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Approaches for extraction of ferulic acid in wheat

Mekala Noah Shanthi Raj[1], Shivika Sharma[2], Vikas Sharma[3*]

[1] Department of Molecular Biology and Genetic Engineering, Lovely Professional University, Jalandhar, Punjab, India

[2] Department of Biotechnology, DAV University, Jalandhar, Punjab, India

[3] Assistant Professor, Department of Molecular Biology and Genetic Engineering, Lovely Professional University, Jalandhar, Punjab, India

Abstract

Ferulic acid (FA) is a hydrocinnamic acid derivative which has wide range of uses in pharmaceuticals, food sector and cosmetics. Wheat is a second most produced crop in the world and its barn constitute about 700 mg/kg of ferulic acid, which is considered as an important source of FA. This ferulic acid is been explored in recent times for its many health benefits to mankind. The various approaches are evolved and applied for its extraction. In this paper we will discuss briefly about few important extraction methods of ferulic acid.

Keywords: ferulic acid, wheat, extraction, cosmetics, pharmaceuticals, wheat barn

Introduction

Wheat is considered as major food crop with much of its production from India, China, Russia, European Union, United States and Canada [1]. In wheat grain, ferulic acid is the most abundant phenolic acid that has antioxidant capacity [2]. This ubiquitous compound, also known as 4-hydroxy-3-methoxycinnamic acid has numerous benefits against health related diseases like cancer, neurodegenerative diseases, diabetes and more [3]. About 150M tons of wheat bran is produced by industries and most of ferulic acid component is present in barn [4]. Most of the ferulic acid is present in bound from [5]. It is cross linked with polysaccharides by ester and ether bounds making complexes (lignin carbohydrate or phenolic carbohydrate), hence its release and purification a difficult process [6].

Bioavailability of ferulic acid

Ferulic acid main source is wheat barn but this compound FA is mainly bound with arabinoxylans of plant cell walls [7]. In wheat 90% of phenolic acids is ferulic acid and in the 90 % of ferulic acid 99% is in present in bound form [8]. However bio processing of wheat bran can increase the bioavailability of nutrients and chemical compounds which can be done through enzymatic treatment or other modern assisted technologies by feruloyl esterasen or by chemical treatment using bases [9].

Table 1: Ferulic acid concentration in wheat grain in mg/g dry matter:

Wheat bran tissues	Ferulic acid
Barn	5.26
Endosperm	0.10
Aleurone	8.17
Intermediate layer	5.92
Pericarp	8.18
Scutellum	3.48
Embryonic axis	0.31

From source [10]

Kinds of extraction

There are various kinds of methods administered for the extraction of component FA, some of the conventional extractions includes soxhlet extraction, mixing manually [11]. Conventional extraction uses traditional methods for extraction of phytochemicals by utilizing different kinds of solvent (ethanol, water, acetone, methanol). The other kinds of methods for extraction in use are, liquid pressurized extraction, enzyme mediated extraction, solid phase extraction, ultra sound mediated extraction, and microwave mediated extraction [11].

Microwave Assisted Extraction

Microwaves are electromagnetic waves made up of electric and magnetic field with frequency range 300 MHz to 300 MHz [12]. This method of extraction involves using microwave energy and solvents. Among the many solvents used, water is most used solvent because it is easily available and eco-friendly [13]. Acetone is accepted highly in extracting phenolic compounds from tissues of plants [14]. In MAE, microwave energy absorbed is converted into heat, when an electric field is applied; hence the solvent used must have dielectric constant high because of the heat generated via microwaves, have direct effect on molecules [14, 15]. With the ionic conduction and dipole rotation the temperature of solvents and solubility of desired analytes are increased [15]. MAE allows the localized heating with the compounds in matrix, leading to the expansion and rupturing of cell wall, thereby allowing essential organic materials or oils to flow into the organic solvent [16]. When wheat germ was evaluated with MAE at different levels of extraction time, ethanol concentration, irradiation power and liquid-solid ratio, the quantity of yield have obtained highest response value [17]. The MAE was not only administered successfully for the extraction of polyphenols in wheat bran but also in apple pomace, green tea leaves, grape seed and red raspberies [18].

Ultrasonic-Assisted Extraction

UAE is usually performed in ultrasonic device and is considered as better alternative for conventional mode of extraction technique due to its solvent composition, lower energy and higher efficiency [19]. The usual frequency of ultrasound waves occurs between 20KHz and 10 MHz. UAE is proven to be effective method for extraction with shortening the time and It is selectively used for the extraction of unstable and heat liable components [20]. Comparing to hydrolytic techniques, UAE is practiced to get the rich fraction of polyphenol extractions [21]. It is brought as important technology for reaching best result in extraction yields with quicker extraction rates [21].

In the experiment conducted by Hoa Thi Truong and his team, on ferulic acid production from rice ban, they have concluded that the yield of FA at 60 degree Celsius was 45% and at 75 degree Celsius was 80%, however by the use of ultrasonic method its yield increased to, 65% and 90% at 60 and 75 degree Celsius respectively [22]. UAE functions by the passing of ultrasonic energy through a liquid solvent, in the form of waves. When these waves hit the surface, force is generated either the parallel or perpendicular to the surface [23]. As the result, pressure increase with temperature and the cellular membranes disrupts resulting in the migration of chosen solvent into cell and extraction of desired compounds [23].

Pressurized Liquid extraction

This method of extraction was developed in mid 1990s [24]. PLE is a newly managed extraction method which uses organic solvents at high temperature and pressure [25]. The temperature normally used is 40 to 200 degree Celsius and pressure is 500 to 3000 p.s.i [25]. This kind of high temperature and pressure is used to maintain the solvent liquid state. As a result there is a physiochemical change in their properties, like surface tension of solvents and viscosity decreased with rate of mass transfer and solubility of analytes increased. By this solvent is penetrated inside the solid matrix easier, so high yield is seen incomparision with conventional mode of extraction [26].

When phenolic compounds are extracted by PLE in propolis samples, result shoed that recovery rate of phenolic compounds was in the range of 97.2% to 99.7%, which have shown much efficiency in extraction [27].

Enzyme mediated extraction

Phenolic acid esterases was first identified while preparation of extracellular enzyme from *Streptomyces virdosporus*. These help in hydrolases of the ester bond between hydroxyl cinnamic acid (ferulic acid) and hemicellulose which is present in plant cell wall [28]. Feruloyal esterases is an important enzyme in the extraction of ferulic acid from plant cell walls, these esterases are obtained in fungi and bacteria [29]. In fungi species *Aspergillus*(*A. niger and A. flavipes*) are active producers [29]. Currently, feuloyl esterase or in combination with other kind of enzymes like xylanase is administered for the extraction of ferulic acid from by-products of crop like wheat bran, rice barn and more [30]. These enzymes work co-ordinately in breaking arabinoxylan which is an important and abundant polysaccharides that may be feruloyated with the FA of wheat grain [31, 32]. These enzymes help in isolation of ferulic acid, from the bound form [32].

Conclusion

Wheat bran is rich sources of polyphenols like ferulic acid which has many health related benefits. It led in exploring the FA in recent times and its extraction methods are also evolving continuously. Importantly noted that, although many mechanisms for extraction of ferulic acid are available and administered, the enzymatic extraction is appreciated because of its eco-friendly steps as compared to other energy intense methods. The benefits of ferulic acid and evolving technologies have made its extraction easier with efficiency.

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