POLYPHENOL (APFC) CONTENT IN CERTAIN PLANT EXTRACTS CORRELATED WITH ANTITUMOR THERAPEUTIC ACTIVITY

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DOI: https://doi.org/10.66793/titum19proceeding21

Abstract

Phytotherapy is widely used to treat and prevent various medical conditions and is well known among the general population. Interest in natural compounds with therapeutic potential has increased significantly, as they represent a rich source of bioactive substances with diverse pharmacological properties. In this article, we will analyze the composition of polyphenols and the biological roles of some plants, highlighting their importance in phytotherapy and nutrition. Comparing three plants, it is observed that each has a unique polyphenol composition: plantain contains predominantly flavonoids and caffeic acid, rhubarb is rich in anthraquinones and phenolic acids, and echinacea contains chicoric acid and echinacoside. Thus, the three plants complement each other and can be associated in natural therapies aimed at immune protection and cell regeneration.

1. INTRODUCTION

Phytochemistry, the main branch of Pharmacognosy, has as its basic objective the isolation of phytochemical compounds contained in various plant and animal raw materials, through the use of different technological processes, and subsequently the identification and dosage of these compounds through physicochemical methods frequently used in specific laboratories [1, 2].

APFC (Antioxidant Polyphenolic Functional Compounds) polyphenols represent a complex category of natural compounds present in the plant kingdom. They are recognized for multiple beneficial effects on the human body: antioxidant properties (neutralize free radicals and protect cells), anti-inflammatory effects (reduce chronic inflammation), anticancer effects (inhibit tumor cell proliferation), cardiovascular protection (improve blood vessel function), and neuroprotective effects (help maintain brain health) [3].

APFC polyphenols are found in numerous medicinal plants, including plantain, rhubarb, and echinacea. Each plant contains a specific profile of polyphenols responsible for its therapeutic effects. In this article, we will analyze these plants' polyphenol composition and biological roles, highlighting their importance in phytotherapy and nutrition [4].

Plantain is one of the most widely used medicinal plants in Romania's wild flora. It contains a wide range of polyphenols, including caffeic acid, ferulic acid, chlorogenic acid, verbascoside (acteoside), luteolin, and apigenin. Plantain leaves are also rich in tannins, which contribute to their astringent and antibacterial effects [5].

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Rhubarb is a perennial plant known for its laxative, hepatoprotective, and antitumor properties. Its rich content of polyphenols explains many of its therapeutic actions. Among the most important compounds are gallic acid, caffeic acid, and catechins [6].

Echinacea is one of the most popular immunostimulating plants. It contains numerous polyphenolic compounds, the most important of which are chicoric acid, caffeic acid, ferulic acid, echinacoside, and kaempferol. Of these, chicoric acid is considered the primary phytochemical marker of the plant [7].

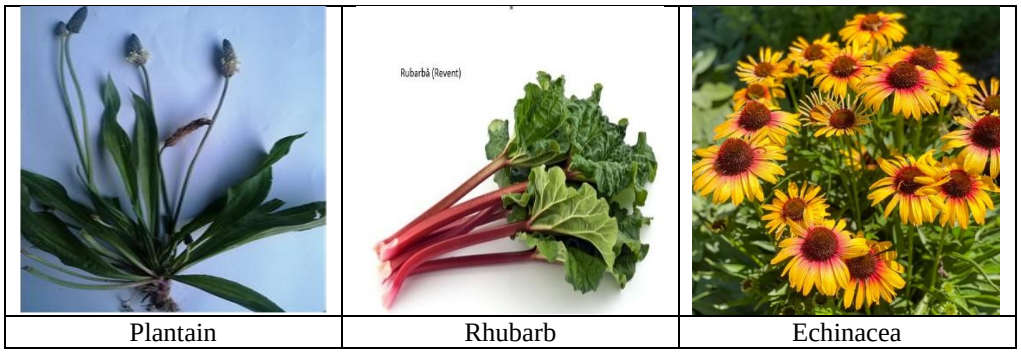
2. EXPERIMENTAL DETAILS

Compounds isolated from plant materials are analyzed through qualitative and quantitative methods to determine these products' identity, purity, and quality with recognized therapeutic potential. We identified and characterized the bioactive compounds in plantain, rhubarb, and echinacea extracts using advanced analytical techniques, exploring how they influence therapeutic activity.

Plantain is a herbaceous plant, widely distributed throughout the world. It is known for its ability to survive in diverse environmental conditions and its rich chemical composition, which includes a variety of bioactive compounds, such as polyphenols, flavonoids, iridoids, and terpene compounds. Plantain is a valuable plant appreciated for its multiple benefits to the body. It contains a variety of bioactive compounds, including flavonoids, alkaloids, terpenoids, phenolic compounds (derivatives of caffeic acid), iridoid glycosides, fatty acids, polysaccharides, and vitamins (**Figure 1**).

Rhubarb is one of the oldest, most commonly used, and important medicinal plants in Chinese medicine. Modern research on rhubarb has clarified its efficacy, phytochemical compounds, and mechanisms of action in a more scientific and rigorous way. The main chemical constituents of rhubarb include anthraquinones, anthrones, stilbenes, tannins, and polysaccharides (**Figure 1**).

Echinacea is a medicinal plant native to North America. It has been used for centuries to strengthen the immune system and prevent colds and diseases. Echinacea is one of the most important modern medicinal plants, with remarkable properties in stimulating immunity and preventing diseases. Used correctly, it helps maintain the body's health and protects against infections (**Figure 1**).



Plantain	Rhubarb	Echinacea

Figure 1. Medicinal plants

2.1. Obtaining plantain, rhubarb and echinacea extracts in the laboratory

Extracts derived from plantain, rhubarb, and echinacea were obtained through a systematic series of processes utilizing hydroalcoholic or aqueous solvents. The extracts generated are characterized by their hydroalcoholic or aqueous nature.

The isolation of water-soluble active principles from the studied plant products is carried out by aqueous extraction. Ethyl alcohol is used in different concentrations (30-70%) to isolate compounds soluble in organic solvents. In the laboratory experiments, alcoholic extraction was used to obtain tinctures, hydroalcoholic extracts by various methods, such as maceration, percolation, and reflux extraction. In the laboratory, hydroalcoholic extracts were obtained from plantain, rhubarb, and echinacea powder by the reflux extraction process, with 30%, 50% and 70% alcohol and a tincture, obtained by cold maceration with ethyl alcohol of 50-70% concentration.

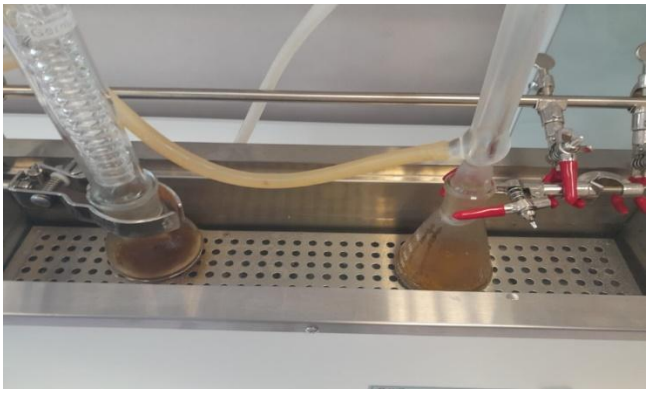


Figure 2. Reflux extraction process

These laboratory-obtained extracts were used to identify and study the dosage of active compounds from plantain, rhubarb, and echinacea.

2.2. Physico-chemical characteristics of the raw material of plantain, rhubarb, and echinacea

According to the data presented in the monograph of the European Pharmacopoeia, the current edition for the plant products plantain, rhubarb, and echinacea, the pharmacognostic analysis provides for a series of qualitative and quantitative analysis methods. The identification methods are based on color or precipitation reactions with the necessary reagents. High-performance instrumental techniques such as UV-Vis spectrophotometry and flame atomic absorption spectrometry are used for the dosages.

2.3. Identification of flavone derivatives

The identification of flavone derivatives present in plant products such as plantain, rhubarb, and echinacea was carried out in the laboratory based on the color reaction that occurs in the presence of aluminum chloride and sodium acetate. In this case, a yellow color is observed, characteristic of the presence of flavone derivatives in the sample to be analyzed.

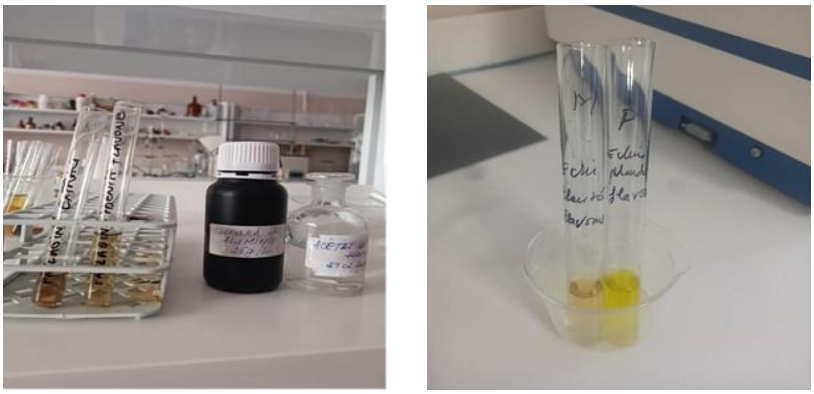


Figure 3. Identification of flavones from the extracts

2.4. Identification of polyphenolcarboxylic acids

From the plant products plantain, rhubarb, and echinacea, to identify phytochemical compounds with antioxidant properties from the category of polyphenolcarboxylic acids, the color reaction that occurs in the presence of Folin

Ciocâlteu reagent and sodium carbonate solution was used. In this case, the appearance of a blue-green color is characteristic of the presence of these compounds.

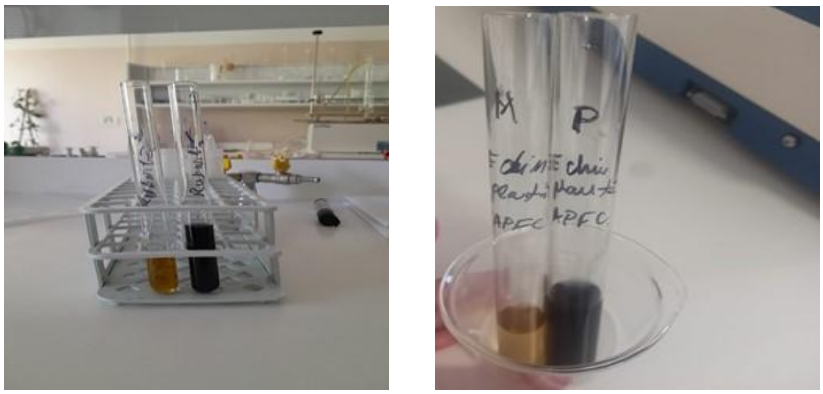


Figure 4. Identification of polyphenolcarboxylic acids

2.5. Determination of total polyphenol content expressed in gallic acid equivalent and caffeic acid equivalent in plantain, rhubarb and echinacea

The total polyphenols expressed in gallic acid equivalent and caffeic acid equivalent was determined using UV-Vis spectrophotometry. Samples of the plant product, plantain, rhubarb and echinacea powder and tincture prepared in the laboratory by maceration in 70% ethyl alcohol, and a series of hydroalcoholic extracts obtained by reflux extraction with 30%, 50% and 70% ethyl alcohol, as well as an aqueous extract obtained by reflux extraction, were analyzed.

Figure 5. Determination of total polyphenols by UV-Vis spectrophotometry

To determine the total polyphenol content, 5 mL of diluted Folin–Ciocalteu reagent is added to a volume of 1 mL of test solution, homogenized by stirring. After an interval of 3–5 minutes, it is completed with 4 mL of sodium carbonate solution (7.5%). The mixture obtained is left to stand for one hour, a period necessary for developing the specific color of the phenolic complex. Subsequently, the spectrophotometric absorption of the solution is determined at a wavelength of 765 nm (for gallic acid equivalent) and 748 nm (for caffeic acid equivalent). As a control (blank), a sample prepared identically to the one to be analyzed is used, in which 9 mL of purified water, without Folin–Ciocalteu reagent, is added to 1 mL of extract. Using the same spectrophotometric equipment, the total polyphenol concentration is calculated based on the calibration curve obtained for gallic acid (at 765 nm) and caffeic acid (at 748 nm). The results are expressed in µg/mL, and the values obtained are presented in the Table, corresponding to total polyphenols expressed in gallic acid equivalent and caffeic acid equivalent.

Table 1. Total polyphenol content expressed in gallic acid and caffeic acid equivalents from extract samples

Plant product	Sample name	Total polyphenol content - gallic acid, [g/100g]	Total polyphenol content - caffeic acid, [g/100g]
Rhubarb	Aqueous extract	0,04	0,036
	30% ethyl alcohol extract	3,5	3,2
	70% ethyl alcohol extract	4,9	4,4
	Tincture	4,6	4,3
Echinacea	Aqueous extract	0,21	0,19
	30% ethyl alcohol extract	0,28	0,24
	70% ethyl alcohol extract	0,56	0,52
	Tincture	0,52	0,48
Plantain	Aqueous extract	0,18	0,10
	30% ethyl alcohol extract	2,6	2,2
	70% ethyl alcohol extract	3,1	2,9
	Tincture	3,0	2,7

3. ANTITUMOR EFFECTS OF PLANT PRODUCTS CONTAINING POLYPHENOLS

Polyphenolic compounds exhibit multiple mechanisms of antitumor action, acting at different stages of cancer development - initiation, promotion, and progression. Their effects include:

a) inhibition of cell proliferation (certain flavonoids, such as quercetin, apigenin, and luteolin, interfere with cell cycle progression by inducing G1 or G2/M arrest, reducing tumor cell proliferation)

b) induction of apoptosis (phenolic acids and anthraquinones activate intrinsic apoptotic pathways, increasing the expression of pro-apoptotic proteins (Bax, caspase-3) and reducing anti-apoptotic proteins (Bcl-2)

c) suppression of angiogenesis and metastasis

d) epigenetic modulation

e) immunomodulatory effects (plant extracts enhance the activity of macrophages and natural killer (NK) cells, increasing the ability of the immune system to identify and eliminate malignant cells)

Polyphenolic compounds represent a valuable category of natural antioxidants with demonstrated antitumoral potential [8]. Their multifactorial mechanisms-from free radical scavenging to apoptosis induction and immune modulation-make them promising candidates for preventive and adjuvant cancer therapy. The continuous study of polyphenols as individual molecules and as part of complex plant extracts offers new directions in developing natural and biocompatible anticancer agents [9].

4. CONCLUSIONS

Polyphenols (APFC) are an important group of natural compounds that play an essential role in protecting the human body. Regular consumption of foods rich in polyphenols contributes to the prevention of chronic diseases,

strengthening the immune system, and maintaining cellular youth. These compounds demonstrate that nature provides valuable resources for human health, and a balanced plant-based diet is the key to longevity.

Polyphenols in plantain, rhubarb, and echinacea play an essential role in the therapeutic action of these plants. Through their antioxidant, anti-inflammatory, and immunostimulatory effects, these compounds contribute to maintaining the physiological balance of the body and preventing degenerative diseases. Controlled consumption of these plants, in teas, extracts, or supplements, can represent a valuable natural source of antioxidants.

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