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Extraction of polyphenols: A new perspective in chemical synthesis

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Abstract
Polyphenols are class of compounds which are found in fruits, vegetables, walnuts, olives, tea leaves and many more. Polyphenols are antioxidant phyto-chemicals that prevent or neutralize the damaging effects of free radicals. They are secondary metabolites of plants and are generally involved in defense against ultra-violet radiation or aggression against pathogens. Polyphenols are various alcoholic compounds containing two or more benzene rings that each has at least one hydroxyl group attached. There are more than 100 naturally available products which contain polyphenols, the major dietary supplements are strawberry, grapes, pomegranate, cloves, spinach, black olive and tea which are available in the country and can be easily consumed. Polyphenols have wide range of applications *viz*., anti-ageing cosmetics, anti- cancer drugs, drugs to cure chronic disease, anti-oxidant rich beverages, helps in reducing cardio-vascular diseases, also constraints the levels of LDL.

Keywords: Extraction, polyphenols, Super critical extraction, antioxidant activity

Introduction

Polyphenols

Polyphenolic compounds are class of plant secondary metabolites characterized by polyphenol structure, which has several hydroxyl groups on two or more benzene rings. Several plant species have been reported to possess polyphenol, these polyphenols have the ability to scavenge free radicals formed from glycation and end products of the system. They prevent degenerative disease mainly cardio vascular and cancer [1].

Different class of polyphenols are phenolic acid, flavonoids, Stilbenes Lignans. Polyphenols are classified on the basis of the number of phenol rings that they contain and of the structural elements that bind these rings to one another. The chemical structure is illustrated in Figure 1 [2]. Three cups of tea per day has shown reduced risk of myocardial infarction of 11% and moderate consumption of wine and beer was associated with reduction of vascular risks. Table 1 signifies the action of polyphenols on human health [2].

Sources of Polyphenols

Polyphenols are mainly present in many fruits and vegetables. Some of them which contains maximum levels of dietary polyphenols are cloves, black olive, tea, apple, pomegranate, broccoli, green grape carrot, beetroot etc. Not all the polyphenols present in these food compounds are absorbed with equal efficiency, so study on polyphenols and bioavailability has been extensive in the recent ten years [3].

Table 1: Proposed mechanisms by which polyphenols may reduce risk for cardiovascular diseases

Antioxidants
Scavenge reactive oxygen and nitrogen species
Chelate redox-active transition metal ions
Spare and interact with other antioxidants
Inhibition of the redox-sensitive transcription factors
Inhibition of pro-oxidant enzymes
Induction of antioxidant enzymes
Growth of atherosclerotic plaque
Reduce adhesion molecule expression
Anti-inflammatory
Reduce the capacity of macrophages to oxidatively modify LDL
Platelet function and haemostasis
Inhibit platelet aggregation
Blood pressure and vascular reactivity
Promote nitric oxide-induced endothelial relaxation
Plasma lipids and lipoproteins
Reduce plasma cholesterol and triglycerides

Note: LDL; low-density lipoprotein [5].

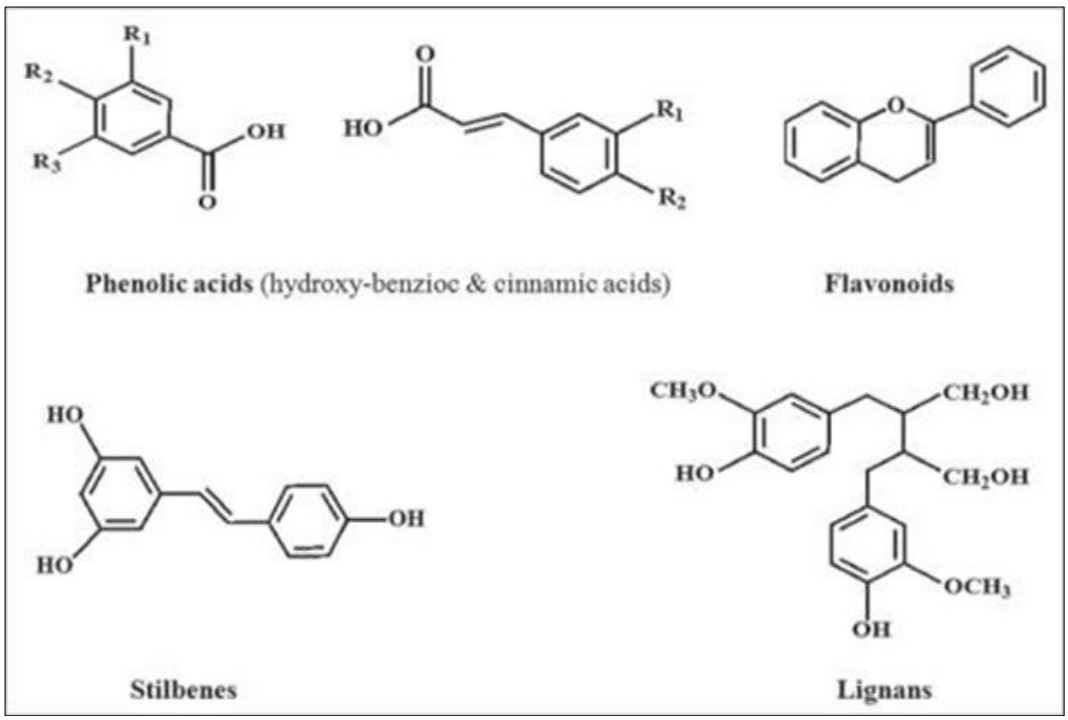

Fig 1: Chemical Structure of Different Class of Polyphenols

Extraction

Extraction is a separation process in which a substance is separated from a matrix. Since ages people have been practising different methods of extraction to obtain various substances. The extraction of metals from ores and medicines from plants are followed from ancient times. Many industries now find separation indispensable, petroleum industry separates crude oil into products useful as fuels, and medicines are extracted from plants for healthy living [4]. Extraction normally is carried out using different solvents, where one or more solvents are used to dissolve the solute. The solvents used will only dissolve the solute rather it does not affect the chemical structure of the solute. One of the solvents is organic phase and the other is aqueous phase [5, 6].

Preparation of sample

Sample preparation is of main importance in any extraction analysis. Because of the great assortment of phenolics with respect to polarity, acidity, number of hydroxyl groups and aromatic rings, concentration levels, and complexity of the matrix, there is no coherence in the choice of pretreatment procedures. So the appropriate pre-treatment method can be found according to the analysed sample and compounds. Generally solid samples are subjected to milling, grinding, and homogenization which are then preceded by freeze drying or air drying. Liquid samples are first filtered or centrifuged and taken for extraction analysis [7].

Types of extraction process

Extraction is the main step for the recovery and isolation of bioactive phytochemicals from plant materials, before analysis. This is influenced by sample particle size, chemical nature, extraction method employed. Some of the important extraction method are solid phase, liquid- liquid, solid- liquid, soxhlet, supercritical fluid extraction and many more. The extraction strategies is shown in Figure 2 [8].

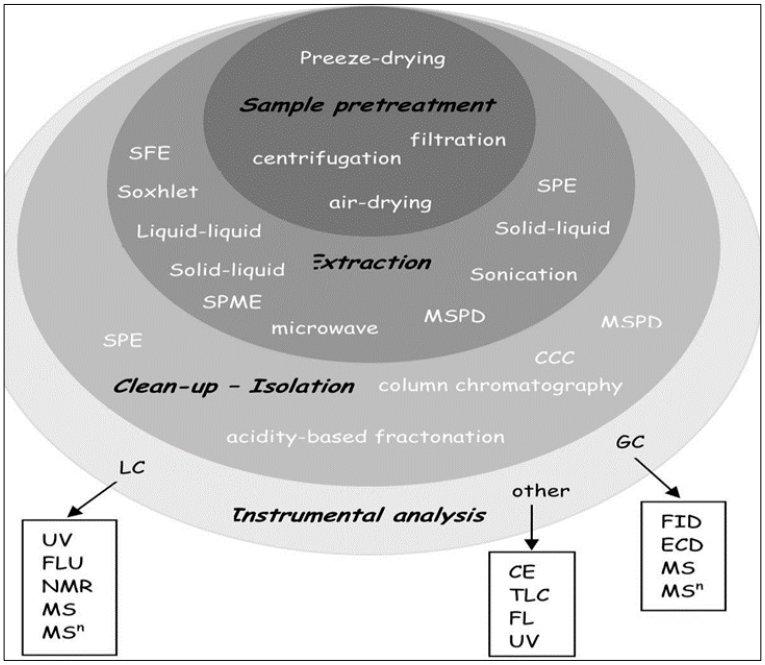

Fig 2: Schematic representation of extraction strategies of phenolic compounds

Liquid-liquid and solid-liquid extraction are commonly used for phenolic compounds because of their ease of use and wide range of applicability. But in recent times there are advanced technologies from which we can extract more amount of polyphenols than in solid-liquid or liquid-liquid extraction.

Liquid-Liquid Extraction

It is the concept of separating one or more components from a liquid mixture using a solvent. Here in this extraction the extractant get dissolved in the solvent and gets separated from the liquid mixture. The simplest extraction system comprises three components: the solute or the material to be extracted; the solvent, which must not be completely miscible with the other liquids; and the "carrier," or non-solute portion of the feed mixture to be separated. This extraction can be carried out in single stage or multiple stage extractor with counter current and co-current fashion [8].

Solid-Liquid Extraction

Solid-liquid extraction is commonly known as leaching. The soluble matter which is present in an inert matrix are extracted by means of a solvent. One of the best example is extraction of caffeine from coffee [9].

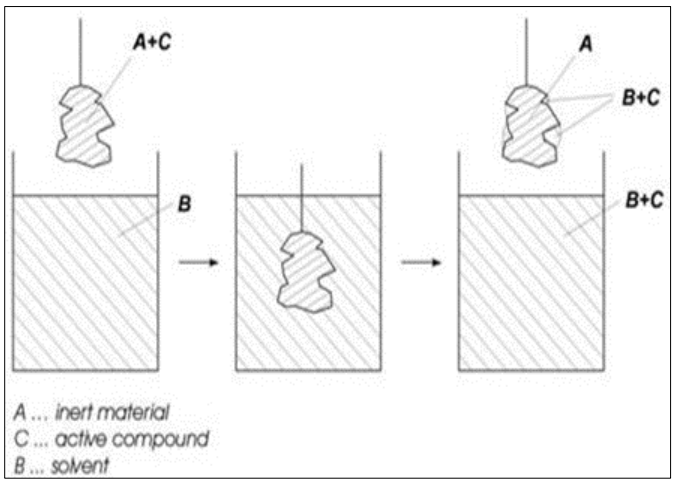

Fig 3: Schematic Representation of General Solid-Liquid Extraction

Leaching process can be considered in three parts

- Diffusion of the solvent through the pores of the solid
- The diffused solvent dissolves the solutes (i.e. transfer the solute to the liquid phase).
- Transfer of the solution from porous solid to the main bulk of the solution.

A simple diagram representing the solid-liquid extraction is given in the Figure 3 [10]. Certain points have to be considered for economic extraction of the material. The extraction material must be made in such a way as to achieve extract in short period of time, this can be done by grinding and milling. Solvent selectivity and temperature of extraction is a major step, the solvent has to be selected so only the desired extract is soluble in the solvent. Separation of solvent and desired extract must be economical. Microwave assisted, solid-phase, soxhlet extraction are different types of extraction which are under soli-liquid extraction process.

Soxhlet Extraction

Soxhlet extraction was first designed for extraction of lipid material from a solid matter, but this can be used for extraction when if the desired component has limited or low solubility in a solvent. The typical extractor is shown in the Figure 4 [11].

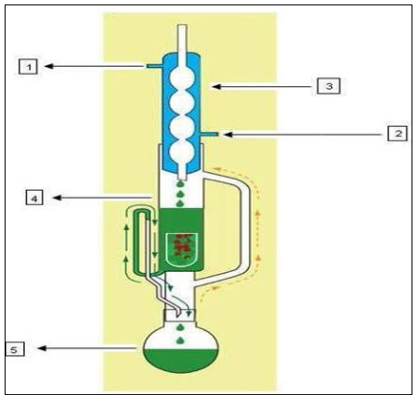

Fig 4: Soxhlet Extractor: 1). Water Outlet, 2). Water Inlet, 3). Soxhlet Condenser 4). Soxhlet Extractor, 5). Round Bottom Flask.

Microwave Assisted Extraction

Microwave assisted extraction (MAE) is a process of heating solvents in contact with a sample with microwave energy to partition compounds of analytical interest from the sample matrix into the solvent. This method allows rapid sample preparation and extraction with limited solvent and elevated temperatures. In this method the solvent is in direct contact with the matrix unlike the soxhlet extraction method. The major advantage of MAE over the soxhlet is it can reach elevated temperature and these temperatures can be maintained for consistent amount of time [12].

Solid Phase Extraction

Solid phase extraction mainly concentrates on separating out a desired component from liquid mixture by passing it on to a stationary phase. This technique involves the affinity of solute to the solid matrix through which the samples are passed. The SPE consists of a reservoir tube in which the liquid mixture is given as the input. This sample passes through the matrix and the mixture having low affinity towards the matrix flows down and can be collected [13].

High Pressure Extraction

Supercritical Fluid Extraction (SFE) is the process of separating one component (the extractant) from another (the matrix) using supercritical fluids that is CO_2 as the extracting solvent, this is the only method followed in high pressure extraction process.CO_2 is the king of extraction solvents for botanicals. Extraction conditions for supercritical CO_2 are above the critical temperature of 31 °C and critical pressure of 74 bar. Supercritical fluids are highly compressed gases, which have combined properties of gases and liquids in an intriguing manner.

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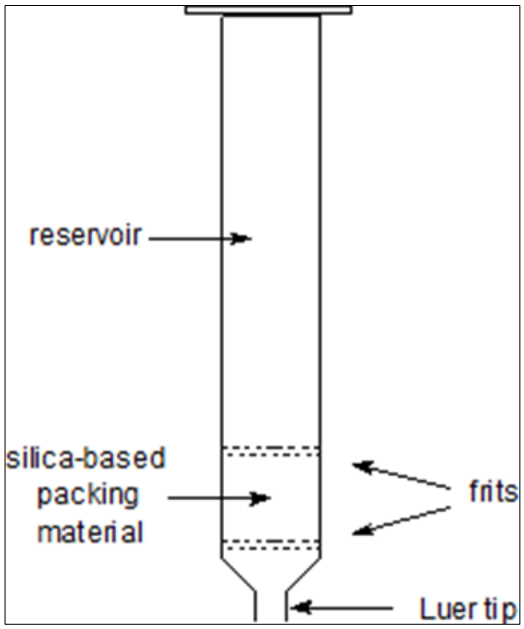

Fig 5: Representation of SPE Tube

Properties of Supercritical Fluids (SCF)

In slight changes in the temperature at critical point has impact on its pressure. The other properties which have drastic change at critical point are surface tension and viscosity. These changes make supercritical fluid more feasible over other solvents.

Advantages of SFE

Solvating power of SCF are similar to other solvents but with higher diffusivities, lower viscosity and lower surface tension. The SCF's are easily available, cheap and simple [14].

Conclusion

According to the recent review, supercritical fluid extraction is more feasible than any other kind of extraction method. The separation of the desired component from the solvent can be achieved more when compared with liquid- liquid or solid-liquid extraction. The huge number of research carried out in the recent years on phenolic compounds and flavonoids justifies the significance of the compound. Finding out an appropriate extraction method is based on the matrix structure, selectivity of the process based on the desired product. Complex extracts of plant constituents often require very effective separation techniques to allow the identification of different compounds, so research is extensive in the field of SFE. Since polyphenols are present in all most all fruits and vegetables, so use of solid waste should be emphasized for extraction to reduce the environmental pollution.

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