Chenthuram* was also observed and the surface characteristic features were recorded.

INTRODUCTION

Siddha system of medicine is the oldest documented medical system in the world. *Siddha* is a medical system that was passed on from generation to generation through the ancient system of *Guru – Shidar* (Teacher –Student). It flourished among the "*Dravidians*" especially in the South Indian state of Tamil Nadu [1]. A major portion of the *Siddha* medicines uses herbs and green leaved medicines. One *Ayurvedic* standardization and quality control analysis research paper explained the importance of herbal medicine [2].

Siddha medicines have developed a unique pattern of medicinal preparation in the name of the text ***Gunapadam*** (*Siddha* pharmacology). It explains the preparation and therapeutic uses of products. In *Siddha* system, besides herbs, metal and mineral drugs are also used as medicines. The drugs used by the *Siddhars* could be classified into three groups: Herbal product (*Thavaram*), Inorganic substances (*Thathu*) and Animal products (*Jeevam*). Inorganic substances based drugs are further classified into four categories by the *Siddhar Bhogar* in his book "*Bhogar karasara thurai*" as:

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(4), 1622-1630 | ISSN:2251-6727

Metals and their ores (*Ulogam*)-11, Toxins or Arsenics (*Pasanam*)-64, (Water insoluble inorganic substances and include *panchasutham* (mercury and its salts)), Minerals (*Karasaram*)-25 (Water-soluble salts), and Hydro chemicals (*Uparasam*)-120, **totally 220 chemicals** [3]. Medicines are prepared from the above materials. It divided the medicines into sixty four types of internal and external medicines

Red oxide of medicines prepared from metals, mineral deposits or arsenics or salted materials are called *Chenthuram.* In this categorised medicines made from grinding them with specified juices or distillates or extractives and subjecting to a procedure of calcinations of sublimation or flaming or burning or revealing to insolation [4]. In general centuram are red in colour [5] and it can retain its potency for 75 years [6]. The present work, ***Gowri Chinthamani Chenthuram*** (GCC) is selected to understand the Nanotechnology and nano science involved in the preparation process in which some of the steps similar to modern nano particle synthesis are observed. GCC contained three components namely elemental mercury, elemental sulphur and chemical compound of Borax (Sodium tetra borate) in the same measures [7]. Even though it is a mercury-based *Siddha* medicine, it does not create any poisonous signs and symptoms, which has been proven previously by a research paper by *Sugumar* et al.,2018 [8].

Therapeutically GCC is given to cure all types of body ache such as sudden onset of pain, constant pain, neurological pain, nociceptive pain and radicular pain. Medically it is used to treat with honey and three pungent powder Chronic fevers, all types of stomach problems, rat bite, pneumonia, bronchitis, dyspnoea, Tuberculosis, bronchial asthma, piles, jaundice, inflammation of male & female genital organs accompanied by severe pain, orchitis, urinary obstructions, polyuria and scrofula [9]. Its anti-arthritic activity has been confirmed and accepted by a previous *invivo* study [10]. Its therapeutic dose level is 130 mg given along with honey and *thirikadugu choornam* [11]. One previous toxicological study on GCC has declared that the prescribed dose level was very safe but higher dose levels produced hepatic changes [12]. One more chronic toxicological in vivo study concluded that daily oral administration of GCC at doses of up to 400 mg/kg/day was non toxic in rats [13].

The Herbal mixer contained of Nutmeg, Mace, cloves and Atis given with honey for diarrhoea, stomach irritation and all types Sprue. For piles and fistula given this with herbal ingredients of wild amorpho phallus, chebulic myrobalan, Dry ginger & Long pepper along with honey. Juice extracted from the just warmed yellowed leaves of calotropis leaves to be given along with the medicine on alternative days creates severe purgation. To prevent this butter milk rice is to be used. This is effective in the suppression of toxaemic states, oedema, jaundice, biliousness enlargement of liver, dropsy. Only goat's milk and rice is permitted during this period [4]. After the stoppage of medicine, mildly salted articles and dried goat's meat are to be administered first before the commencement of normal diet [12].

In this present work, quality control studies on GCC were carried out to determine the quality standards of the formulation. Surface characterization studies were done using sophisticated instrument techniques like SEM and XRD. FTIR spectroscopy was also performed to find the interactions if any between purifying agents and the starting metals. Elemental composition was detected using EDAX analysis. One more mercury based research work of *Sukala* et al., 2021 proven that GCC doesn't produce any toxic effects [14]. These nano particle synthesis of GCC, a mercury based *Siddha Chenthuram* was also observed and the surface characteristic features were proven scientifically, these same method was established from medicinal plants [15].

MATERIALS AND METHODS

The prepared medicine of GCC was procured in three different batches from *Siddha* medicine dealers, *Chennai, Tamilnadu*. In the preparation process detoxification process was followed as per *Siddha* literature, by using herbal resources [16]. *Curcuma longa* rhizome and *Acalypha indica* were used to process mercury [17]. Sulphur was processed by the mixture of *Lawsonia inermis* leaf paste and curd [17]. Its ingredients (after processed) were taken equally and ground of mercury and sulphur for three hours become to black mass. Borax was then added and grinded to obtain a homogenous mixture [4]. Using small pieces of cloth, the product was tied into small bundles the diameter of which should not exceed 1.5cm. Pasted the outside layer with clay. Placed these bundles on a layer of sand in a

Journal of Chemical Health Risks

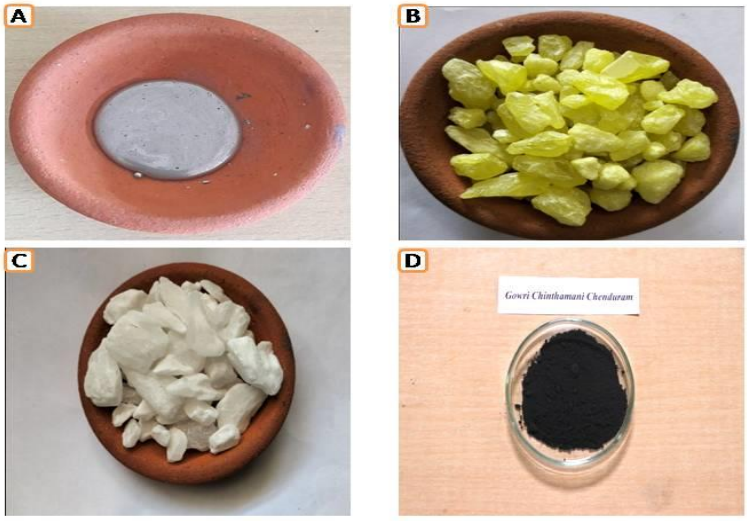
www.jchr.org

JCHR (2024) 14(4), 1622-1630 | ISSN:2251-6727

earthen disc. The rim was sealed after covering with another layer of sand and disc. Burned the capsule with about hundred cow dung cakes. The setup was cooled, opened and the medicine was collected in packets. It was finely grinded and the soot black final product was stored [4] .The ingredients and final products are shown in Fig.1 (A-D). The same type of *Siddha* mineral drugs purification process was did and identified the elements for *pachai karpoora mathirai* [18].

Fig.1: Ingredients of GCC

A.Mercur B.Sulphur C. Borax D. *Gowri Chinthamani Chenthuram*



Quality control studies:

Quality control studies were carry out three times as per the standard methods given in the *Ayurvedic* Pharmacopoeia of India [19] and Quality control methods for medicinal plant materials [20]. Loss on drying (LOD) was estimated by placing 1gm of GCC in a pre-weighed plate and reserved in the hot air oven at a temperature of 105° C and the LOD was calculated by following the formula (weight of the plate before heating – weight of the plate after heating / weight of the sample ×100). Total ash of GCC was measured accepting the standard procedures of Joshi and Aeri [21] GCC (1000mg) was kept in a pre-weighed silica crucible and heated in the muffle furnace at 400° C for about 3 h. Then the crucible was safely put in a desiccators and allowed to cool to room temperature and the weight was finally calculated. The percentage weight of the total ash was calculated using the formula (weight of the ash / weight of the drug × 100). Acid insoluble ash was calculated using the formula (weight of the residue / weight of the powder × 100), where the weight of the residue is the net weight of ash. Water soluble extractive of the sample was tested using the same procedure. Dry powder (1gm) was taken in a glass beaker and 50 ml of water was added and shaken well manually. The beaker was set aside for 24 h and thereafter 10 ml of the solution was taken and kept in hot air oven at 105°C. Finally, the percentage weight of the extract was calculated. This like quality control work was followed to *Ayurvedic* medicine *vasavaleha* [22].

Instrumental analysis:

Energy dispersive analysis of X-rays (EDAX):

The test materials were mounted on a brass stub and sputter covered with gold and initiated into the specimen chamber of the cold field emission scanning electron microscope (JSM-6701F. JEOL, Japan) under ultra high vacuum for Energy Dispersive X-ray analysis.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(4), 1622-1630 | ISSN:2251-6727

FTIR:

Fourier Transform Infrared (FTIR) spectroscopy (Spectrum100, Perkin Elmer, USA) is a spectroscopic method that utilizes lower energy radiation to induce vibration and rotational excitation of atoms and groups of atoms within molecules. It can also be used in understanding the complex formation of different metals with phyto –constituents.

SEM analysis:

In SEM (SEM, JSM6701F, Jeol, Japan), a source of electrons is determined in vacuum into a fine probe that is accepted over the surface of the specimen. SEM works on a voltage between 2 to 50kV and its beam diameter that scans the specimen is 5nm – 2µm. This SEM image attained can help in understanding the surface characters and its nano forms and size.

Powder X-ray Diffractometry (p-XRD):

X-ray diffraction techniques (XRD, D8 Focus, Bruker, Germany) are based on the elastic scattering of x-rays from structures that have long range order. This instrumentation technique helps in understanding the nature of particle by the peaks got through this analysis.

RESULTS AND DISCUSSIONS

Quality control studies

Table-1 tabulated the results of quality control studies of three batches of GCC. It is a black coloured fine powder and had a slightly aromatic odour [20]. The LOD at 105°C indicated that moisture content in the samples were about 2% to 3%. The total ash content of all the three batches were nearly 20%. All the three batches of GCC had negligible amount of acid insoluble ash. The majority of the sample contained water soluble components which were evidenced from the high water-soluble extractive content of 20% in the sample. Similar results were obtained in first and third batches, but second batch value was very low (4%). Other than this, the data for all the parameters were nearly similar. From the data it was evident that the preparation was free from moisture and unwanted chemical molecules. The same method was performed previously for *Ayurvedic* formulation *agastya rasayanam* [23].

Table 1.Quality control studiesof all three batches of GCC

S.No	Standards Determined (%)	Batch-1	Batch-2	Batch-3
1	Appearance	Black coloured fine powder	Black coloured fine powder	Black coloured fine powder
2	Loss on drying at 105^0C(%, w/w)	2.177±0.13	2.775±0.02	3.485±0.14
3	Total ash (%, w/w)	20.78±0.13	20.69±0.25	22.30±0.15
5	Acid insoluble ash (%, w/w)	0.016±0.01	0.026±0.01	0.026±0.003
6	Water soluble ash	20.15±0.15	4.15.±0.12	21.86±0.15
	Siddha specification			
	Lustreless	No metallic lustre	No metallic lustre	No metallic lustre
	Floatability	Partially settled down	Partially settled down	Partially settled down
	Smoke test	Light smoke	Light smoke	Light smoke

Journal of Chemical Health Risks

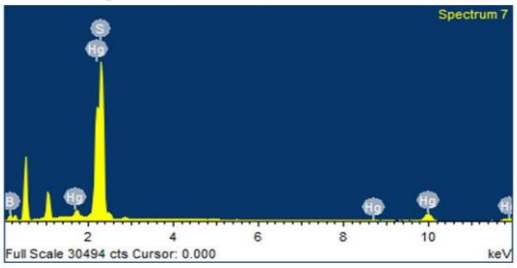
www.jchr.org

JCHR (2024) 14(4), 1622-1630 | ISSN:2251-6727

EDAX

According to The *Siddha* Formulary of India, Part–I, the major inorganic constituents of GCC are mercury, sulphur and borax. The EDAX results shown in Fig.2 are consistent with the reported composition of GCC. From the results it was concluded that mercury was present in major concentration (67.09%), followed by sulphur (23.86%) and borax (9.06%). This result is also in agreement with the work carried out previously on other herbo - metallic preparations *Naga parpam*[24].

Fig.2: EDAX results of all three batches of GCC



FTIR:

The Fourier Transform Infrared Spectrum of all three batches of GCC are given in Fig.3, 4, 5 and Table.2. In the first batch spectroscopic peaks were viewed in the region of 3335 $cm^{-1}$to 825 cm^{-1}. Totally 4 peaks were found which included one single bond region and three fingerprint regions [25]. The-OH stretching appeared at 3335$cm^{-1}$and 3342cm^{-1} [26] with a possible C-H bending around 1251 cm^{-1}. The IR group on 1012 cm^{-1} communicated to C-O stretching. The peak patterns of second and third batches were also similar to the first batch. The region 2919cm^{-1} indicated the presence of fatty acids, dominated by the stretching of CH_3, CH2 and CH which are present mainly in the fatty acids [27]. All the three samples showed peaks at around 2960 cm^{-1} indicating a methane C-H stretch. All the three samples showed peaks at wave number around 1250 cm^{-1} indicating methane C-H stretch [28]. These similar analysing was carried out in *Ayurvedic* formulation *nagarmotha churna* on 2019 [29].

FTIR Spectrum of GCC

Fig.3: 1st Batch

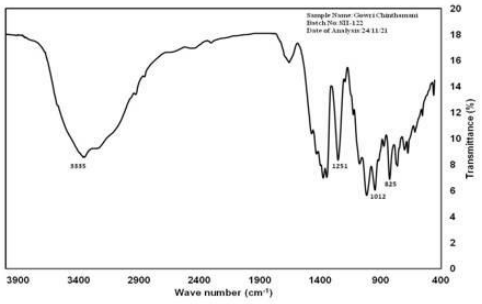


Fig.4: 2nd Batch

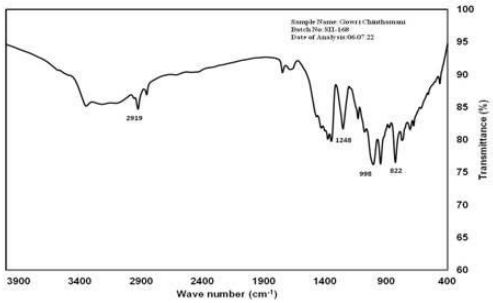
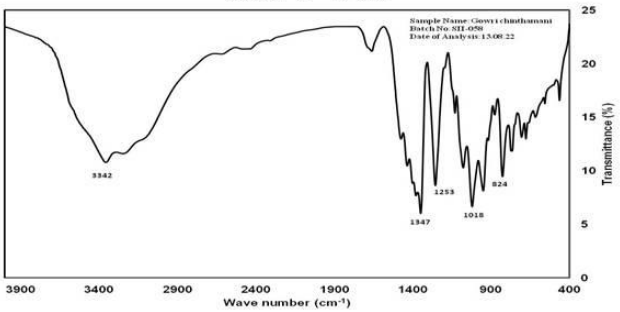


Fig.5: 3rd Batch



Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(4), 1622-1630 | ISSN:2251-6727

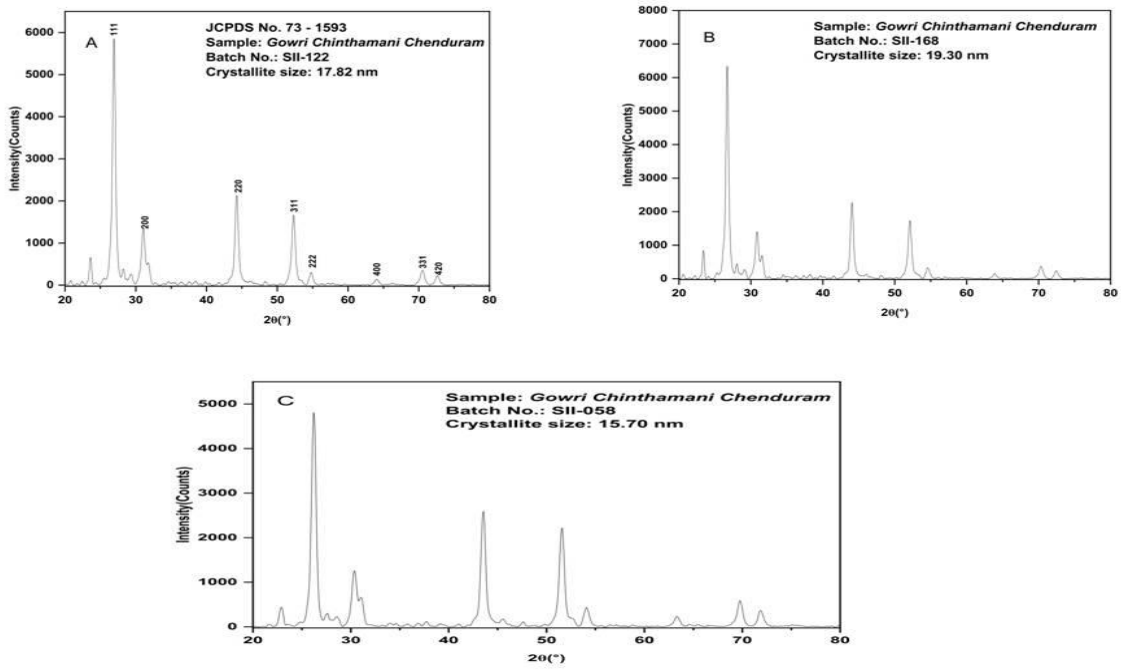
Table.2: FTIR Peaks of GCC (3-Batches)

Batch1	Batch 2	Batch 3
3335cm^{-1}	2919 cm^{-1}	3342 cm^{-1}
1251cm^{-1}	1248 cm^{-1}	1347 cm^{-1}
1012cm^{-1}	998 cm^{-1}	1253 cm^{-1}
825cm^{-1}	822 cm^{-1}	1018 cm^{-1}
		824 cm^{-1}

X- ray diffraction:

The results of powder X-ray diffraction pattern of GCC is shown in Fig.6 which revealed the presence of crystalline shape and can be indexed to the pure cubic phase of Beta-HgS (Mercuric sulphide). The 2θ peaks corresponding to 111, 220, 200, 311, 222, 400, 331 and 420 phases matched with the JCPDS data for Beta-mercuric sulphide (JCPDS 73-1593) [30]. The X-ray diffraction pattern of batch – II and batch – III samples also confirmed the same. The crystalline size of the GCC was present between 15 nm to 19.3 nm. The same like *Unani* mineral medicine *Kushta-e-sadaf* also proven the important of XRD analysis [31].

Fig.6: Powder X–ray diffraction pattern of *GCC* A- 1st Batch, B- 2nd Batch and C- 3rd Batch



SEM analysis:

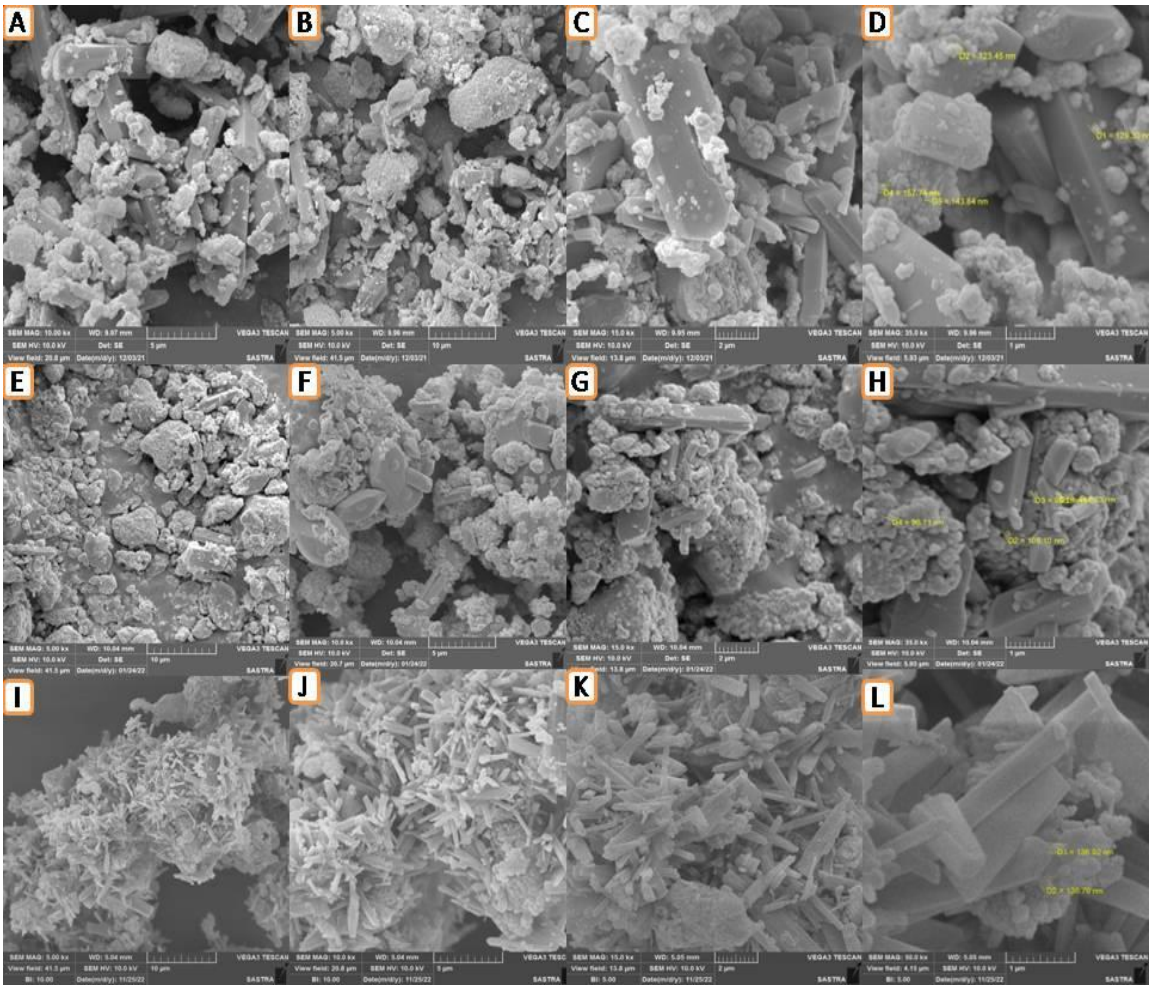
In the present study, the SEM images of the three batches of GCC were obtained (Fig.7). The results concluded the presence of bulky uneven formation of agglomerated clusters of particles. These particles had a nano formation and rod like structure. Three batches of SEM image sizes ranging from 95nm to 140 nm which are expected to improve therapeutic activity. The surface region of GCC was observed to be soft, may be due to the contribution of processes involved in the manufacturing [32]. The first and second batch showed similar shape but the last one had more fibre shaped particles.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(4), 1622-1630 | ISSN:2251-6727

Fig. 7 :SEM Images of GCC from Batch-1 at 5kx(A),10kx (B),15kx(C),35kx(D). Batch-2 at 5kx(A),10kx (B),15kx(C),35kx(D), Batch-3 at 5kx(A),10kx (B),15kx(C),35kx(D)



CONCLUSION

Chenthurams are believed to be nano medicines comprising metal-mineral nano particles. Natural synthesis of metal nano particles have already been proved to have enhanced therapeutic efficacy. In the present paper, raw mercury in GCC was purified using plants such as *Acalypha indica*, *Curcuma longa* and sulphur was purified with *Lawsonia innerme* leaf paste and curd. The nano features of GCC was observed and the surface characteristic features were also recorded. The SEM images obtained showed the samples in all three batches to be in nano size. Besides exploring scientifically the nano-particle nature of *chenthuram* in the present study, attempts were also made to determine the quality control and surface characteristic features. These standards could be useful in determining the quality and purity of preparation. Such standard herbo metallic preparations can contribute the health care of human society even at a very minimal dose.

ACKNOWLEDGEMENT

The writers thankfully acknowledge the financial support provided by the Department of AYUSH (Z.15015/1/2010-COE), India, Drugs and Pharmaceutical Research (VI-D&P/267/08/09/TDT), Department of Science & Technology (DST), India and SASTRA University for this work. We also acknowledge the funding from Nano Mission Council(SR/S5/NM-07/2006 and SR/NM/PG-16/2007), DST, India for SEM and XRD.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(4), 1622-1630 | ISSN:2251-6727

REFERENCES:

1. Sambasivam Pillai TV. Tamil Dictionary Vol.1.Fourth edition. Chennai :Tamilnadu Siddha Medical Council; 1992.
2. Manas Ranjan Sahoo, Ramesh Raghava Varier, Anithakumar Rajendran, Ramesh K., 2023 Standardization and Quality Control Analysis of Marichadi tailam: An Ayurvedic Formulation. Asian Journal of Research in Chemistry. 16(2):133-8.
3. Thyagarajan R. *Gunapadam Thaathu Jeeva Vaguppu*, 4th ed. Chennai: Department of Indian Medicine and Homeopathy; 2004.
4. Anonymous. The *Siddha* Formulary of India, Part I. New Delhi: Ministry of Health and Family Welfare, Government of India; 1992.
5. Pholtan Rajeev SR., 2019. Standardization of "*Chendooram*" Drug in Siddha Medical Systematic Concepts. International Journal of Pharmacy and Drug Research. 8(1): 1-9.
6. Rajalakshmi P, Geethasudeer R, Vadivel V, Sahayam CS and Brindha P., 2017. Anaytical studies on Annabethi Chenthuram, A Siddha Herbo - mineral formulations. Indian J. Pharm. Sci. 79 (6): 987 – 93.
7. Narayanaswami V. Pharmacopoeia of Hospital of Indian Medicine, 2nd edition.Chennai: Tamilnadu Siddha Medical Board; 1995.
8. Ilango B, Vinothkumar K, Rajkumar R, Sugumar E.,2018 Effect of a mercurial drug of Siddha medicine on haematological, biochemical and antioxidant status in rats. Indian Journal of Traditional Knowledge. 17(3):480-84.
9. Kuppusamy Mudaliyar KN, Uthamarayan KS. *Siddha vaithiya thirattu*, 1st edn, 2nd reprint. Chennai: Tamilnadu *Siddha* Medical Council;2009.
10. Velpandian V, Pitchiah Kumar M, Anbu N, Musthafa Md.,Kanakavalli K.,2013. Clinical Evaluation of Siddha Drug Gowri Chinthamani Chendooram in the Management of Osteoarthritis. Int. J. Pharm. Sci. 2013; 2(1):20-32.
11. Anonymous, Formulary of *Siddha* medicines, 17thedn, Adyar, Madras: Indian Medical Practitioners' Cooperative Pharmacy and Stores Ltd; 2018.
12. Shanmugapriya P, Thamodharan S, Ramamurthy M, Mol VCJ, Nijavizhi M.,2014. Toxicological Screening of Gowri Chinthamani Chendooram - A Siddha Metallic Preparation; Pharma Tutor. 2(9): 119-22.
13. Elankani P, Dayanand Reddy G, Ganesan R, Rama Devi B, Narasimha Kumar GV.,2020. Evaluation of chronic toxicity of gowri chinthamani chenduram in wistar albino rats. J.Bio.Innov. 9(4): 557-76.
14. Sukala PM, Muthusamy R, Tamilalagan V, Baskaran S.,2021. Arbind Kumar Choudhary. Journal of Clinical and Diagnostic Research. 15(12): FC01-FC05
15. Sapna Tyagi, Tanveer Alam, Mohd Azhar Khan, Hina Tarannum, Neha Chauhan.,2018. Biosynthesis of Silver Nanoparticles using Medicinal Plant Anacyclus pyrethrum and its Antibacterial Efficacy. Asian J. Research Chem. 11(3):515-520.
16. Sorrnamariyammal I. Boghar elayirathil siddha maruthuva kanimangal. Chennai: Ulaga *Siddha* Arakkattalai: 2016.
17. Anonymous, *Sarakku Suthi Seimuraigal*, 1st Edn. Chennai: Department of Indian System of Medicine and Homeopathy; 2008.
18. Saraswath R, Elavarasi A.,2023. Bio-Chemical Analysis of Pachai Karpoora Mathirai. Asian Journal of Pharmaceutical Analysis. 13(2):140-2.
19. Pharmacopoeial Standards for Ayurvedic Formulations. New Delhi: Central Council for Research in Ayurveda and *Siddha* (India). Ministry of Health and Family Welfare; 1987.
20. Quality control methods for medicinal plant materials, Geneva: World Health Organization; 1988.
21. Joshi S & Aeri V. Practical Pharmacognosy, 1st Edn. New Delhi: Frank Bros & Co. Publishers ; 2009.
22. Bharti Ahirwar.,2012. Evaluation of formulation variables for Ayurvedic formulation vasavaleha. Research J. Science and Tech. 4(6): 295-297.
23. Gayatri S, Monisha S, Mythili K, Chitra K., 2018. Standardization and Quality Control Studies of Agastya Rasayanam–An Ayurvedic Drug for Asthma.Research J. Pharm. and Tech. 11(6): 2271-75.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(4), 1622-1630 | ISSN:2251-6727

24. Sahulhameed R , Velpandian V, Pitchiah Kumar M, Sathya B, Balasubramanian S and Banumathi V., 2015. Physicochemical Characterization and Instrumental Analysis of the Siddha Mineral Drug Naga Parpam. Int. J. of Med. and Phar. Res. 3(1): 897–901.
25. Nandiyanto ABD, Oktiani R, Ragadhita R., 2019. How to Read and Interpret FTIR Spectroscope of Organic Material. Indones. J. Sci. Technol. 4(1):97–118.
26. Rajendra Jangde, Deependra Singh., 2014. Compatibility Studies of Quercetin with Pharmaceutical Excipients Used in the Development of Novel Formulation. Research J. Pharm. and Tech. 7(10): 1101-1105.
27. Mazen Bahadi, Ashraf A. Ismail and Elsa Vasseur., 2021. Fourier Transform Infrared Spectroscopy as a Tool to Study Milk Composition Changes in Dairy Cows Attributed to Housing Modifications to Improve Animal Welfare. Foods. 10(2):1-17.
28. Zulkifli F, Nora'aini Ali, M Sukeri M Yusof, Wan M. Khairul, Rafizah Rahamathullah, Isa MIN and Wan Nik WB.,2017. The Effect of Concentration of Lawsonia inermis as a Corrosion Inhibitor for Aluminum Alloy in Seawater. Advances in Physical Chemistry. 8521623:1-12.
29. Subham Kansabanik, Sangeeta Mukhi, Chandan Das, Debajyoti Das, Anindya Bose.,2019. Establishment of Quality Control Parameters of Nagarmotha Churna. Research J. Pharm. and Tech. 12(12): 5967-5971.
30. Govindaraj M, Arivanandhan M & Vedhi C., 2015. Chemical Vapor Deposition of β-HgS Nanoparticles. From a Precursor, bis (cinnamylpiperazinedithiocarbamato) Mercury(II), Synthesis and Reactivity in Inorganic, Metal-Organic,and Nano-Metal Chemistry. 45(2) 217-24.
31. Nitin Dubey, Nidhi Dubey, RS Mehta, AK Saluja, DK Jain., 2008. Preparation and Physico-chemical Characterization of Kushta-e-sadaf, A Traditional Unani Formulation. Research J. Pharm. and Tech. 1(3): 182-186.
32. Rukmini RK, Sridurga CH, Venkata Subbaiah K.,2018. Analytical study of tamra bhasma. Int. J. Ayurvedic. med. 6(9):1931-41.