

Bio-field Treatment: An Effective Strategy to Improve the Quality of Beef Extract and Meat Infusion Powder

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Abstract

The present research work investigated the influence of bio-field treatment on two common flavoring agents used in food industries namely beef extract powder (BEP) and meat infusion powder (MIP). The treated powders were characterized by Fourier transform infrared spectroscopy (FT-IR), X-ray diffraction (XRD), particle size analysis, surface area analysis, differential scanning calorimetry (DSC), and thermogravimetric analysis (TGA). The FT-IR results showed disappearance of triglycerides peaks in both the treated powders as compared to control. XRD results corroborated the amorphous nature of both control and treated samples. The BEP showed enhanced average particle size (d_{50}) and d_{99} (size exhibited by 99% of powder particles) by 5.7% and 16.1%, respectively as compared to control. Contrarily, the MIP showed a decreased particle size (d_{50} : 0.4% and d_{99} : 18.1%) as compared to control. It was assumed that enormous energy was stored in MIP after bio-field treatment that led to fracture into smaller particles. The surface area was increased in both the treated powders. DSC result showed significant increase in melting temperature, in BEP and MIP, which indicated the higher thermal stability of the samples. However, the specific heat capacity (ΔH) was decreased in both samples, which was probably due to high energy state of the powders.

Keywords: Beef extract powder; Meat infusion powder; Bio-field treatment; Fourier transform infrared spectroscopy; X-ray diffraction; Particle size analysis; Surface area analysis; Differential scanning calorimetry; Thermo gravimetric analysis

Abbreviations: BEP: Beef Extract Powder; MIP: Meat Infusion Powder; FT-IR: Fourier Transform Infrared Spectroscopy; XRD: X-Ray Diffraction; DSC: Differential scanning Calorimetry; TGA: Thermo Gravimetric Analysis; CHD: Coronary Heart Disease; BET: Brunauer-Emmett-Teller; DTG: Derivative Thermo Gravimetry

Introduction

Beef is known to have excellent nutritional value and it has been widely consumed in many countries. The prominent reason for this high food value is its strongest peroxide forming potential due to its excellent myoglobin and haem levels [1,2]. Beef extract powder (BEP) is highly concentrated meat stock and has been used in food industry as a flavouring agent in cooking and to prepare broth for drinks [3]. It has been used since many years as a food additive and taste enhancer in food technological applications. On the other hand, meat infusion powder (MIP) has been used as a microbial growth medium and flavouring agent [4].

Coronary heart disease (CHD) is the main cause of death in western countries. The life style and genetic backgrounds are two important factors, which affects the mortality in CHD. The elevated level of triglycerides is one of the main reasons for CHD. The factors such as obesity, insulin resistance, excessive alcohol consumption, diabetes, and kidney disease also causes risk of high triglycerides [5]. Moreover, the red meat such as beef and less dark meat chicken also have the higher triglycerides. Previously, it was suggested that removing triglycerides from cooked meat affects the aroma and thus it can affect the quality of the beef meat [6]. Hence, reducing the triglyceride content will directly improve the health and it will improve the quality of the meat products. Currently, no alternative and cost effective approaches are available to alter the content of triglycerides, but bio-field treatment may be a new approach to change the physicochemical properties of powders made from these meat products.

In physics, energy is a property of objects that can be transmitted to other objects and changed into different forms but neither can be created or destroyed [7]. According to Einstein's equation ($E=mc^2$) the energy and matter are fundamentally related to each other [8]. Nonetheless, the energy is a field of force which can significantly interact with any object at a distance and cause action. Furthermore, the energy can exist in several forms such as kinetic, potential, electrical, magnetic, and nuclear. Researchers have shown that short lived electrical events or action potential exists in several types of animal cells such as neurons, muscle cells, endocrine cells as well as plant cells. The human nervous system consists the energy/information in the form of electrical signals [9,10]. Whenever, these electrical signals fluctuate with time, the magnetic field generates as per the Ampere-Maxwell law, and cumulatively known as electromagnetic field. Hence, the electromagnetic field being generated from the human body is known as bio-field energy [11].

Mr. Trivedi is known to exert prominent effects on external surrounding using his unique bio-field, herein referred as Bio-field treatment. Recently, it was investigated that bio-field treatment can significantly change the characteristics of living and non-living organisms. Subjecting bio-field treatment on metals and ceramics caused significant changes in crystalline, thermal, and atomic properties [12-19]. It has been recently published that the effect of bio-field treatment resulted in significant improvement of the yield and quality of various agriculture products [20-23]. The said bio-field

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Received June 02, 2015; Accepted June 18, 2015; Published June 23, 2015

Citation: Mahendra KT, Gopal N, Shrikant P, Rama MT, Snehasis J, et al. (2015) Bio-field Treatment: An Effective Strategy to Improve the Quality of Beef Extract and Meat Infusion Powder. J Nutr Food Sci 5: 389. doi:10.4172/2155-9600.1000389

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exposure caused an increase in growth and anatomical characteristics of an herb *Pogostemon cablin* that is commonly used in perfumes, in incense/insect repellents, and alternative medicine [24]. Moreover, in microbiology, bio-field treatment has also changed the antibiotic susceptibility patterns as well as produced biochemical reactions that induced changes in the characteristics of pathogenic microbes [25-27].

Having inspired by these excellent results, in present study, an attempt was made to investigate the physicochemical properties of BEP and MIP that were exposed to the said Bio-field. The bio-field treated powders were thoroughly characterized by FT-IR, XRD, DSC, TGA, CHNSO, and particle size analysis.

Experimental

Materials and methods

The BEP and MIP were procured from HiMedia Laboratories Pvt Ltd, India. The samples were grouped into two parts; one was kept as a control sample, while the remaining part was subjected to Mr. Trivedi's bio-field treatment and coded as treated sample. After that, all the samples (control and treated) were characterized with respect to FT-IR, CHNSO, XRD, particle size analysis, surface area analysis, DSC, and TGA.

Characterization

Fourier transforms infrared (FT-IR) spectroscopy: The infrared spectra of BEP and MIP were recorded with FT-IR spectrometer (Perkin Elmer, USA). IR spectrum was recorded in the range of 4000 to 500 cm^{-1} .

CHNSO analysis: The BEP and MIP were analyzed for their elemental composition (C,H,N,S, and O). The powdered samples were subjected to CHNSO Analyzer using Model Flash EA 1112 Series, Thermo Finnigan Italy.

X-ray diffraction (XRD) study: XRD of BEP and MIP were analyzed using Phillips Holland PW 1710 X-ray diffractometer system. The wavelength of the radiation was 1.54056 angstrom. The data was obtained in the form of 2θ versus intensity (a.u) chart. The obtained data was used for calculation of crystallite size using the following formula.

$$\text{Crystallite size} = k\lambda/b \cos \theta$$

Where, λ is the wavelength and k is the equipment constant (0.94).

Particle size analysis: The average particle size and particle size distribution were analyzed using Sympetac Helos-BF Laser Particle Size Analyzer with a detection range of 0.1 μm to 875 μm . Average particle size d_{50} and size exhibited by 99% (d_{99}) of powder particles were computed from laser diffraction data table. The d_{50} and d_{99} value were calculated using following formula.

Percentage change in d_{50} size = $100 \times (d_{50} \text{ treated} - d_{50} \text{ control}) / d_{50} \text{ control}$.

Percentage change in d_{99} size = $100 \times (d_{99} \text{ treated} - d_{99} \text{ control}) / d_{99} \text{ control}$.

Surface area analysis: The surface area of BEP and MIP were characterized using Surface Area Analyzer, SMART SORB 90 BET (Brunauer-Emmett-Teller), which had a detection range of 0.1-100 m^2/g .

Differential scanning calorimetry (DSC) study: The BEP and

MIP were used for DSC study. The samples were analyzed using a Pyris-6 Perkin Elmer DSC on a heating rate of 10 $^{\circ}\text{C}/\text{min}$ under oxygen atmosphere.

Thermo gravimetric analysis (TGA): Thermal stability of the BEP and MIP were analyzed using Mettler Toledo simultaneous TGA. The samples were heated from room temperature to 400 $^{\circ}\text{C}$ with a heating rate of 5 $^{\circ}\text{C}/\text{min}$ under oxygen atmosphere.

Results and Discussion

FT-IR spectroscopy

The FT-IR spectrum of control and bio-field treated samples are illustrated in Figure 1. The IR spectrum of control and BEP showed (Figure 1) prominent vibration bands at 1760 cm^{-1} (-C=O) and 1151 cm^{-1} (-C-O) due to presence of triglycerides peak stretching in the sample. Other important peaks were observed at 2895 and 2817 cm^{-1} which can be attributed to C-H stretching vibration peaks. The spectrum showed peaks at 1635 and 1587 cm^{-1} attributed to presence of characteristic protein bands such as amide-I and amide -II stretching vibration peaks [28-31]. Another peak was observed at 3078 to 3780.2 cm^{-1} attributed to -OH stretching vibration peak. The treated sample showed considerable change in FT-IR spectrum (Figure 1). We observed that the presence of triglycerides peak of -C=O (1760 cm^{-1}) and C-O (1151 cm^{-1}) was disappeared in the treated BEP. The result showed that the bio-field treatment, probably removed the fatty triglycerides components from the treated BEP. Additionally, it was also observed that the characteristic -OH/-NH stretching vibration peaks were reduced to lower wavenumbers 3064 cm^{-1} , which indicated the formation of strong intermolecular hydrogen bonding in the treated sample [32,33]. These results suggest that bio-field treatment has induced structural changes in the treated sample.

The FT-IR spectrum of control and treated MIP are presented in Figure 2. The FT-IR of control powder showed (Figure 2) important peaks at 1689 and 1589 cm^{-1} due to amide-I and amide-II stretching vibration peaks, respectively. Other important peaks were observed at 1760 and 1157 cm^{-1} for C=O and C-O group, respectively due to triglycerides. However, these two peaks were completely disappeared in treated MIP (Figure 2) which indicated that bio-field treatment affected chemical changes in the treated sample.

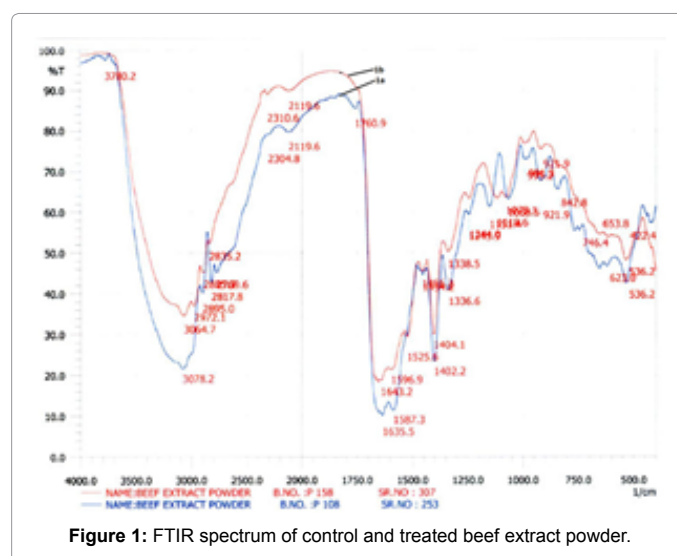


Figure 1: FTIR spectrum of control and treated beef extract powder.

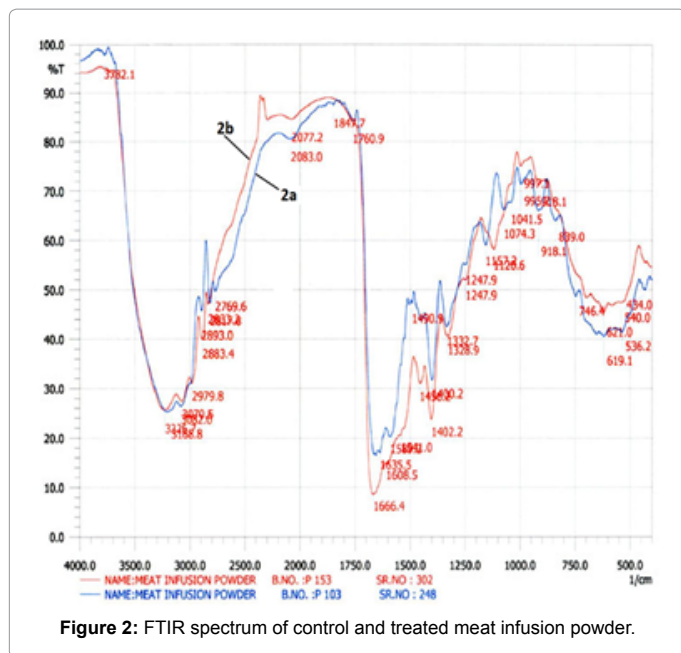


Figure 2: FTIR spectrum of control and treated meat infusion powder.

CHNSO analysis

Table 1 shows the results of CHNSO analysis of BEP and MIP. The treated BEP showed substantial changes in terms of elemental composition of the treated sample. The treated BEP showed 5.05% increase in nitrogen as compared to control. The oxygen percentage was increased by 3.82% in the treated BEP as compared to control. The carbon percentage was also improved by 2.09% as compared to control sample. Moreover, the treated BEP showed the presence of sulphur element; however no trace of sulphur was found in control sample. The presence of sulphur might play a crucial role in preserving the comminuted meat products [34]. This data showed that the bio-field treatment led to change the elemental composition in BEP.

Whereas the treated MIP showed small percentage change in nitrogen (0.77%) as compared to control powder. However, carbon and hydrogen percentage was decreased by 1.22% and 7.13%, respectively in the treated sample as compared to control. It was observed that there was a significant change in oxygen percentage in treated MIP (24.48%) as compared to control sample. The treated MIP showed some trace of sulphur (0.27%) though no sulphur was found in control sample. All together, the CHNSO results confirmed that bio-field treatment significantly changed the elemental percentage in treated samples.

X-ray diffraction studies

The XRD diffractogram of control and treated BEP sample are illustrated in Figure 3, where, a and b represented to control and treated sample respectively. The XRD showed the amorphous nature of the control sample (Figure 3a) with a broad halo at 2θ equals to 20.0° . The XRD of treated BEP did not reveal (Figure 3b) any differences in X-ray pattern of the sample. The treated samples also showed the broad amorphous nature which was probably due to less ordered atomic arrangement in the sample. The X-ray diffractogram of control and treated MIP are presented in Figures 4a and 4b. The Figure 4a showed a broad amorphous peak at 2θ equals to 22° and Figure 4b showed similar XRD pattern with no change in peak position. Amorphous materials due to random or irregular arrangement in atoms show broad and diffused peaks [35].

Particle size and surface area analysis

The particle size analysis was carried out on BEP and MIP. The percentage of average particle size (d_{50}) and (d_{99}) were computed and results are presented in Figure 5. The control BEP showed d_{50} value $11.75 \mu\text{m}$ and d_{99} value of $85.39 \mu\text{m}$ respectively. After treatment d_{50} value was increased to $12.42 \mu\text{m}$ and d_{99} value was increased to $99.1 \mu\text{m}$. The percentage change in d_{50} value and d_{99} value of the treated BEP was increased by 5.7% and 16.1%, respectively as compared to control sample (Figure 5). This showed that bio-field treatment led to an increase in particle size of the treated samples. It is postulated that the agglomeration of treated BEP may be due to bio-field treatment which causes joining of particle boundaries and hence increase in particle size.

Contrarily, in case of MIP the d_{50} and d_{99} values were decreased by 0.4% and 18.1% (Figure 6). Here we assume that the treated powder particles received high bio-field energy which led to deformation of the particle boundaries, and hence it caused a reduction in particle size.

The surface area was analyzed by BET analysis and results are presented in Table 2. The treated BEP showed substantial increase in surface area ($1.291 \text{ m}^2/\text{g}$) as compared to control powder ($1.027 \text{ m}^2/\text{g}$). This was contrary to our particle size results. The surface area of treated

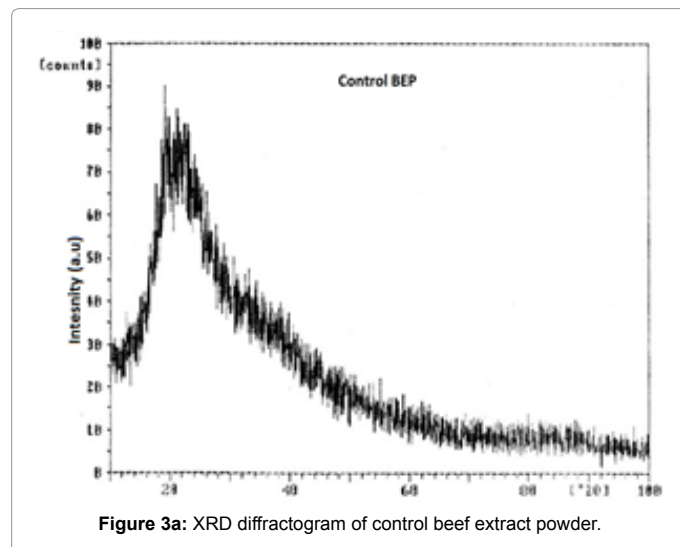


Figure 3a: XRD diffractogram of control beef extract powder.

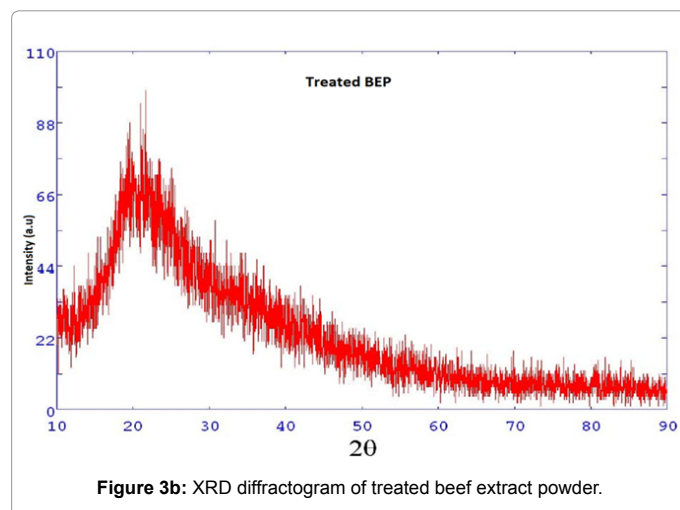
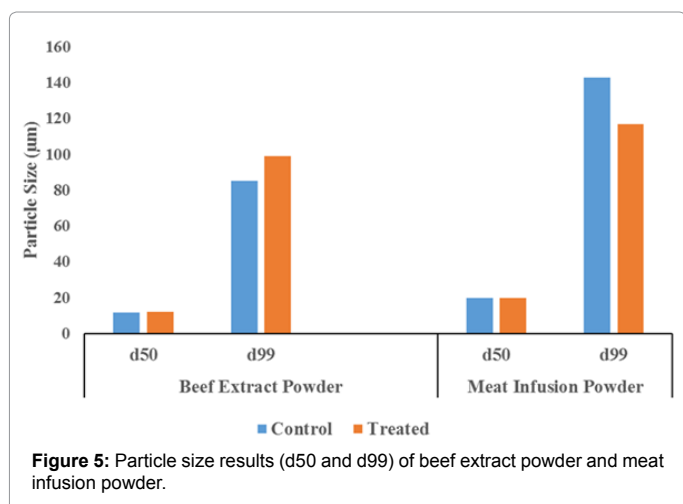
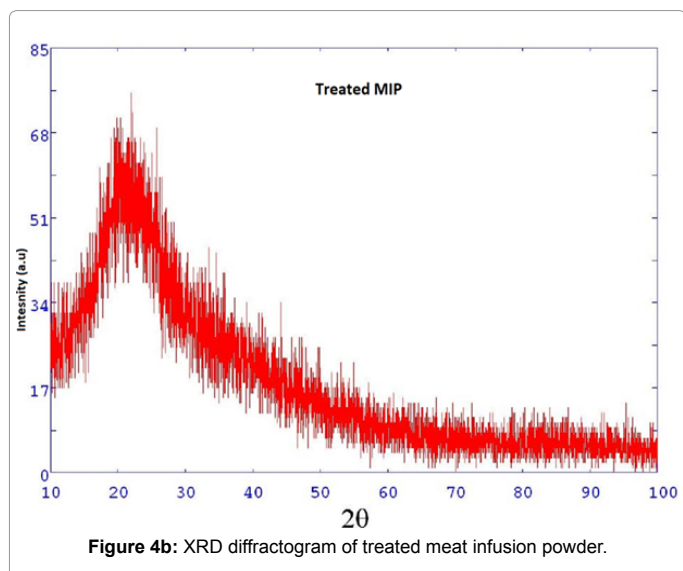
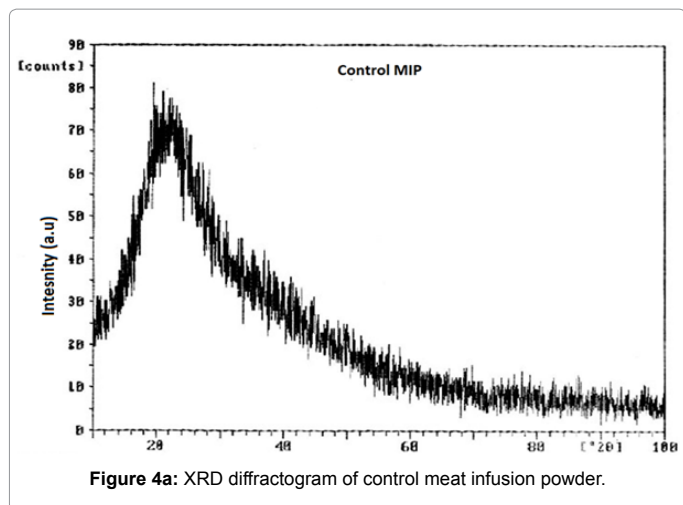


Figure 3b: XRD diffractogram of treated beef extract powder.



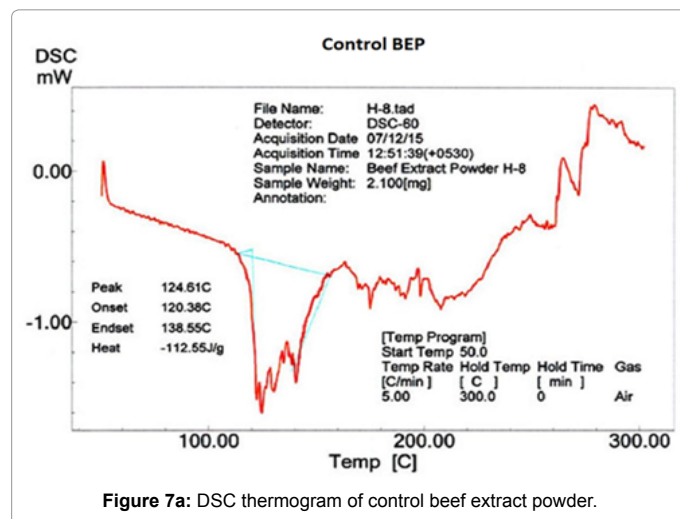
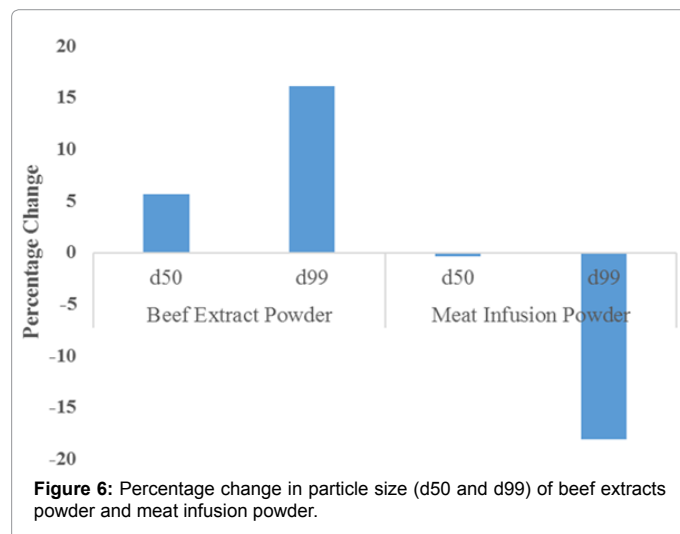
MIP (0.625 m²/g) was also increased as compared to control powder (0.488 m²/g). The percentage changes in surface area of the samples (BEP and MIP) were 25.7% and 28% respectively. This was probably

due to the fact that, the decreased particle size in MIP caused an increase in surface area. The surface area and particle size changes are usually opposite to each other i.e., smaller the particles size, larger the surface area and vice versa [36-38]. Hence the more surface area could have been exposed to solvents thereby causing increased solubility.

Differential scanning calorimetry study

DSC is an excellent technique to investigate the glass transition, melting temperature and change in heat capacity of different materials. DSC thermogram of control and treated BEP are presented in Figures 7a and 7b, respectively. The DSC thermogram of control sample (Figure 7a) showed a broad endothermic inflexion at 124.61°C, which was due to melting temperature of the control sample. However, the treated BEP sample showed an elevation in melting temperature as compared to control. DSC thermogram of treated powder showed (Figure 7b) a broad endothermic peak at 192°C. This sharp increase in melting temperature was probably due to the higher absorption of bio-field in the treated sample. Hence, the treated BEP need more external thermal energy in order to melt the sample which increased its melting temperature as compared to control.

The DSC thermo gram of both control and treated MIP are presented in Figures 8a and 8b. The DSC thermogram of control MIP



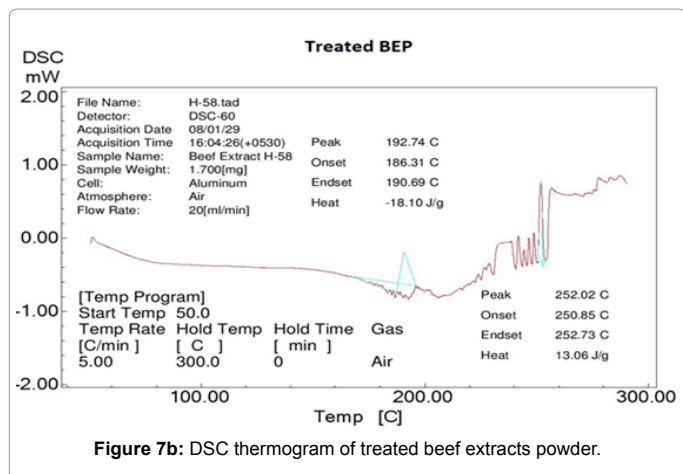


Figure 7b: DSC thermogram of treated beef extracts powder.

showed (Figure 8a) a sharp endothermic inflexion at 131.67°C, which was responsible for its melting temperature. Contrarily, the bio-field treated sample showed (Figure 8b) a broad endothermic inflexion at 182°C which was due to melting temperature of the sample. This confirmed that bio-field treatment enhanced the melting temperature of the treated MIP. This was probably due to increased internal energy that was caused due to Bio-field, which subsequently needed more external energy in order to disturb the material chains.

The increased melting temperature could be correlated to higher thermal stability of the treated BEP and MIP. It can be hypothesized that bio-field has acted as a crosslinker for the collagen present in meat products (BEP and MIP) which probably restricted the molecular mobility that resulted in enhanced thermal denaturation and stability [39,40]. Moreover, the specific heat capacity of the control and treated samples were computed from DSC data and results are presented in Table 3. The specific heat capacity was found to be decreased proportionally in both the samples (83.92% and 3.84%). It was assumed that the treated samples (BEP and MIP) were present in corresponding high energy state.

Thermal stability

TGA thermo gram of control and treated BEP are illustrated in Figures 9a and 9b. The thermograms of control powder showed (Figure 9a) one step thermal degradation pattern. The control sample started to degrade at 188°C and degradation was terminated at 235°C. Derivative thermogravimetry (DTG) thermogram of the control powder showed the maximum thermal decomposition temperature at 206°C. Similarly, the treated BEP also displayed (Figure 9b) one step thermal degradation pattern. The treated sample started to decompose at 180°C and decomposition step was terminated at 250°C. However, significant increase in maximum thermal decomposition temperature (218°C) was observed in the treated sample, which could be correlated with its higher thermal stability.

Figures 10a and 10b shows the TGA thermogram of control and bio-field treated MIP. TGA thermogram of control MIP showed (Figure 10a) single step decomposition pattern. The sample started to degrade at 165°C and decomposition was stopped at 250°C. The sample showed maximum thermal decomposition temperature at 209°C contrarily the treated MIP showed (Figure 10b) no DTG peak for maximum thermal decomposition temperature. Based on These results, we assume that the bio-field treatment has induced significant thermal changes in both BEP and MIP. The TGA results were also well supported by the DSC

data.

The FT-IR data showed a complete disappearance of triglyceride (C=O and C-O) peak in the treated BEP and MIP as compared to control sample. It was shown previously that elevated level of triglycerides could cause serious health concerns such as obesity, hypertension, and high blood glucose levels. More consumption of red meat such as beef could increase the triglyceride level in the humans that further increases health problems. Hence, present work describes that bio-field treatment could be used as possible strategy to remove excess triglycerides. Moreover, it was recently shown that reduced level of triglyceride might improve the aroma and quality of cooked meat. Hence, we assume that bio-field treatment could improve the health and quality of beef and meat products.

Conclusion

This research study was an attempt to improve the physicochemical properties of BEP and MIP using bio-field treatment. FT-IR data showed that bio-field treatment has changed characteristics of treated powders at the structural level. DSC study corroborated increase in

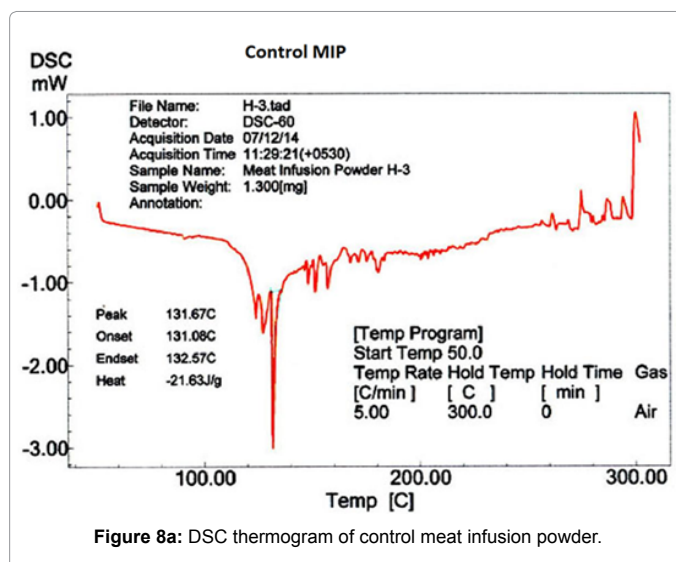


Figure 8a: DSC thermogram of control meat infusion powder.

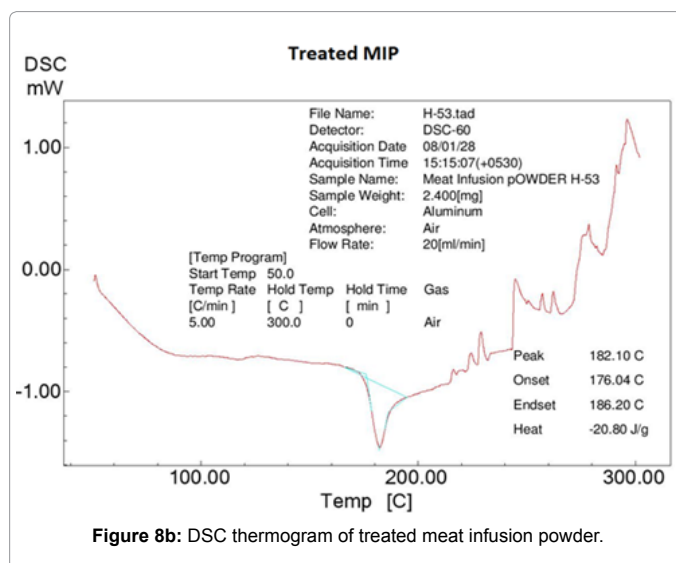


Figure 8b: DSC thermogram of treated meat infusion powder.

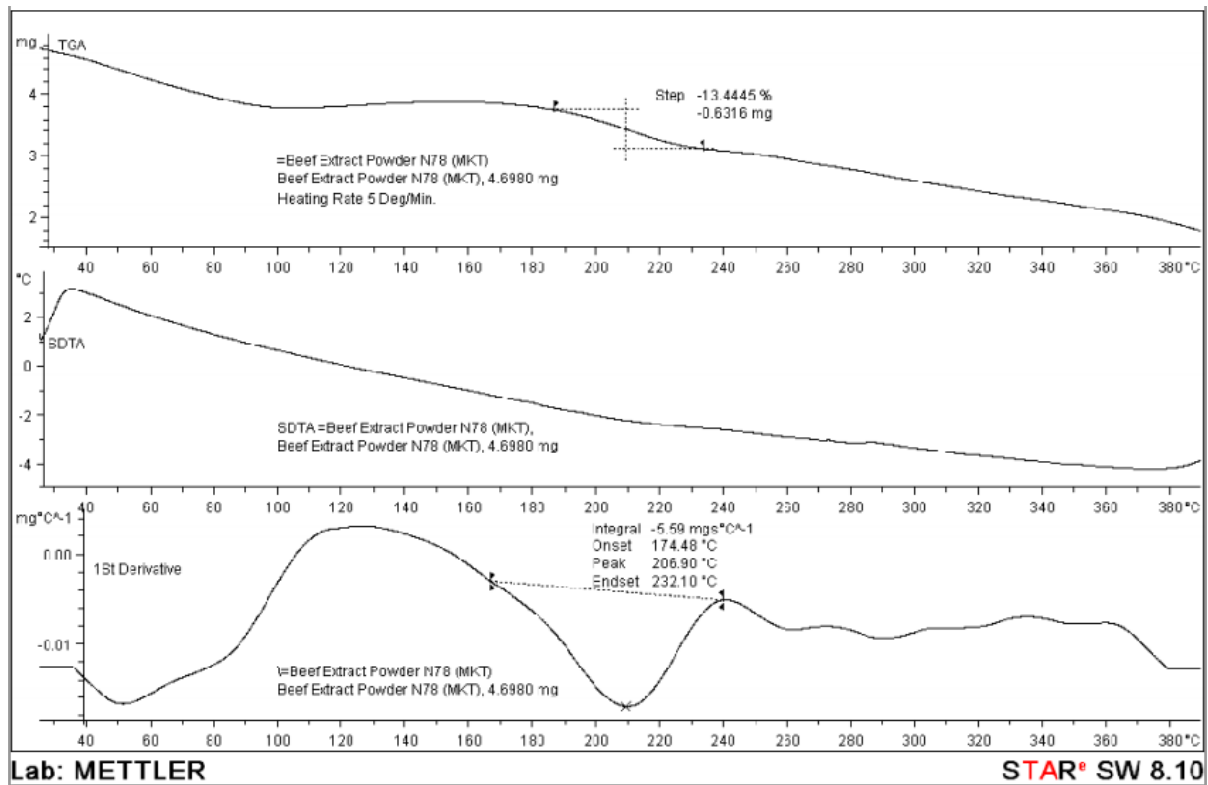


Figure 9a: TGA thermogram of control beef extract powder.

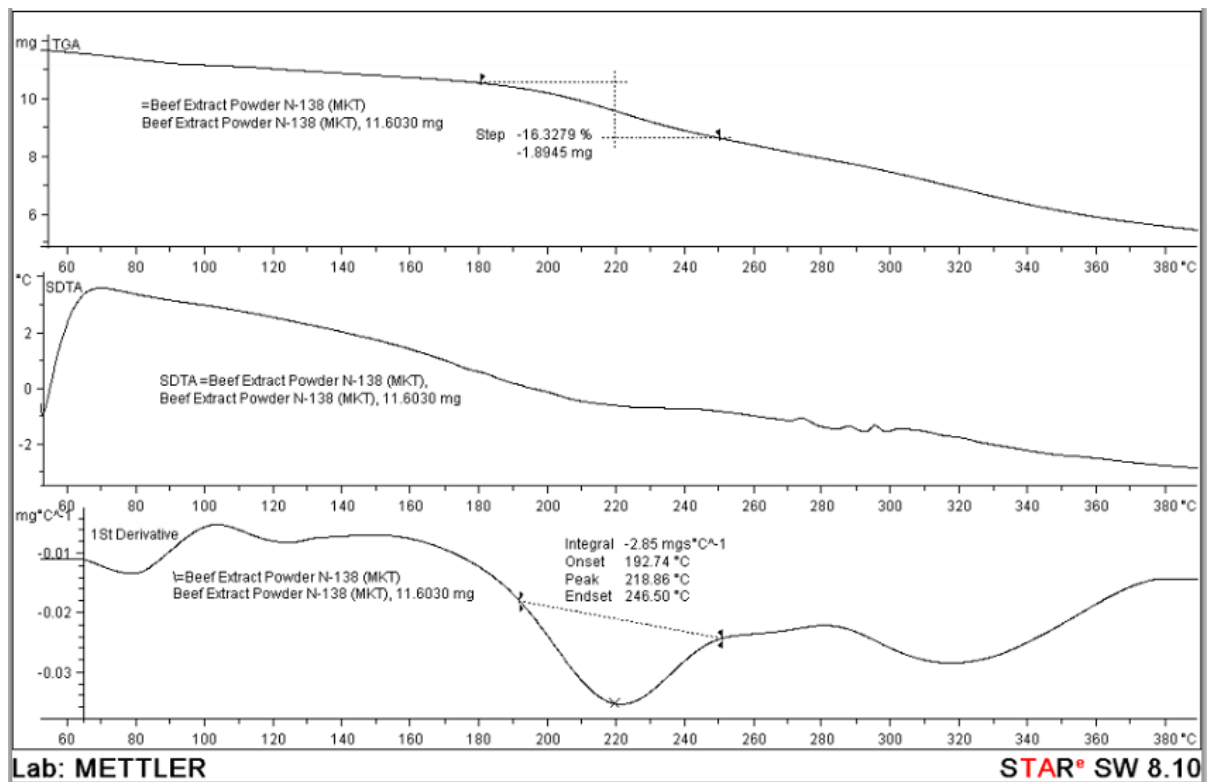


Figure 9b: TGA thermogram of treated beef extract powder.

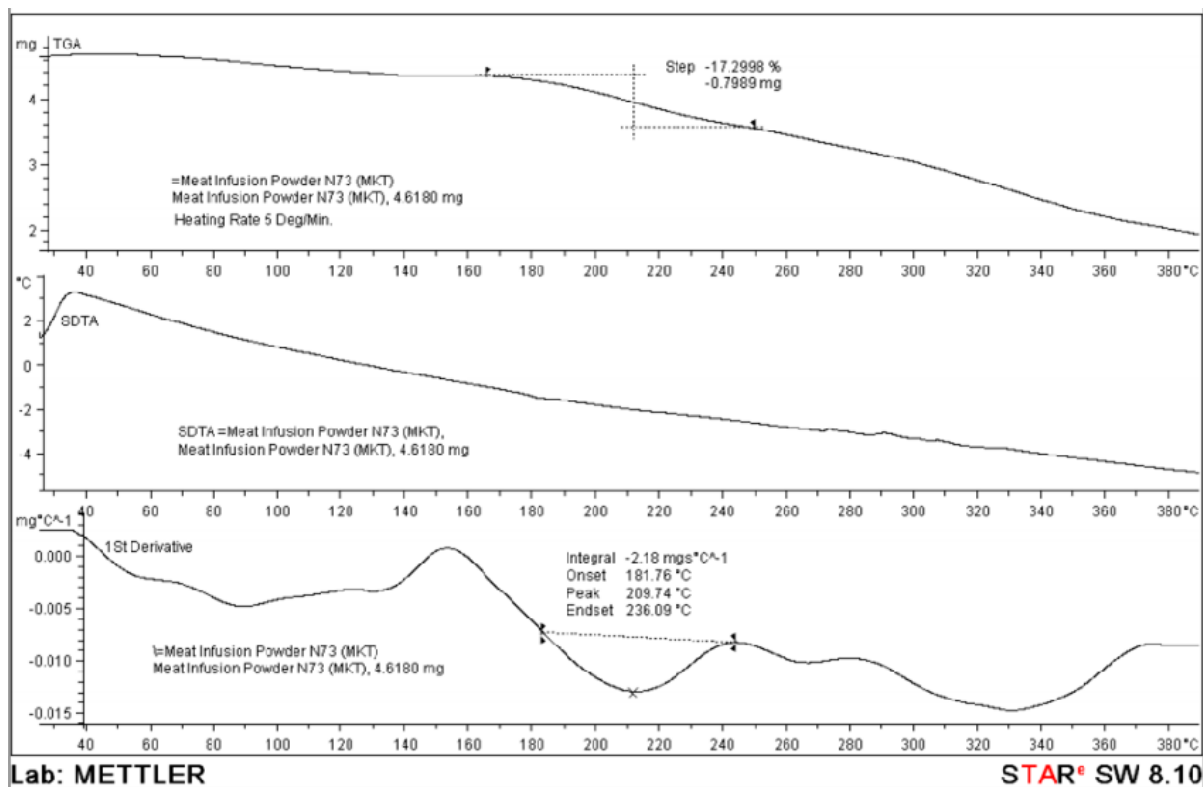


Figure 10a: TGA thermogram of control meat infusion powder.

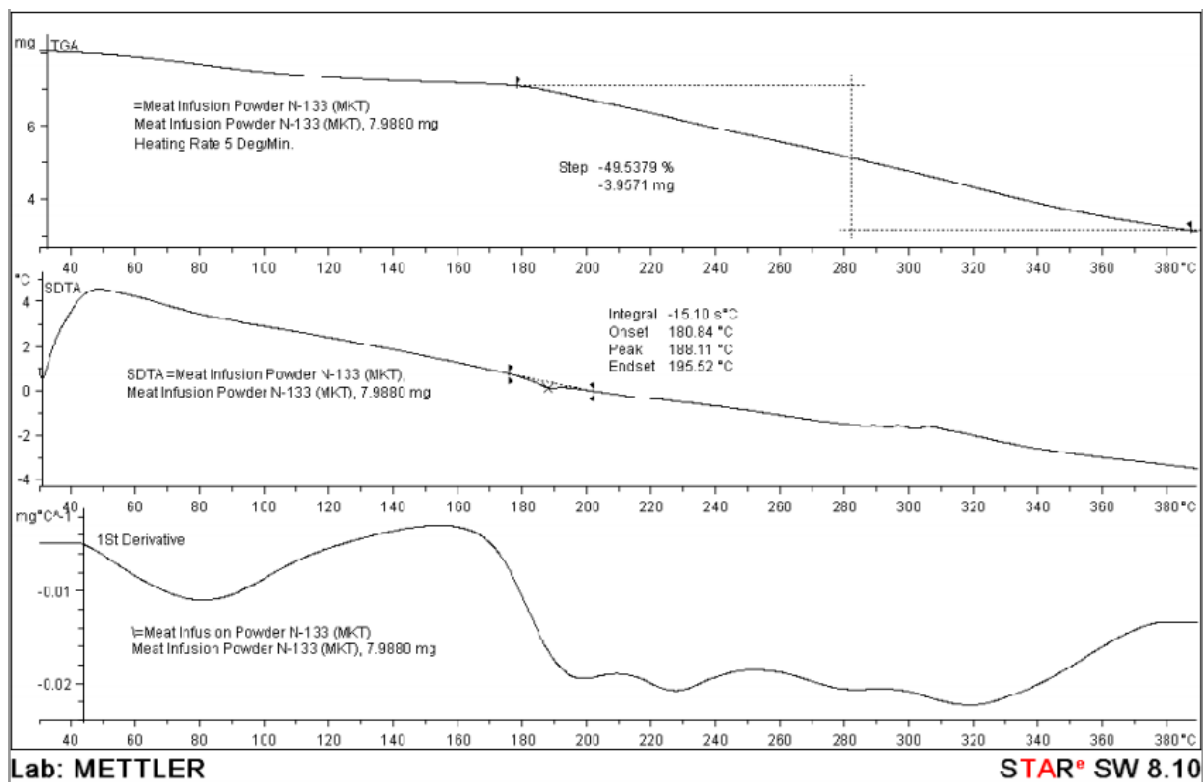


Figure 10b: TGA thermogram of treated meat infusion powder.

melting temperature in BEP and MIP of treated powders as compared to control. However, decrease in specific heat capacity (ΔH) was observed in treated samples (BEP and MIP) as compared to control. It is postulated that no extra energy or heat was required in order to raise the powder temperature as the treated samples were already in high energy state due to bio-field treatment. The increased melting temperature and maximum thermal decomposition temperature of treated samples showed the higher thermal stability. Based on the results achieved, we conclude that, the removal of triglycerides could lead to an improvement in the aroma and food quality of beef extract and meat infusion powder.

Acknowledgement

The authors would like to thank all the laboratory staff of MGV Pharmacy College, Nashik for their assistance during the various instrument characterizations. We thank Dr. Cheng Dong of NLSC, institute of physics, and Chinese academy of sciences for permitting us to use Powder X software for analyzing XRD results.

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