

A Study of Extraction of Ferulic Acid from Bamboo Plant

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Abstract: Bamboo is intricately associated with humans from times immemorial. Popularly known for their industrial uses, a lesser known fact of bamboos is the usage of its young shoots as a food that can be consumed fresh, fermented, or canned. Due to demand, new and improved methods are implemented for extraction of Ferulic acid from bamboo shoots. Recent development in solvent extraction techniques focuses on enhancing the conventional techniques with the assistance of microwave heating (MAE), electric fields (PF & HVED). The present work discusses the effect of microwave radiation & high voltage electric discharge on rate of extraction. The efficiency of the solvent extraction can be enhanced by employing microwave and electric fields and charges into the extraction system. Various parameters like effect of solvent, microwave power, irradiation time, and effect of pulse rate were studied. The results obtained show that rate of extraction is significantly higher than conventional extraction techniques. These methods have high prospect of industrial applications for release of valuable components from bamboo shoot.

Keywords: Bamboo Shoot, Ferulic acid, HVED & MAE.

1. Introduction

The potentially reactive derivatives of oxygen, attributed as Reactive Oxygen Species (ROS), are continuously generated as a by-product of metabolism of oxygen in mitochondrial respiratory chain inside the human body. Reactive oxygen species may cause damage to DNA and cell membranes, including oxidation that membrane lipid peroxidation, decreased membrane fluidity and mutation leading to cancer, degenerative disease including atherosclerosis, ischemic heart disease, ageing diabetes mellitus and others.

Antioxidants are compounds that inhibit or delay the oxidation process by blocking the initiation or propagation of oxidizing chain reactions, so diseases linked with free radicals can be therapy. Reactive Oxygen Species (ROS) are fully inactivated by intricate cellular and extracellular Antioxidants Defense Systems (AODS). An imbalance between the generation and neutralization of ROS due to altered redox homeostasis within the cell leads to Oxidative stress (OS) & persuade oxidative damage to various biomolecules including lipids, proteins, DNA and lipoproteins. This imbalance may be either due to deficiency of the antioxidants system or overproduction of Reactive Oxygen Species (ROS) [1].

Although body's intrinsic AODS including ROS quencher

enzymes such as Dismutase (SOD) Superoxide, Glutathione Peroxidase (GPx), Glutathione Reductase(GRed), Glutathione-Stransferase, monamine oxidase, Catalase (CAT) and xanthine

Oxidase etc. are able to arrest these Reactive Oxygen Species (ROS). But prolonged exposure to xenobiotic and infections cause irreversible oxidative to damage body by overtaking the intrinsic AODS and. Therefore, under the conditions of prolonged OS an exogenous supply of Antioxidants (AO) is warranted in order to maintain the redox homeostasis. This leads in keeping the debilitating disease in check.

Natural products from plants in human history have been used as fragrances, food additives, medicines and pesticides. Various medicinal properties have been attributed to natural herb. Medicinal plants contribute main source of new healthcare & pharmaceuticals products. The history of plants being used for medicinal purpose is as old as the history of mankind. The use of medicinal plants in industrialized society has been traced to extraction & development of several drugs from such plants. This green factory have given birth to some high activity profile drugs by extraction & characterization of several active phytochemicals.

One of the largest groups of plant metabolites are phenolic compounds that possess an aromatic ring bearing one or more hydroxyl constituents. These phenolic compounds are widely found in many edible plants as well as medicinal plants. A number of studies have focused on the biological activities of phenolic compounds, which are potential antioxidants and free radical scavengers. They possess biological properties such as anti-carcinogen, anti-inflammation, anti-aging, anti-atherosclerosis and cardiovascular protection. Several studies have described antioxidant properties of foods, medicinal plants and beverages which are rich in phenolic compounds. Many report suggest that plant which are having more phenolic content show good antioxidant activity because there is a direct correlation between total phenol content and antioxidant activity [2].

The possible reasons for carrying out an extraction might be: (1) the purification of a small amount of material for initial biological and chemical characterization to be performed, (2) to purify sufficient material in order to complete structural studies and further biological activity characterization or (3) the generation and supply of larger amounts of an already known

compound so that extensive biological testing such as pharmacology and toxicology can be performed on the material [3].



Fig. 1. Bamboo shoot

A. Nutrients present in bamboo shoot

The main nutrients present in bamboo shoots are protein, amino acids, carbohydrates, minerals, fat, sugar, inorganic salts and fiber. The shoots have a good profile of minerals, consisting mainly of manganese, potassium, calcium, chromium, copper, zinc, iron, plus lower amounts of phosphorus, and selenium. Fresh shoots are a good source of thiamine, vitamin A, vitamin B6, niacin and vitamin E. They contain 17 amino acids. 8 of them are essential for the human body. Tyrosine amounts to 57-67% of the total amino acid content. Fat content is comparatively low (0.26-0.94%). The shoots contain important essential fatty acids. It has total sugar content of 2.5% on average, is lower than that of other vegetables. The content of water is 90% or more.

Bamboo leaves are a rich source of hydrocyanic and benzoic acids. Tender bamboo shoots contain various enzymes such as nuclease, proteolytic enzyme, deamidase, amylase, amigdalin splitting and silicon splitting enzymes. Besides, the juice of the pressed bamboo-shoots possesses protease activity which helps digestion of proteins.

B. Medicinal value

Bamboo shoots have good anti-oxidant, anti-free-radical and anti-aging agents with different flavones, glycosides.

Bamboo shoots contain arginine, tyrosine, histidine and leucine as amino acids. The presence of amino acid such as tyrosine facilitates biochemical metabolism of our body. Adrenaline is synthesized in the medulla of the adrenal gland in an enzymatic pathway which converts the amino acid tyrosine into a series of intermediates and, ultimately, adrenaline. Thus it can be beneficial in patients with Parkinson's disease. It also plays important role in function of thyroid and pituitary glands that are involved in producing and regulating hormones in human body. Presence of high fiber and phytosterols in bamboo shoot reduces fat and cholesterol levels. Making them one of the important healthy foods in patients with lifestyle related disorders. The dietary fiber has a number of health benefits as it can protect our body from coronary diseases and potential carcinogens. Bamboo shoot was found to show increased gastro-intestinal movement, indicating its role in cholesterol lowering in individuals provided with bamboo diets.

The extracts of bamboo have anti-inflammatory, anthelmintic, antibacterial, diuretic property, antiulcer, antifertility, antimicrobial and hypoglycaemic activities. Leaves decoction is used as an antispasmodic in amenorrhea and dysmenorrhea. Bamboo leaf juice is given for strengthening the cartilage in osteoporosis and osteoarthritis.

2. Method of analysis

A. UV Spectrophotometer

We know that the spectrophotometry involves the use of a spectrophotometer. A spectrophotometer is a device that measure the light intensity measuring the intensity as a function of the source wavelength. The important features of spectrophotometer are spectral bandwidth and linear range of absorption or reflectance measurement.

A spectrophotometer device is commonly used for measurement of transmittance or reflectance of the solutions, transparent or opaque solids, like polished glasses, or gases. However, they can be designed to measure the diffusivity on any of the listed ranges that usually cover around 200 nm-350 nm using different controls and calibration within these ranges of light. Calibrations are needed on the machine using standards that vary in type depending upon the wavelength of the photometric determination. In present work we are using UV spectrophotometer for the analysis of Ferulic acid from Bamboo shoot [4].

3. Results and Discussion

A. Effect of solvent

Experiments were carried out using different solvents such as Methanol, Ethanol and Distilled water were used. It can be observed that the concentration of Ferulic acid increases with increase in polarity of the solvents. It is observed that the maximum percentage of extraction of Ferulic acid in Bamboo shoot is obtained by using Ethanol solvent. The initial rate of extraction of Ferulic acid is very rapid and becomes constant after about 90 minutes. The concentration obtained at this time were considered to be equilibrium concentration attained during the extraction. Initially concentration is more as more solute will be extracted by the solvent but as time goes on amount of solute will be lowers down.

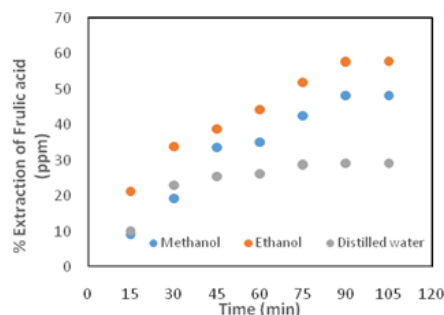


Fig. 2. Effect solvent on extraction of Ferulic acid from Bamboo shoot

Simultaneously rate of extraction will be less and also the ability of solvent to extract the solute from the Bamboo shoot will become less as solvent gradually reaches to its saturation point so extraction will be more during the first half period of extraction and in other half extraction is very minute compared to first half period. Fig. 2 shows the effect of solvents on extraction of Ferulic acid from bamboo shoot. The polarity of compounds and principle properties were responsible for this result [5].

B. Effect of Temperature

The experimentation study was carried out at various temperatures such as 25° C, 40° C and 50° C. It can be observed that the concentration of Ferulic acid increases with increase in temperature. The initial rate of extraction of Ferulic acid is very rapid and becomes constant after about 90 minutes.

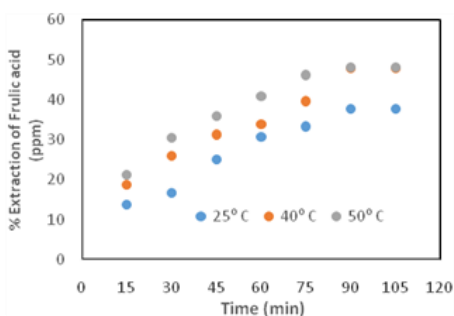


Fig. 3. Effect of temperature on extraction of Ferulic acid from Bamboo shoot

The concentrations obtained at this time were considered to be equilibrium concentration attained during the extraction. The concentration of extraction of Ferulic acid obtained at higher value at higher temperature of 50° C. Fig. 3 shows the effect of temperature on extraction of Ferulic acid from Bamboo shoot.

C. Effect of speed of agitation

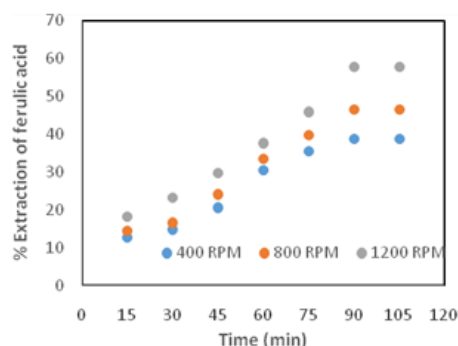


Fig. 4. Effect of speed of agitation on extraction of Ferulic acid from Bamboo shoot

The extraction of Ferulic acid was carried out at 400 rpm, 800 rpm and 1200 rpm. It was observed that the concentration of Ferulic acid increases with increase in speed of agitation. The initial rate of extraction of Ferulic acid is very rapid and

becomes constant after about 90 minutes. The concentration obtained at this time was considered to be equilibrium concentration attained during the extraction. The concentration of extraction of Ferulic acid obtained at higher value at maximum agitation speed of 1200 rpm. Fig. 4 shows the effect of speed of agitation on extraction of Ferulic acid from Bamboo shoot.

D. Effect of microwave oven power

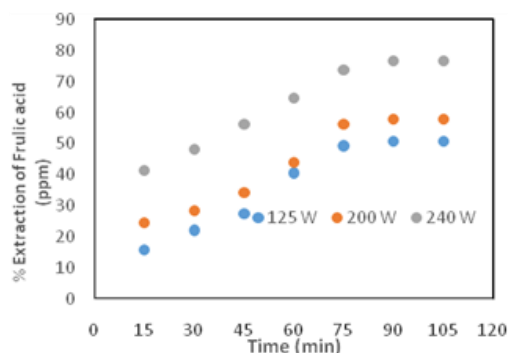


Fig. 5. Effect of microwave power on extraction of Ferulic acid from Bamboo Shoot

Extraction of Ferulic acid was studied by adjusting microwave oven power at 125W, 200W and 240W. It was observed that the concentration of Ferulic acid increases with increase in microwave oven power. The initial rate of extraction of Ferulic acid is very rapid and becomes constant after about 90 minutes. The concentration obtained at this time was considered to be equilibrium concentration attained during the extraction. As the microwave power increases, the intensity of wave increases which causes more cell rupture and higher rate of extraction. Fig. 5 shows the effect of microwave power on extraction of Ferulic acid. Similar results were obtained from experimental and modeling studies on microwave-assisted extraction of thymol from *Trachyspermum-ammi* (TA) [6].

4. Mathematical Modelling

The quantity and quality of the total phenolic compounds extracts are affected by numerous factors such as extracting solvents, solid to solvent ratio, the speed of agitation and extraction temperature. All these parameters were optimized by varying one parameter at a time while keeping other operating parameters constant. The maximum values of extraction concentration obtained from the various process parameters were considered as optimized parameters. Afterwards, the experimental kinetic data were analyzed with a steady state model equation imitative by Spiro and Siddique [7]. The extraction obtained at optimized parameters is the result of high rate of mass transfer into the liquid phase. The obtained optimized results and kinetics validation can be used to design the process for the commercial platform. The values of diffusion coefficient and mass transfer coefficient were comparable with the literature [7].

Table 1
 Effect of Various Parameters on Extraction of Ferulic Acid from Bamboo shoot

Parameter		Total FA contents (mg of FA/g of Bamboo shoot)	Kobs (min ⁻¹)	Diffusion coefficient D ×10 ⁻¹² (m ² /sec)
Effect of Solvent	Methanol	6.27	0.006	3.267
	Ethanol	9.077	0.007	5.079
	Distilled water	5.06	0.004	2.413
Effect of Tempera-ture	25 ⁰ C	5.75	0.005	2.064
	40 ⁰ C	6.44	0.006	3.312
	50 ⁰ C	6.87	0.006	3.938
Effect of Speed of agitation	400 rpm	6.54	0.005	3.339
	800 rpm	5.98	0.005	2.784
	1200 rpm	8.18	0.007	4.074
Effect of Microwave power	125 w	6.91	0.006	3.713
	200 w	9.89	0.007	5.034
	240 w	12.31	0.010	8.600

5. Conclusion

The effect of different parameters such as solvents, rate of pulse on MAE and HVED has been extensively studied. Extraction of Ferulic acid was performed with different solvents such as ethanol and methanol. Methanol was found to be the best solvent but Ferulic acid is used for consumption purpose and methanol is not suited for this purpose. Hence ethanol is used as solvent for extraction.

The extraction obtained at optimized parameters is the result of high rate of mass transfer into the liquid phase. The obtained optimized results and kinetics validation can be used to design the process for the commercial platform.

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