

Estimation of Curcumin from Medicinal Sample Curcumin Gold 95 its SEM and FTIR Analysis

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Abstract

Turmeric is a flowering plant, *Curcuma longa*, of the ginger family, Zingiberaceae, the rhizomes of which are used in cooking. The golden yellow color of turmeric is due to curcumin. Some 34 essential oils are present in turmeric, among which turmerone, germacrone, atlantone, and zingiberene are major constituents. Curcumin is a bright yellow chemical produced by plants of the *Curcuma longa* species. It is the principal curcuminoid of turmeric (*Curcuma longa*), a member of the ginger family, Zingiberaceae. It is sold as a herbal supplement, cosmetics ingredient, food flavoring, and food coloring. Chemically, curcumin is a diarylheptanoid, belonging to the group of curcuminoids, which are phenolic pigments responsible for the yellow color of turmeric. Patanjali Ayurveda Curcumin Gold 95 Immunity Booster Tablet helps in boosting the immune system after chronic diseases and reduces debility. It helps relieve stress and fatigue, offers alleviation from stress and anxiety, works to provide relief in the case of itchy and watery eyes. It is an ayurvedic formulation made using traditional techniques to improve stamina, vitality and boost immunity. It also wards off digestive and cardiac issues. It helps lower cholesterol levels, henceforward maintaining healthy heart functioning and restoring natural respiratory functions. These tablets help our body fight various bacterial infections and recurring diseases. Present Paper deals with Estimation of Curcumin from medicinal sample Curcumin Gold 95, SEM Analysis of Curcumin Gold 95, FTIR Analysis of Curcumin and FTIR Analysis of Curcumin Gold 95. This research, along with better regulation and reporting, will enable consumers to choose products with confidence. This in turn will allow companies to benefit from these novel technologies in the long term while retaining customer confidence.

Keywords: Turmeric, Curcumin, Curcumin Gold 95, SEM Analysis, FTIR Analysis

1. Introduction

Turmeric

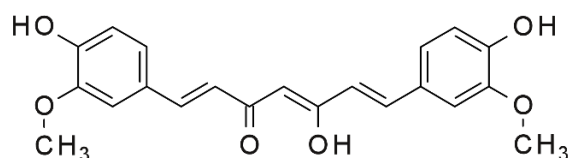
Turmeric is a flowering plant, *Curcuma longa*, of the ginger family, Zingiberaceae, the rhizomes of which are used in cooking. The plant is a perennial, rhizomatous, herbaceous plant native to the Indian subcontinent and Southeast Asia. Curcumin, a bright yellow chemical produced by the turmeric plant, is approved as a food additive by the World Health Organization, European Parliament, and United States Food and Drug Administration. Turmeric powder is about 60–70% carbohydrates, 6–13% water, 6–8% protein, 5–10% fat, 3–7% dietary minerals, 3–7% essential oils, 2–7% dietary fiber, and 1–6% curcuminoids. The golden yellow color of turmeric is due to curcumin. Phytochemical components of turmeric include diarylheptanoids, a class including numerous curcuminoids, such as curcumin, demethoxycurcumin, and bisdemethoxycurcumin. [1, 2] Curcumin constitutes up to 3.14% of assayed commercial samples of turmeric powder (the average was 1.51%); curry powder contains much less (an average of 0.29%).[3] Some 34 essential oils are present in turmeric, among which turmerone, germacrone, atlantone, and zingiberene are major constituents.[4-6].

Curcumin

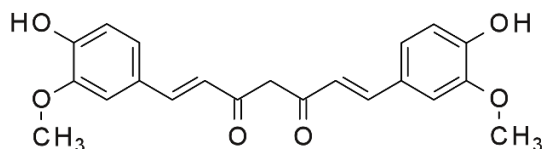
Curcumin is a bright yellow chemical produced by plants of the *Curcuma longa* species. It is the principal curcuminoid of turmeric (*Curcuma longa*), a member of the ginger family, Zingiberaceae. It is sold as a herbal supplement, cosmetics ingredient, food flavoring, and food coloring. Chemically, curcumin is a diarylheptanoid, belonging to the group of curcuminoids, which are phenolic pigments responsible for the yellow color of turmeric. Curcumin incorporates a seven carbon linker and three major functional groups: an α,β -unsaturated β -diketone moiety and an aromatic O-methoxy-phenolic group. The aromatic ring systems, which are phenols, are connected by two α,β -unsaturated carbonyl groups. It is a diketone tautomer, existing in enolic form in organic solvents and in keto form in water. The diketones form stable enols and are readily deprotonated to form enolates; the α,β -unsaturated carbonyl group is a good Michael acceptor and undergoes nucleophilic addition. Because of its hydrophobic nature, curcumin is poorly soluble in water. However, it is easily soluble in organic solvents. Curcumin is used as a complexometric indicator for boron. It reacts with boric acid to form a red-colored compound, rosocyanine. [8-13]



Botanical view of *Curcuma longa* [7]



Curcumin Enol form



Curcumin Keto form

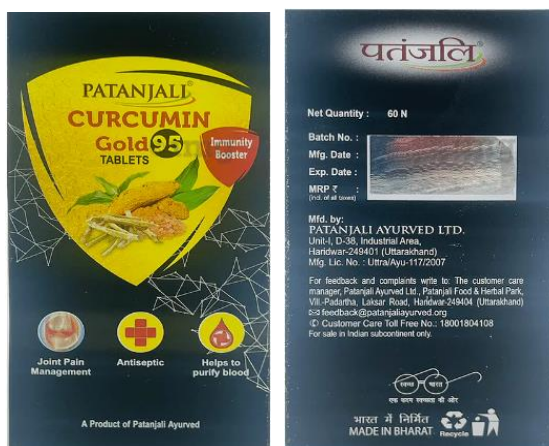
Patanjali Ayurveda Curcumin Gold 95 Immunity Booster Tablet

Patanjali Ayurveda Curcumin Gold 95 Immunity Booster Tablet helps in boosting the immune system after chronic diseases and reduces debility. It helps relieve stress and fatigue, offers alleviation from stress and anxiety, works to provide relief in the case of itchy and watery eyes. It is an ayurvedic formulation made using traditional techniques to improve stamina, vitality and boost immunity. It also wards off digestive and cardiac issues.

(Withania somnifera, Root) 50 mg, Excipients Q.S. Its Key Benefits are as follows.

- It restores energy level to improve physical endurance
- It enhances digestion and manages weight
- Facilitates comfort in the conditions of sneezing, runny nose, itchy nose and throat, watery and itchy eyes
- It also offers relief from loss of appetite and excessive thirst [14].

Present Paper deals with Estimation of Curcumin from medicinal sample Curcumin Gold 95, SEM Analysis of Curcumin Gold 95, FTIR Analysis of Curcumin and FTIR Analysis of Curcumin Gold 95. This research, along with better regulation and reporting, will enable consumers to choose products with confidence. This in turn will allow companies to benefit from these novel technologies in the long term while retaining customer confidence.



It helps lower cholesterol levels, henceforward maintaining healthy heart functioning and restoring natural respiratory functions. These tablets help our body fight various bacterial infections and recurring diseases. Its Key Ingredients are Turmeric extract (*Curcuma longa*, Rhizome) 320 mg, Sudh Salai guggul (*Boswellia serrata*, Resin) 130 mg, Ashwagandha Extract

2. Methodology

1. Estimation of Curcumin from medicinal sample Curcumin Gold 95

Preparation of standard solution of Curcumin

0.1 g of turmeric powder and 30 ml of methanol was taken in 100ml of volumetric flask after dissolving it volume was made with distilled water upto 100 ml.

Preparation of Curcumin Gold 95 solution

0.232 g of crushed tablet powder and 30 ml of methanol was taken in 100ml of volumetric flask after dissolving it volume was made with distilled water upto 100 ml.

Preparation of standard system of Cucumin

System No.	1	2	3	4	5	6	Unit
Curcumin Standard Solution	0.1	0.2	0.3	0.4	0.5	0.6	ml
D. H2O	9.9	9.8	9.7	9.6	9.5	9.4	ml

Preparation of system of Curcumin Gold 95 solution

System No.	7	8	9	10	11	12	Unit
Curcumin Gold 95 Solution	0.1	0.2	0.3	0.4	0.5	0.6	ml
D. H2O	9.9	9.8	9.7	9.6	9.5	9.4	ml

Absorbance of system No. 1 was taken at different wave length and λ_{\max} was found which was 420 nm and then Absorbance of system No. 1 to 12 was taken at 420 nm. Calibration graph was plotted between Concentration of Curcumin and Absorbance and from this concentration of Curcumin in Curcumin Gold 95 was calculated.

2. SEM Analysis of Curcumin Gold 95

The Electron Microscope is an essential component for scientific analysis of a variety of materials. Scanning Electron Microscope (SEM) comprises a powerful tool in studying (cell and molecular biology, anatomy, microbiology, pathology and forensic science) biological specimens, food stuffs and several other areas of material sciences (electronics, metallurgy, polymer and surface science).

Morphological graphs of the Curcumin Gold 95 Tablet samples is provided by scanning electron microscopy (Digital Scanning Electron Microscope - JSM 6100 - JEOL) with a link analytical system operating at 15 KV (Acceleration voltage)

Scanning Electron Microscope (SEM) - Digital Scanning Electron Microscope - JSM 6100 (JEOL) SEM facilitates the observation of very fine details (high resolution) of biological materials and good focus over a wide range of specimen surface (large depth of field). It also produces clear image of specimen ranging from object

visible to the naked eye to a structure spanning few nanometers. Besides its use in studying soils, sedimentary particles and rock materials, it also helps to elucidate the architecture and evolution of microfossils. Digital Scanning Electron Microscope - JSM 6100 (JEOL) is used with a digital image processor. It has a large specimen chamber that allows observation of the entire surface of a specimen upto 150 mm and a tilt of -5 to 90o. A special feature of this SEM is a cryostage attached to it to study the low melting point specimens.

The image processing function permits image averaging and storage, filling of acquired still images and comparison of two/four images displayed simultaneously on the 12 inch CRT. This function makes it possible to observe specimens without causing damage to them.

Other features of this microscope are:

- Resolution: 4.0 nm at 8mm working distance
- Working distance: 6 to 48 mm
- Accelerating Voltage: 0.3 to 30 KV
- Magnification: x 10 to x 300,000
- Image Recording: on 120 B&W Roll Film (100 ASA) or 35mm B &W roll (25 ASA)
- Instant Print: an instant print is also possible on a Thermal Video Printer (8x10.5).

3. FTIR Analysis of Curcumin

FTIR can be routinely used to identify the functional groups and identification/quality control of raw material/finished products. Spectrum RX-I offers fast throughput and rapid access to reliable and dependable IR results. High signal to noise ratio makes FTIR more useful for difficult samples. It has resolution of 1 cm⁻¹ and scan range of 4000 cm⁻¹ to 250 cm⁻¹. In the normal mode around 10 mg sample is required in the form of fine powder. The sample can be analyzed in the form of liquid, solid and thin films also.

FTIR spectra of Curcumin is obtained at room temperature by using an FTIR Spectrophotometer - Perkin Elmer - Spectrum RX-IFTIR. The spectra is collected in a range from 462.92 to 3984.93 cm⁻¹

4. FTIR Analysis of Curcumin Gold 95

FTIR spectra of Curcumin Gold 95 is obtained at room temperature by using an FTIR Spectrophotometer - Perkin Elmer - Spectrum RX-IFTIR. The spectra is collected in a range from 650 to 4000 cm⁻¹

3. Observation

1. Estimation of Curcumin from medicinal sample Curcumin Gold 95

Absorbance of System No. 1 at different wavelength

Wave length, nm	Absorbance
400	0.07
420	0.08
470	0.07
500	0.06
530	0.06
620	0.05
660	0.04
700	0.04

Absorbance at λ_{\max} 420 nm

System No	Absorbance
1	0.03
2	0.06
3	0.09
4	0.12
5	0.14
6	0.17
7	0.10
8	0.09
9	0.12
10	0.16
11	0.17
12	0.24

2. SEM Analysis of Curcumin Gold 95

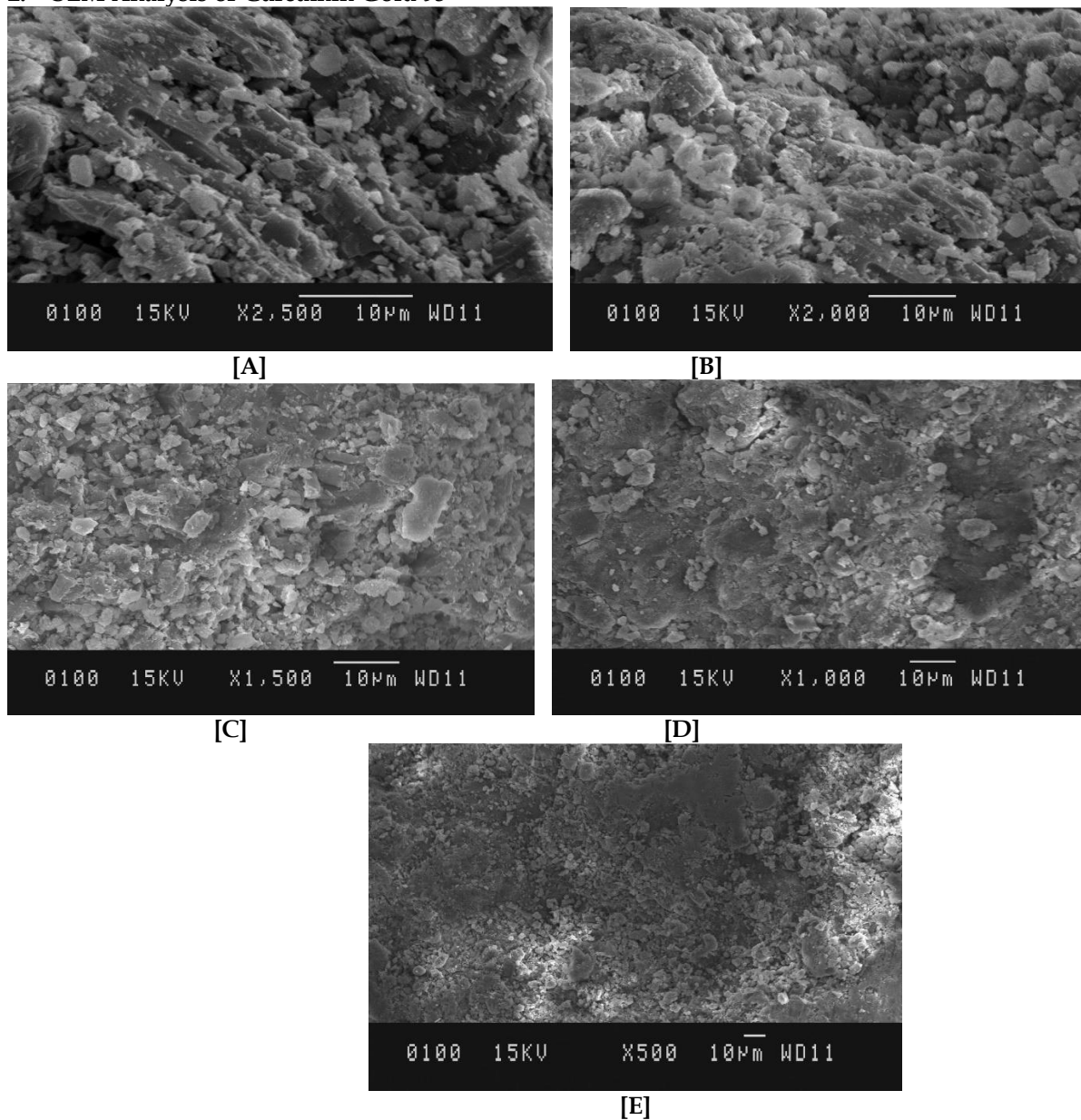


Figure 5. [A] – [E] . Scanning Electron Microscope images of Curcumin Gold 95 Tablet

Scanning Electron Microscope image of Curcumin Gold 95 Tablet shows that the material mainly consisted of round and elongated shape with 1-3µm size chips and has a smaller aggregated particle.

3. FTIR Analysis of Curcumin

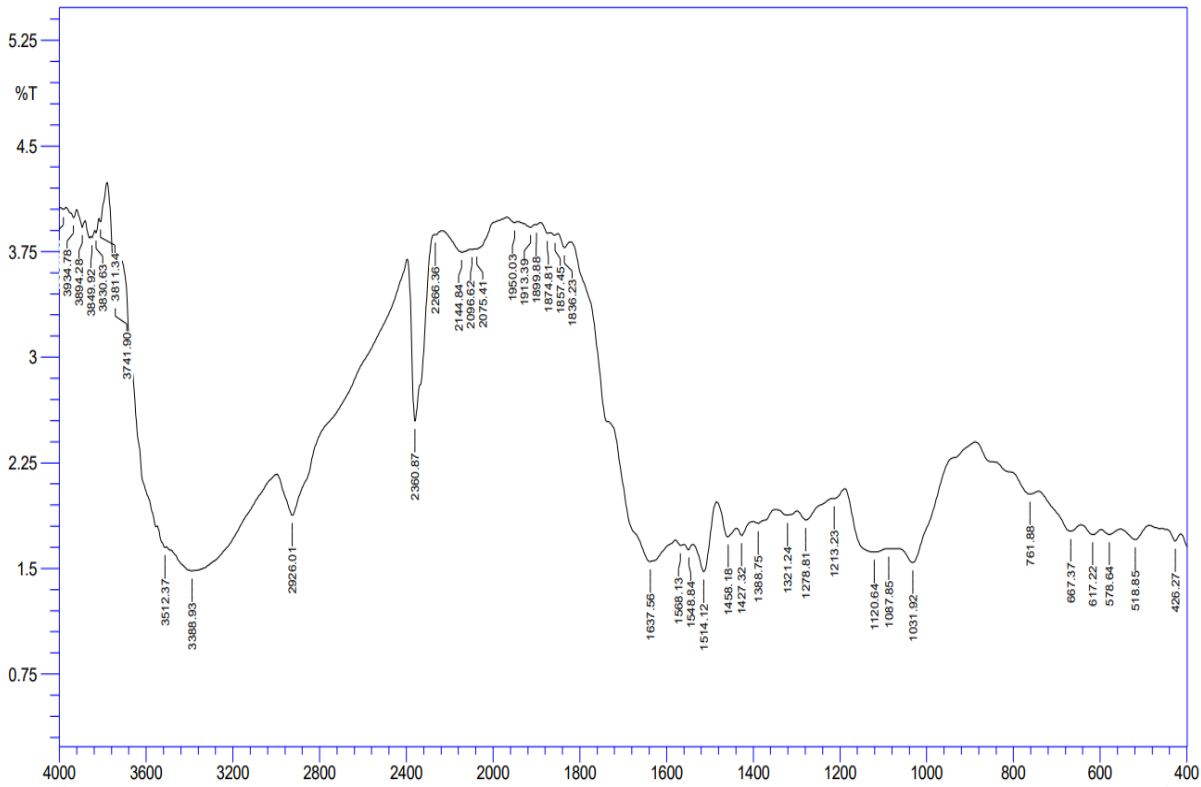


Figure 6. FTIR Spectra of Curcumin

4. FTIR Analysis of Curcumin Gold 95

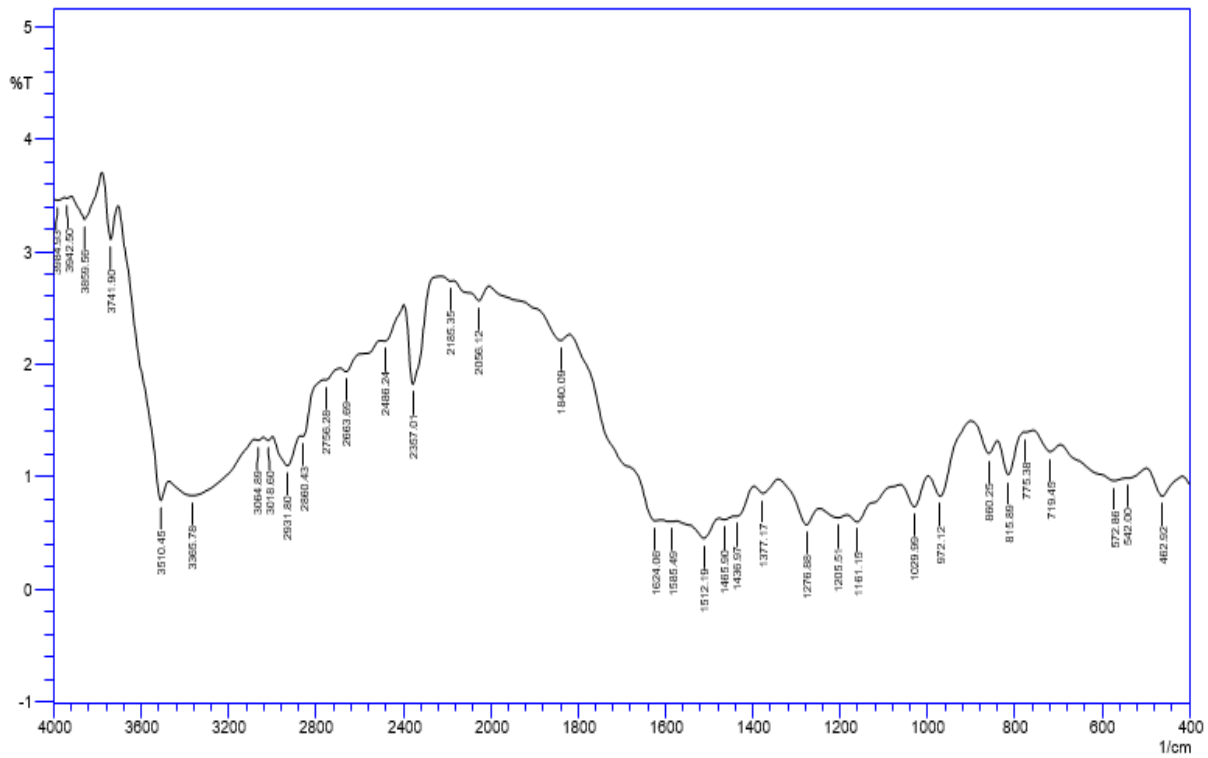
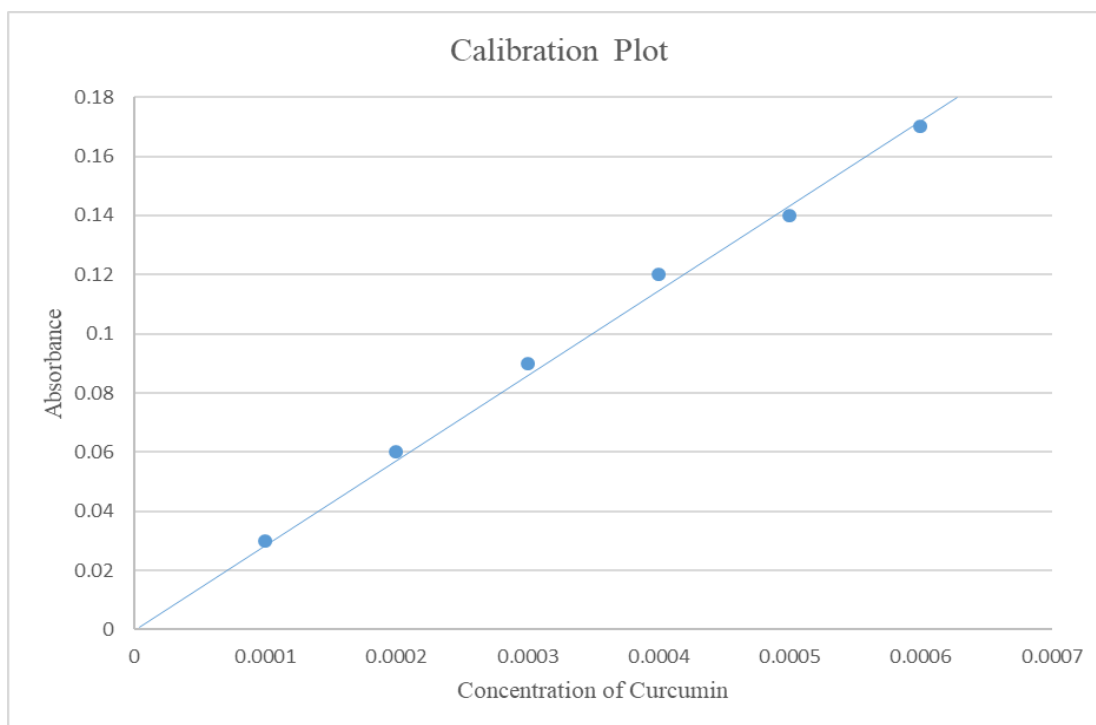


Figure 7. FTIR Spectra of Curcumin Gold 95

4. Results and Discussions

1. Estimation of Curcumin from medicinal sample Curcumin Gold 95

System No	Curcumin Solution taken	Concentration of Curcumin, g	Absorbance
1	0.1ml	$0.1 \times 0.1 / 100 = 1 \times 10^{-4}$	0.03
2	0.2ml	$0.2 \times 0.1 / 100 = 2 \times 10^{-4}$	0.06
3	0.3ml	$0.3 \times 0.1 / 100 = 3 \times 10^{-4}$	0.09
4	0.4ml	$0.4 \times 0.1 / 100 = 4 \times 10^{-4}$	0.12
5	0.5ml	$0.5 \times 0.1 / 100 = 5 \times 10^{-4}$	0.14
6	0.6ml	$0.6 \times 0.1 / 100 = 6 \times 10^{-4}$	0.17



System No.	Concentration From Calibration plot g	Vol. of Curcumin Gold 95 sample taken ml	Concentration of Curcumin in 100 ml solution g	Average Concentration of Curcumin in 100 ml solution G
7	3.35×10^{-4}	0.1	$100 \times 3.35 \times 10^{-4} / 0.1 = 0.335$	$(0.1500 + 0.1333 + 0.1337 + 0.1130 + 0.1333) / 5 = 0.1327$
8	3.00×10^{-4}	0.2	$100 \times 3 \times 10^{-4} / 0.2 = 0.1500$	
9	4.00×10^{-4}	0.3	$100 \times 4 \times 10^{-4} / 0.3 = 0.1333$	
10	5.35×10^{-4}	0.4	$100 \times 5.35 \times 10^{-4} / 0.4 = 0.1337$	
11	5.65×10^{-4}	0.5	$100 \times 5.65 \times 10^{-4} / 0.5 = 0.1130$	
12	8.00×10^{-4}	0.6	$100 \times 8 \times 10^{-4} / 0.6 = 0.1333$	

Weight of Curcumin Gold 95 Tablet is = 0.560 g.

Theoretical value of Curcumin in 0.232 g Curcumin Gold 95 Tablet is found to be 0.1327 g.

Hence 0.560 g Curcumin Gold 95 Tablet 1 Tablet will contain 0.320 g Curcumin.

Quoted Value of Curcumin per Cucumin Gold 95 Tablet was 0.320 g.

Hence Theoretical value and Quoted Value of Curcumin per Cucumin Gold 95 Tablet is in good agreement with each other which is 0.320 g.

2. SEM Analysis of Curcumin Gold 95

Scanning Electron Microscope image of Curcumin Gold 95 Tablet shows that the material mainly consisted of round and elongated shape with 1-3 μ m size chips and has a smaller aggregated particle.

3. FTIR Analysis of Curcumin

Interpretation of IR spectra of Curcumin is done as follows

S.N.	Spectral region wave no cm^{-1}	Bond Causing Absorption	Compound Class	Pattern and Intensity of Band
1	3984.93	-	-	Broad and Low Intensity
2	3942.50	-	-	Broad and Low Intensity
3	3859.56	-	-	Sharp and Low Intensity
4	3741.90	-	-	Sharp and Low Intensity
5	3510.45	O-H Streaching	Alcohol	Sharp and Strong Intensity
6	3365.78	N-H Streaching	Aliphatic Primary Amine	Broad and Moderate Intensity
7	3064.89	O-H Streaching	Alcohol	Broad and Low Intensity
8	3018.60	O-H Streaching	Alcohol	Broad and Low Intensity
9	2931.80	C-H Streaching	Alkane	Sharp and Moderate Intensity
10	2860.43	C-H Streaching	Alkane	Broad and Moderate Intensity
11	2756.28	C-H Streaching	Aldehyde	Broad and Moderate Intensity
12	2663.69	C-H Streaching	Aldehyde	Broad and Moderate Intensity
13	2486.24	-	-	Broad and Moderate Intensity
14	2357.01	O=C=O	Carbon dioxide	Sharp and Strong Intensity
15	2185.35	-	-	Broad and Low Intensity
16	2056.12	-	-	Broad and Low Intensity
17	1840.09	C-H Bending	Aromatic Compound	Broad and Low Intensity
18	1624.06	C=C Stretching N-H Bending C=C Stretching	Conjugated Alkene Amine Cyclic alkene	Broad and Moderate Intensity
19	1585.49	C=C Stretching N-H Bending	Cyclic alkene Amine	Broad and Moderate Intensity
20	1512.19	-	-	Broad and Moderate Intensity
21	1465.90	-	-	Broad and Low Intensity
22	1436.97	-	-	Broad and Low Intensity
23	1377.17	-	-	Broad and Low Intensity

24	1276.88	-	-	Broad and Low Intensity
25	1205.51	-	-	Broad and Low Intensity
26	1161.15	-	-	Broad and Low Intensity
27	1029.99	-	-	Broad and Moderate Intensity
28	972.12	-	-	Broad and Moderate Intensity
29	867.25	-	-	Broad and Moderate Intensity
30	815.89	C=C Bending	Alkene	Sharp and Moderate Intensity
31	775.38	-	-	Broad and Low Intensity
32	719.45	-	-	Broad and Low Intensity
33	572.86	-	-	Broad and Low Intensity
34	542.00	-	-	Broad and Low Intensity
35	462.92	-	-	Sharp and Moderate Intensity

Interpretation of FTIR Spectra of Curcumin shows presence of various functional Group such as C-H Stretching - Alkane, C-H Stretching - Aldehyde, C-H Bending - Aromatic Compound, C=C Stretching - Cyclic alkene, C=C Bending - Alkene, C=C Stretching - Conjugated Alkene, O=C=O - Carbon dioxide, O-H Stretching - Alcohol, N-H Stretching - Aliphatic Primary Amine, N-H Bending - Amine

4. FTIR Analysis of Curcumin Gold 95

Interpretation of IR spectra of Curcumin Gold 95 is done as follows

S.N.	Spectral region wave no cm^{-1}	Bond Causing Absorption	Compound Class	Pattern and Intensity of Band
1	3934.78	-	-	Broad and Low Intensity
2	3894.28	-	-	Broad and Low Intensity
3	3849.92	-	-	Broad and Low Intensity
4	3830.63	-	-	Broad and Low Intensity
5	3811.34	-	-	Broad and Low Intensity
6	3741.90	-	-	Broad and Low Intensity
7	3512.37	O-H Stretching	Alcohol	Broad and Strong Intensity
8	3388.93	O-H Stretching	Alcohol	Broad and Strong Intensity
9	2926.01	C-H Stretching	Alkane	Sharp and Moderate Intensity
10	2360.87	O=C=O Stretching	Carbon dioxide	Sharp and Strong Intensity
11	2266.87	C≡N Stretching C≡C Stretching	Nitrile Alkyne	Broad and Low Intensity
12	2144.84	C≡C Stretching	Alkyne	Broad and Low Intensity
13	2096.62	-	-	Broad and Low Intensity
14	2075.41	-	-	Broad and Low Intensity
15	1950.03	C-H Bending	Aromatic Compound	Broad and Low Intensity

16	1913.39	C-H Bending	Aromatic Compound	Broad and Low Intensity
17	1899.88	C-H Bending	Aromatic Compound	Broad and Low Intensity
18	1874.81	C-H Bending	Aromatic Compound	Broad and Low Intensity
19	1857.45	C-H Bending	Aromatic Compound	Broad and Low Intensity
20	1836.23	C-H Bending	Aromatic Compound	Broad and Low Intensity
21	1637.56	C=C Stretching	Alkene	Broad and Strong Intensity
22	1568.13	-	-	Broad and Low Intensity
23	1548.84	-	-	Broad and Low Intensity
24	1514.12	N-O Stretching	Nitro Compound	Broad and Strong Intensity
25	1458.18	-	-	Broad and Low Intensity
26	1427.32	-	-	Broad and Low Intensity
27	1388.75	-	-	Broad and Low Intensity
28	1321.24	-	-	Broad and Low Intensity
29	1278.81	-	-	Broad and Low Intensity
30	1213.23	-	-	Broad and Low Intensity
31	1120.64	C-O Stretching	Secondary Alcohol	Broad and Strong Intensity
32	1087.85	C-O Stretching	Secondary Alcohol	Broad and Strong Intensity
33	1031.92	S=O Stretching	Sulfoxide	Sharp and Strong Intensity
34	761.88	-	-	Broad and Low Intensity
35	667.37	-	-	Broad and Low Intensity
36	617.22	-	-	Broad and Low Intensity
37	578.64	-	-	Broad and Low Intensity
38	518.85	-	-	Broad and Low Intensity
39	426.27	-	-	Broad and Low Intensity

Interpretation of FTIR Spectra of Curcumin Gold 95 shows presence of various functional Group such as C-H Stretching -Alkane, C-H Bending - Aromatic Compound, O-H Stretching - Alcohol, C-O Stretching - Secondary Alcohol, N-O Stretching - Nitro Compound, C=C Stretching - Alkene, O=C=O Stretching - Carbon dioxide, S=O Stretching - Sulfoxide, C≡N Stretching - Nitrile, C≡C Stretching - Alkyne

5. Conclusion

1. Estimation of Curcumin from medicinal sample Curcumin Gold 95

Theoretical value and Quoted Value of Curcumin per Patanjali Ayurveda Curcumin Gold 95 Immunity Booster Tablet an ayurvedic formulation made using

traditional techniques to improve stamina, vitality and boost immunity is in good agreement with each other which is 0.320 g.

2. SEM Analysis of Curcumin Gold 95

Scanning Electron Microscope image of Curcumin Gold 95 Tablet shows that the material mainly consisted of

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3. FTIR Analysis of Curcumin

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Conflicts of interest: The author stated that no conflicts of interest.

6. References

1. Curcumin". PubChem, US National Library of Medicine. 21 November 2020. Retrieved 25 November 2020.
2. Nelson, KM; Dahlin, JL; Bisson, J; et al. (2017). "The Essential Medicinal Chemistry of Curcumin: Miniperspective". *Journal of Medicinal Chemistry*. 60 (5): 1620-1637. doi:10.1021/acs.jmedchem.6b00975. PMC 5346970. PMID 28074653.
3. Tayyem RF, Heath DD, Al-Delaimy WK, Rock CL (2006). "Curcumin content of turmeric and curry powders". *Nutr Cancer*. 55 (2): 126-131. doi:10.1207/s15327914nc5502_2. PMID 17044766. S2CID 12581076.
4. Hong, SL; Lee, G. S; Syed Abdul Rahman, SN; et al. (2014). "Essential Oil Content of the Rhizome of *Curcuma purpurascens* Bl. (Temu Tis) and Its Antiproliferative Effect on Selected Human Carcinoma Cell Lines". *The Scientific World Journal*. 2014: 1-7. doi:10.1155/2014/397430. PMC 4142718. PMID 25177723.
5. Hu, Y; Kong, W; Yang, X; et al. (2014). "GC-MS combined with chemometric techniques for the quality control and original discrimination of *Curcuma longae* rhizome: Analysis of essential oils". *Journal of Separation Science*. 37 (4): 404-11. doi:10.1002/jssc.201301102. PMID 24311554.
6. Braga, ME; Leal, PF; Carvalho, JE; Meireles, MA (2003). "Comparison of yield, composition, and antioxidant activity of turmeric (*Curcuma longa* L.) extracts obtained using various techniques". *Journal of Agricultural and Food Chemistry*. 51 (22): 6604-11. doi:10.1021/jf0345550. PMID 14558784.
7. https://en.wikipedia.org/wiki/Turmeric#/media/File:Curcuma_longa_-_K%C3%B6hler%E2%80%9393s_Medizinal-Pflanzen-199.jpg
8. Majeed S (28 December 2015). "The State of the Curcumin Market". *Natural Products Insider*.
9. CID 969516 from PubChem
10. Farooqui, Tahira; Farooqui, Akhlaq A. (2019). "Curcumin: Historical Background, Chemistry, Pharmacological Action, and Potential Therapeutic Value". *Curcumin for Neurological and Psychiatric Disorders*. pp. 23-44. doi:10.1016/B978-0-12-815461-8.00002-5. ISBN 978-0-12-815461-8. S2CID 146070671.
11. Miłobędzka J, van Kostanecki S, Lampe V (1910). "Zur Kenntnis des Curcumins" [Knowing about curcumin]. *Berichte der Deutschen Chemischen Gesellschaft (in German)*. 43 (2): 2163-2170. doi:10.1002/cber.191004302168.
12. Manolova Y, Deneva V, Antonov L, Drakalska E, Momekova D, Lambov N (November 2014). "The effect of the water on the curcumin tautomerism: a quantitative approach" (PDF). *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*. 132: 815-20. Bibcode:2014AcSpA.132..815M. doi:10.1016/j.saa.2014.05.096. PMID 24973669.
13. EPA Method 212.3: Boron (Colorimetric, Curcumin)" (PDF).
14. <https://www.1mg.com/otc/patanjali-ayurveda-curcumin-gold-95-immunity-booster-tablet-otc683071>