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Physicochemical and Thermal Characterization of Ascorbic Acid: Impact of Biofield Energy Treatment

Gopal Nayak[1], Mahendra Kumar Trivedi[1], Alice Branton[1], Dahryn Trivedi[1], Snehasis Jana[2*]

[1]Trivedi Global, Inc., Henderson, USA

[2]Trivedi Science Research Laboratory Pvt. Ltd., Bhopal, India

[*]**Corresponding author:** Snehasis Jana, Trivedi Science Research Laboratory Pvt. Ltd., Bhopal, India. Tel: +91-022-25811234; Email: publication@trivedieffect.com

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Abstract

Ascorbic acid (vitamin C) acts as an antioxidant and plays a vital role in maintaining good health. The study was designed with the aim to determine the influence of the Trivedi Effect® on the various properties of ascorbic acid by using the modern analytical techniques. The study sample was divided into two parts. The first part was considered as control (no treatment), while the second part was termed as the Biofield Energy Treated sample and it was treated with the Trivedi Effect®-Consciousness Energy Healing Treatment by a renowned Biofield Energy Healer, Gopal Nayak. The PXRD peak intensities and the crystallite sizes were significantly altered ranging from -67.75% to 1059.21% and -29.41% to 271.10% respectively, whereas the average crystallite size was significantly increased by 50.67% in the treated sample compared to the control sample. The particle size analysis of the treated ascorbic acid was reduced by 8.23% (d_{10}), 22.07% (d_{50}), 11.64% (d_{90}), and 15.81% {D(4,3)} and the surface area was increased by 15.38% as compared to the untreated sample. The weight loss was 20.57%; however, the residue amount was significantly increased by 573.99% in the treated sample compared to the control sample. The maximum thermal degradation temperatures were increased by 0.58% and 4.93%, respectively, of the treated sample compared to the control sample. The decomposition temperature was decreased by 4.17%; however, the ΔH_{fusion} and $\Delta H_{decomposition}$ were increased by 9.13% and 110.60%, respectively of the treated sample compared to the control sample. The Consciousness Energy Healing Treatment showed the possible formation of a new polymorph of ascorbic acid that may show better solubility, dissolution, and bioavailability, as well as more thermally stable compared to the control sample. Hence, it might be advantageous to use the Biofield Energy Treated ascorbic acid in various nutraceutical/pharmaceutical formulations to improve their efficacy.

Keywords: Ascorbic acid, Consciousness Energy Healing Treatment, The Trivedi Effect®, Complementary and Alternative Medicine, PXRD, Particle size, TGA/DTG

Introduction

Ascorbic acid, also known as vitamin C, is a type of water-soluble vitamin that acts as an antioxidant [1]. It is present in the form of a white or slightly yellow powder having slightly acidic in taste [2]. It is an antiscorbutic compound that plays various important roles in the body. Vitamin C is used in the body for healthy skin, teeth, cartilage, bone, and blood vessels. Moreover, it also protects the cells of the body from damage. The supplements of Vitamin C are used in the treatment of burns, ulcers, and other injuries as it stimulates the collagen formation [3]. The use of vitamin C is also evident in the treatment of prostate, pancreas, liver, and ovarian cancers as adjuvant where it might act by slowing the growth and proliferation of cancer cells [4,5]. Besides, it reduces the symptoms of nausea, vomiting, pain, tiredness, and anorexia as well as, elevates the mood and improves the physical health. Some studies reported the use of vitamin C supplement in the reduction of cardiovascular risk and heart attack [3]. The other benefits of the use of vitamin C are in the treatment of hypercholesterolemia, hypertension, diabetes mellitus, angina pectoris, coronary heart disease, and congestive cardiac failure. Use of vitamin C as the adjuvant therapy also improves the blood flow by vasodilation to various vital organs [6]. Also, it acts in enhancing the immune functions by improving the cellular motility, resistance to oxidative

damage, phagocytosis, and interferon release [7].

In humans, the ascorbic acid acts in the body by reversibly oxidized to dehydroascorbic acid and these two forms play a vital role in the oxidation-reduction reactions [8]. The ascorbic acid is also important for tyrosine metabolism, carbohydrate metabolism, conversion of folic acid to Folinic acid, iron metabolism, and synthesis of proteins and lipids [3]. The deficiency of vitamin C causes scurvy. Moreover, the deficiency also affects the collagenous structures and some lesions started developing in the blood vessels and bones. The other symptoms involve the impaired development of bone and tooth, bleeding gums, gingivitis, and loosened teeth [9]. The supplementation of vitamin C is also needed in some health conditions such as the chronic illness, febrile states, and infection related to pneumonia, tuberculosis, whooping cough, diphtheria, rheumatic fever, hemovascular disorders, sinusitis, delayed fracture and wound healing, burns, etc. [10,11]. The ADME profile of Vitamin C such as its absorption, dissolution, tissue distribution, and other pharmacokinetic properties, etc. depends upon it's physiochemical properties [8]. Hence, the researchers are using various approaches for improving the physiochemical properties of compounds to achieve the maximum biological activity and efficacy. One among such approaches is the use of Biofield Energy Treatment for altering the properties of various compounds. Putative energy fields (also known as Biofield) are based on the concept that human beings are infused with a subtle form of energy [12]. Therefore, a human has the ability to harness energy from the universe and it could be transmitted to any living organism(s) or non-living object(s) around the globe. Biofield Energy Healing has been used in the treatment against various diseases and it is also considered and accepted as Energy therapy by the National Center for Complementary and Alternative Medicine (NCCAM) [13]. The other similar Energy therapies recommended by NCCAM under the Complementary and Alternative Medicine (CAM) are deep breathing, Tai Chi, yoga, Qi Gong, meditation, chiropractic/osteopathic manipulation, massage, special diets, progressive relaxation, homeopathy, guided imagery, acupressure, acupuncture, hypnotherapy, relaxation techniques, healing touch, movement therapy, pilates, Ayurvedic medicine, naturopathy, traditional Chinese herbs and medicines, etc. [14,15]. The Trivedi Effect®-Consciousness Energy Healing Treatment is a type of such CAM therapies that have been known worldwide for its impact on the non-living materials and living organisms. It is reported for its significant impact on the physicochemical and thermal properties of various organic, pharmaceutical, and nutraceutical compounds [16-19], changing the characteristics in the field of microbiology [20,21], biotechnology [22], agriculture science [23,24], metals, ceramics, and polymers [25-27], and bone and skin health [28,29]. Thus, in this study, the effect of Biofield Energy Treatment was studied on the physicochemical and thermal properties of ascorbic acid by using various modern analytical techniques.

Materials and Methods

Chemicals and reagents

Ascorbic acid was purchased from Alfa Aesar, USA. Remaining chemicals used during the experiments were of analytical grade purchased from India.

Consciousness energy healing treatment strategies

The ascorbic acid sample used in the experiment was equally divided into two parts. The first part of the sample was not given the Biofield Energy Treatment and considered as a control sample. Besides, the second part of the sample was provided the Trivedi Effect®-Energy of Consciousness Healing Treatment remotely under standard laboratory conditions for 3 minutes and known as the Biofield Energy Treated sample. This Biofield Energy Treatment was provided by a famous Biofield Energy Healer, Gopal Nayak, India, through the unique energy transmission process to the test sample. Further, regarding the comparison, the control sample was treated with a "sham" healer as the "sham" healer did not have any knowledge about the Biofield Energy Treatment. Alter the treatment, the control, and the Biofield Energy Treated samples were kept in sealed conditions and characterized using modern analytical techniques.

Characterization

Powder X-ray Diffraction (PXRD) analysis

The PXRD analysis of control and Biofield Energy Treated ascorbic acid was performed with the help of Rigaku MiniFlex-II Desktop X-ray diffractometer (Japan) [30,31]. The average size of individual crystallites was calculated from XRD data using the Scherrer's formula 1:

$$G = k\lambda/\beta\cos\theta \quad (1)$$

Where k is the equipment constant (0.94), G is the crystallite size in nm, λ is the radiation wavelength (0.154056 nm for Kα1 emission), β is the full-width at half maximum (FWHM), and θ is the Bragg angle [32].

The % change in crystallite size (G) of ascorbic acid was calculated using the following equation 2:

$$\%\ \text{change in crystallite size} = \frac{[G_{Treated} - G_{Control}]}{G_{Control}} \times 100 \quad (2)$$

Where $G_{Control}$ and $G_{Treated}$ are the crystallite size of the control and Biofield Energy Treated samples, respectively.

Particle Size Analysis (PSA)

The particle size analysis of ascorbic acid samples was conducted on Malvern Mastersizer 2000, from the UK with a detection range between 0.01 µm to 3000 µm using the wet method

[33,34]. The calculations were done by using software Mastersizer Ver. 5.54.

The % change in particle size (d) for at below 10% level (d_{10}), 50% level (d_{50}), 90% level (d_{90}), and D (4,3) was calculated using the following equation 3:

$$\% \text{ change in particle size} = \frac{[d_{Treated} - d_{Control}]}{d_{Control}} \times 100 \quad (3)$$

Where $d_{Control}$ and $d_{Treated}$ are the particle size (µm) for at below 10% level (d_{10}), 50% level (d_{50}), and 90% level (d_{90}) of the control and Biofield Energy Treated ascorbic acid samples, respectively.

The % change in surface area (S) was calculated using the following equation 4:

$$\% \text{ change in surface area} = \frac{[S_{Treated} - S_{Control}]}{S_{Control}} \times 100 \quad (4)$$

Where $S_{Control}$ and $S_{Treated}$ are the surface area of the control and Biofield Energy Treated ascorbic acid samples, respectively.

Thermal Gravimetric Analysis (TGA)/ Differential Thermogravimetric Analysis (DTG)

TGA/DTG thermograms of the control and Biofield Energy Treated ascorbic acid were obtained with the help of TGA Q50TA instruments. A sample of 4-15 mg was loaded to the platinum crucible at a heating rate of 10 °C/min from 25 °C to 1000 °C with the recent literature [35]. The % change in weight loss (W) was calculated using the following equation 5:

$$\% \text{ change in weight loss} = \frac{[W_{Treated} - W_{Control}]}{W_{Control}} \times 100 \quad (5)$$

Where $W_{Control}$ and $W_{Treated}$ are the weight loss of the control and Biofield Energy Treated ascorbic acid, respectively.

The % change in maximum thermal degradation temperature (T_{max}) (M) was calculated using the following equation 6:

$$\% \text{ change in Tmax (M)} = \frac{[M_{Treated} - M_{Control}]}{M_{Control}} \times 100 \quad (6)$$

Where $M_{Control}$ and $M_{Treated}$ are the T_{max} values of the control and Biofield Energy Treated ascorbic acid, respectively.

Differential Scanning Calorimetry (DSC)

The DSC analysis of ascorbic acid was performed with the help of DSC Q200, TA instruments. A sample of ~1-5 mg was loaded to the aluminium sample pan at a heating rate of 10 °C/min from 30 °C to 350 °C [35]. The % change in melting point (T) was calculated using the following equation 7:

$$\% \text{ change in melting point} = \frac{[T_{Treated} - T_{Control}]}{T_{Control}} \times 100 \quad (7)$$

Where $T_{Control}$ and $T_{Treated}$ are the melting point of the control and treated samples, respectively.

The % change in the latent heat of fusion (ΔH) was calculated using the following equation 8:

$$\% \text{ change in latent heat of fusion} = \frac{[\Delta H_{Treated} - \Delta H_{Control}]}{\Delta H_{Control}} \times 100 \quad (8)$$

Where $\Delta H_{Control}$ and $\Delta H_{Treated}$ are the latent heat of fusion of the control and treated ascorbic acid, respectively.

Results and Discussion

Powder X-ray Diffraction (PXRD) analysis

The study showed the PXRD diffractograms of the control and Biofield Energy Treated samples (Figure 1) and their corresponding analysis was done to determine the changes in the relative intensity of the characteristic peaks and the crystallite sizes (Table 1). The diffractograms of both the samples of ascorbic acid showed sharp and intense peaks, thereby showing their crystalline nature; however, the Bragg's angles corresponding to those peaks of the treated sample were observed to be altered in comparison to the control sample.

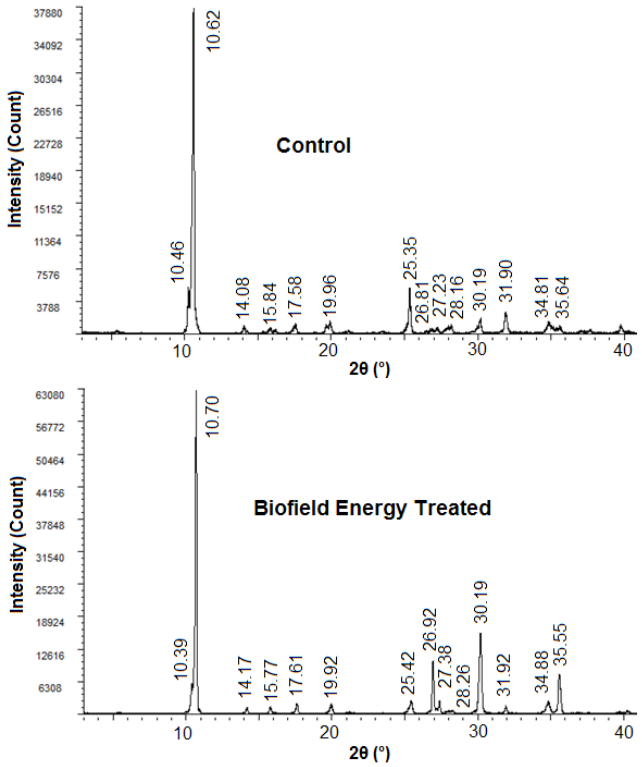

Figure 1: PXRD diffractograms of the control and Biofield Energy Treated ascorbic acid.

Entry No.	Bragg angle (°2θ)		Intensity (cps)			Crystallite size (G, nm)		
	Control	Treated	Control	Treated	% change[a]	Control	Treated	% change[b]
1	10.46	10.39	880	1132	28.64	323	228	-29.41
2	10.62	10.70	3987	5566	39.60	596	760	27.52
3	14.08	14.17	125	149	19.20	486	614	26.34
4	15.84	15.77	117	198	69.23	344	477	38.66
5	17.58	17.61	156	280	79.49	315	611	93.97
6	19.96	19.92	229	302	31.88	301	429	42.52
7	25.35	25.42	707	228	-67.75	716	726	1.40
8	26.81	26.92	76	881	1059.21	322	842	161.49
9	27.23	27.38	88	157	78.41	381	847	122.31
10	28.16	28.26	237	180	-24.05	186	163	-12.37
11	30.19	30.19	213	2336	996.71	398	479	20.35
12	31.90	31.92	363	191	-47.38	453	739	63.13
13	34.81	34.88	290	492	69.66	220	299	35.91
14	35.64	35.55	200	1062	431.00	173	642	271.10
*denotes the percentage change in the crystallite size of Biofield Energy Treated sample with respect to the control sample.								

Table 1: PXRD data for the control and Biofield Energy Treated ascorbic acid.

The further analysis revealed that the peak intensities of the characteristic peaks and corresponding crystallite sizes of the treated sample were significantly changed ranging from -67.75% to 1059.21% and -29.41% to 271.10%, respectively as compared to the control ascorbic acid sample. The Biofield Energy Treated sample also showed significant alteration in the average crystallite size (561.14 nm) as it shows an increase of 50.67% in comparison to the control sample (372.43 nm). The significant alterations in the crystallite properties such as peak intensities and crystallite size signify the possible alteration in the crystal morphology of ascorbic acid that might indicate the formation of a new polymorphic form [36,37]. Moreover, altering the crystal habit and properties are used as a technique to enhance the solubility, absorption, and bioavailability of the compound [38]. Thus, it could be concluded that the bioavailability of the treated ascorbic acid might increase after the Biofield Energy Treatment in comparison to the untreated sample.

Particle Size Analysis (PSA)

The particle size analysis corresponding to d_{10}, d_{50}, d_{90}, and D (4,3) for the control and the Biofield Energy Treated samples were done and results are presented in Table 2. It showed that the particle size distributions of the treated sample were significantly decreased by 8.23%, 22.07%, 11.64%, and 15.81% at d_{10}, d_{50}, d_{90}, and D (4,3), respectively, compared to the control ascorbic acid sample.

Parameter	d_{10} (µm)	d_{50} (µm)	d_{90} (µm)	D(4,3)(µm)	SSA(m^2/g)
Control	76.16	303.80	636.61	332.67	0.039
Biofield Treated	69.90	236.74	562.48	280.06	0.045
Percent change* (%)	-8.23	-22.07	-11.64	-15.81	15.38
d_{10}, d_{50}, and d_{90}: particle diameter corresponding to 10%, 50%, and 90% of the cumulative distribution, D (4,3): the average mass-volume diameter, and SSA: the specific surface area. *denotes the percentage change in the Particle size distribution of the Biofield Energy Treated sample with respect to the control sample.					

Table 2: Particle size distribution of the control and Biofield Energy Treated ascorbic acid.

Moreover, the resultant decrease in the particle size affects the surface area of the Biofield Energy Treated sample (0.045 m^2/g), as it was increased by 15.38% compared to the control sample (0.039 m^2/g). The dissolution, absorption, and bioavailability of a drug are important parameters in terms of its efficacy and these properties are highly influenced by the particle size distribution of the drug [39,40]. Moreover, decreasing the particle size increases the effective surface area of drug, thereby used as an approach to enhance the dissolution and bioavailability of drug [41]. Hence, it could be presumed that the Biofield Energy Treatment of ascorbic acid might improve its efficacy by enhancing the bioavailability in the body compared to the untreated sample.

Thermal Gravimetric Analysis (TGA)/ Differential Thermogravimetric Analysis (DTG)

The thermal degradation and stability profile of the control and treated samples were analysed with the help of the TGA/DTG technique. According to the literature, the heating of ascorbic acid revealed its stability till ~ 200 °C, after which it started degrading and the residual mass contains the non-decomposed ascorbic acid as well as its carbonaceous residues [42]. The TGA thermograms of the control and Biofield Energy Treated sample (Figure 2) also showed the thermal stability of both the samples till 200 °C and thus, observed similarly as reported in the literature. Moreover, the weight loss of the Biofield Energy Treated sample during the thermal heating cycle was found as 76.68%, which is considerably reduced by 20.57% in comparison to the weight loss of the control ascorbic acid sample (96.54%). The residual amount remaining after the thermal degradation of the treated ascorbic acid sample was significantly increased by 573.99% (Table 3) compared to the control sample. Therefore, the TGA analysis revealed improved thermal stability of the treated ascorbic acid sample after the Biofield Energy Treatment compared to the control sample.

Sample	TGA		DTG T_{max} (°C)	
	Total weight loss (%)	Residue %	Peak 1	Peak 2
Control	96.54	3.46	226.49	306.62
Biofield Energy Treated	76.68	23.32	227.80	321.75
% Change*	-20.57	573.99	0.58	4.93
*denotes the percentage change of the Biofield Energy Treated sample with respect to the control sample, T_{max} = The temperature at which maximum weight loss takes place in TG or peak temperature in DTG.				

Table 3: TGA/DTG data of the control and Biofield Energy Treated samples of Ascorbic acid.

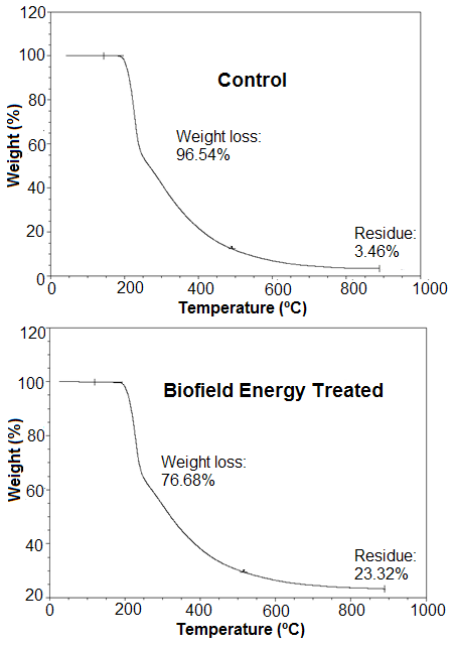

Figure 2: TGA thermograms of the control and Biofield Energy Treated ascorbic acid.

On the other hand, the DTG analysis of both the samples showed the presence of two peaks in the DTG thermograms (Figure 3). The further analysis revealed that the maximum degradation temperature (T_{max}) corresponding to the 1st and 2nd peaks of the Biofield Energy Treated sample was increased by 0.58% and 4.93%, respectively, compared to the T_{max} of the control sample. The T_{max} of 2nd peak of the treated sample was significantly increased by ~15 °C as compared to the control sample, which indicated the significant improvement in the thermal stability profile and reduced degradation of the ascorbic acid after the Biofield Energy Treatment.

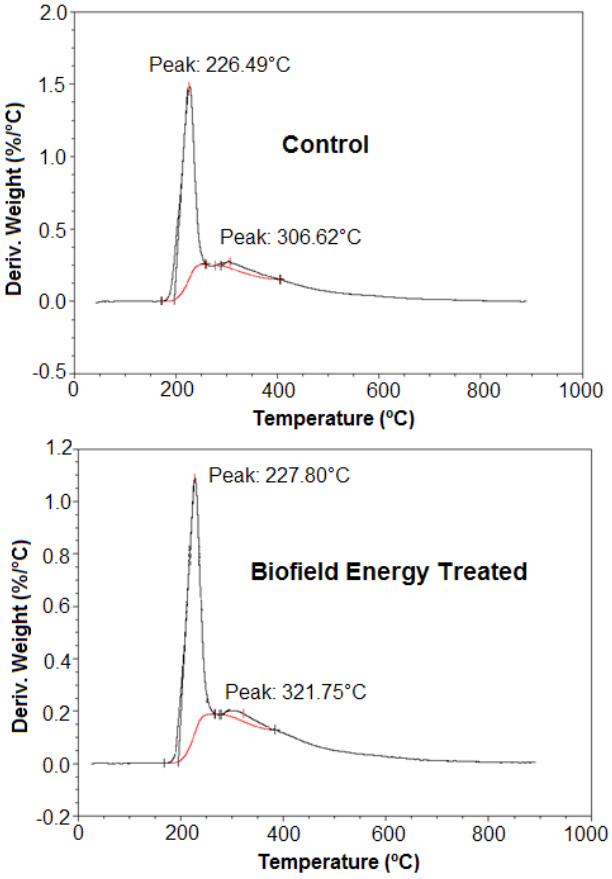

Figure 3: DTG thermograms of the control and Biofield Energy Treated ascorbic acid.

Differential Scanning Calorimetry (DSC) analysis

The DSC analysis of the drug is used to determine the thermal behaviour of the drug during heating [43]. It was reported in the literature that the heating of ascorbic acid at the rate of 10 °C min^{-1} create an endothermic peak in the thermogram at 193 °C, which was considered as the fusion temperature. Besides, there was a second exothermic peak that is reported as the thermal decomposition during heating of the ascorbic acid, which produces a carbonaceous residue after releasing the volatile compounds [42]. The DSC thermograms of the control and the Biofield Energy Treated sample (Figure 4) showed similar peaks as reported in the literature. The endothermic peak was observed at a similar temperature for the control and the treated sample that represents the similar melting point of both the sample (Table 4). However the 2nd peak of the treated sample i.e., the decomposition temperature was observed to be reduced by 4.17% compared to the control sample. Besides, the Latent heat of fusion (ΔH_{fusion}) and Latent heat of decomposition ($\Delta H_{decomposition}$) of the treated ascorbic acid sample was observed to be significantly increased by 9.13% and 110.60%, respectively in comparison to the control sample (Table 4).

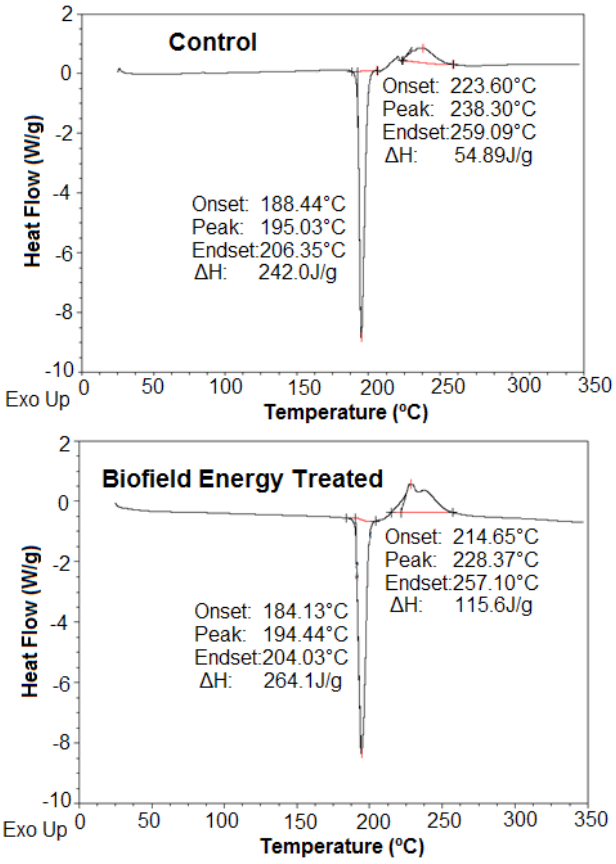

Figure 4: DSC thermograms of the control and Biofield Energy Treated ascorbic acid.

Peak	Description	Melting Point (°C)	ΔH (J/g)
Peak 1	Control sample	195.03	242.00
	Biofield Energy Treated sample	194.44	264.10
	% Change*	0.30	9.13
Peak 2	Control sample	238.30	54.89
	Biofield Energy Treated sample	228.37	115.60
	% Change*	-4.17	110.60

ΔH: Latent heat of fusion/decomposition; *denotes the percentage change of the Biofield Energy Treated sample with respect to the control sample.

Table 4: Comparison of DSC data between the control and Biofield Energy Treated ascorbic acid.

Therefore, the DSC analysis showed the alterations in the decomposition temperature and ΔH_{fusion} and $\Delta H_{decomposition}$ of the treated sample that might happen as a result of some changes arising in the crystallization structure of the ascorbic acid [43] after the Biofield Energy Treatment. Overall, the melting and thermal decomposition profile of the treated ascorbic acid sample was observed to be altered compared to the control sample.

Conclusions

This study evaluated the impact of the Trivedi Effect®-Consciousness Energy Healing Treatment on the physicochemical and thermal properties of ascorbic acid such as crystal properties, particle size, surface area, melting temperature, and other thermal properties. The PXRD results revealed the changes in the Bragg's angles of the peaks present in the diffractograms of the treated sample in comparison to the control sample. Moreover, the Biofield Energy Treated sample showed alterations in the peak intensities and crystallite sizes ranging from -67.75% to 1059.21% and -29.41% to 271.10%, respectively in comparison to the control sample. The average crystallite size of the treated ascorbic acid was increased significantly by 50.67% compared to the control sample. Such changes might appear due to the possible formation of a novel polymorphic form of the ascorbic acid that may show improved bioavailability profile compared to the untreated sample. The particle size distribution of the treated sample was also altered as the particle size values at d_{10}, d_{50}, d_{90}, and D (4,3) were significantly decreased by 8.23%, 22.07%, 11.64%, and 15.81%, respectively in comparison to the control sample. Such changes in the particle size of the treated sample resulted in 15.38% significant increase in the surface area as compared to the untreated sample. Therefore, it is presumed that the Biofield Energy Treatment of the ascorbic acid might help in increasing its solubility and dissolution profile, along with the improved bioavailability parameters compared to the untreated sample. The TGA thermogram of the treated sample revealed a significant decrease in the weight loss by 20.57% during the thermal heating; however, the residual amount was significantly increased by 573.99% in comparison to the control sample. The DTG results revealed two peaks in the thermograms of both the samples. Besides, the T_{max} corresponding to the 1st and 2nd peaks in the thermogram of the treated sample was increased by 0.58% and 4.93%, respectively compared to the T_{max} of the untreated ascorbic acid sample. Thus, the thermal data showed the improved thermal stability of the treated sample after the Biofield Energy Treatment compared to the untreated sample. The ΔH_{fusion} and $\Delta H_{decomposition}$ of the Biofield Energy Treated sample were significantly increased by 9.13% and 110.60%, respectively compared to the untreated ascorbic acid sample. Thus, it can be concluded that the Trivedi Effect®-Consciousness Energy Healing Treatment significantly affects the physicochemical and thermal properties of ascorbic acid that might help in producing a new polymorph with improved solubility, dissolution, and bioavailability compared with the untreated sample. Hence, The Biofield Energy Treated ascorbic acid could be used in the formulation for acting more efficiently in the prevention as well as treatment of many diseases such as common cold, diabetes, scurvy, cataracts, heart diseases, glaucoma, cancer, autoimmune diseases, stroke, chronic degenerative diseases, atherosclerosis, anemia, bleeding gums, infections, muscle degeneration, delayed wound healing, capillary haemorrhage, low immunity, and neurotic disturbances, etc.

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