MATERIALE PLASTICE
https://revmaterialeplastice.ro
https://doi.org/10.37358/Mat.Plast.1964

Extraction and Identification of Natural Rubber from the Latex Obtained from *Ficus Carica*. Latex Characterization

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Abstract: *Natural rubber is a material, of vital importance, which is formed not only by the Hevea brasiliensis tree but also by various plant species (Carica papaya, Ficus carica, Taraxacum kok-saghyz, Parthenium argentatum). Amongst these, only the species Taraxacum kok-saghyz and Parthenium argentatum are explored as alternative sources of natural products. The goal of this article was to assess the screening of latex extracts, the determination of density, the determination of total solids, the determination of alkalinity, the determination of conductivity, the determination of total polyphenol content, the determination of total flavonoid content, the determination of antioxidant activity, the rubber extraction and the determination of rubber moisture. The screening result revealed the presence of proteins, amino acids, fatty acids, carboxylic acids, resins, alkaloids, phytosterols, terpenes, diterpenes, terpenoids, coumarins, polyphenols, flavonoids, saponins, steroids and the absence of catechins, glycosides, xanthoproteins, and anthocyanins. Following the determinations, the following values of the determined parameters were obtained: density 0.977 g* mL^{-1}*, total solids 43.5%, alkalinity 0.53%, conductivity 210* $\mu S\ cm^{-1}$*, total polyphenols 349.7* μg *GAE* mL^{-1}*, total flavonoids 13.4 mg EC* g^{-1}*, DPPH antioxidant activity 59.75%, ABTS antioxidant activity 511* μg *TE* mL^{-1}*, rubber mass 3.78% and rubber moisture 98.2%.*

Keywords: *Ficus carica latex, phytochemical screening, rubber*

1. Introduction

Latex has a white color as milk being formed by droplets of organic matter dispersed in an aqueous medium [1]. Vegetal latex and other exudates are saps that are exuded from points of plant deterioration due to mechanical actions or by insects or herbivores [2].

It accumulates either in the living cells and/or specialized structures called laticifera or in intercellular secretory channels or channels lined by epithelial cells that secrete substances into the channel [3]. Latex consists of three main phases: the rubber phase, the aqueous phase, and the lutoid phase (the lutoid phase consists mainly of water). In addition, it also contains other materials such as soluble proteins, insoluble proteins, phospholipids, and carotenoids) [4]. The physical properties of latex are divided into color, exudation, stickiness, and coagulation.

Based on the physical-chemical properties, there are several subtypes of latex, but the most known is rubber latex which is an important source of natural rubber, a product being a secondary metabolite with no known function in plants [5]. Plant species have been considered as a possible source of latex-containing rubber. *Ficus carica* (figs) is one of the species used in the extraction of natural rubber.

Ficus carica L. is one of the oldest plants cultivated by humans and originates from Southwest Asia [6]. In Romania, the best areas are in the South and Southwest of the country, the Black Sea coast, or areas where the climate has a Mediterranean influence. Therefore, significant fig plantations can be found in Eforie Sud, Eforie Nord, Tuzla, Techirghiol, and Mangalia. The fig tree is also cultivated in Drobeta Turnu Severin, Orșova, Arad, Timișoara, Oradea, on the Danube Cluster, Sviniţa and Simian [7].

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2. Materials and methods

2.1. Chemicals

The following reagents were used in this research:

2,2′-Azinobis-(3-Ethylbenzthiazolin-6-Sulfonic acid) (ABTS), 2,2-diphenyl-1-picrylhydrazyl (DPPH), 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid (TROLOX), absolute ethanol, acetic anhydride, ethanoic acid, aluminum chloride, ammonia, chloroform, cooper acetate, distilled water, Ehrlich reagent, ether, ferric chloride, Folin-Ciocâlteu reagent, gallic acid, hexane, hydrochloric acid, lead acetate, Mayer's reagent, methyl red, Miller's reagent, ninhydrin, nitric acid, potassium acetate, potassium persulfate, sodium bicarbonate, sodium carbonate, sodium hydroxide, sulphuric acid.

The samples were collected in July from Sadova, Dolj County, Romania, with the following geographical coordinates: latitude: 43°54′07″ North, longitude: 23°58′01″ East.

The fresh natural rubber latex was obtained from *Ficus carica* leaves close to the stem and cross-sectioned by surgical scissors and from the place where the leaves are detached from the sprouts, Figure 1. The latex was collected drop by drop in brown glass vials. Since rubber latexes coagulate spontaneously a few hours following harvesting, they must be stabilized to ensure their preservation without coagulations. These coagulations occur following the increase in the acidity of the latex as a result of the interaction of the microorganisms with the non-rubber compounds from latex with the release of H+ ions that neutralize the minus load around the rubber particle. An electrostatic destabilization takes place that causes latex coagulation [4]. Another way of latex coagulation is produced by the release of fatty acid anions resulting from the hydrolysis of lipids present in the latex. These anions adsorbed on the surface of the particles interact with the divalent metal ions, such as Ca^{2+}, and Mg^{2+} initially present in latex, creating the interaction between the rubber particles. This causes the coagulation of rubber particles [4]. The stabilization generally consists of adding ammonia in a proportion of 5 to 7 g per litre of latex and stored at −20°C until use.

Figure 1. Extraction of natural latex from *Ficus carica*

2.2. Characterizations of the fresh natural latex

Analysis and testing of latex properties include: Preliminary phytochemical screening, density determination, total solids determination, latex alkalinity determination, conductivity determination, total polyphenol content determination, total flavonoid content determination, antioxidant activity determination, rubber extraction and rubber moisture determination.

2.3. Preliminary phytochemical screening of latex

To determine the phytochemical screening, the following operations were necessary:

Obtaining the aqueous extract from latex

30 mL of latex was diluted with 15 mL of distilled water and then centrifuged for 10 min at 4.000 rpm to remove the gum and other debris. Following centrifugation, the insoluble material was removed and the supernatant was filtered using Whatman paper no. 1 on the Buchner funnel and collected in a glass vial for direct use in determinations.

Obtaining the methanolic extract from latex

30 mL latex was diluted with 20 mL methanol and centrifuged for 5 min at 4.000 rpm. Following centrifugation, the supernatant liquid was filtered using Whatman paper no. 1 on the Buchner funnel and collected in a glass vial for direct use in determinations.

Obtaining the latex extract with hexane

30 mL latex was mixed with 20 mL hexane and filtered using Whatman paper no. 1 on the Buchner funnel. The filtered liquid was collected in a glass vial for direct use in the determinations.

Preliminary phytochemical screening of latex

The phytochemical screening of the extracts was performed using standard procedures described by other authors [8–15]. The following qualitative tests were performed:

Test for proteins

2 mL of Miller's reagent was added to 2 mL of extract, forming a white precipitate which turns red on heating.

Test for amino acids

A few drops of ninhydrin reagent were added to one mL of extract. The appearance of purple color shows the presence of amino acids.

Test for fatty acids

5 mL of ether was mixed with 1 mL of extract. Extracts were evaporated on a filter paper and the filter paper was dried. The appearance of transparency indicates the presence of fatty acids.

Test for carboxylic acids

Sodium bicarbonate is added to one mL of extract. The production of effervescence indicates the presence of carboxylic acids.

Detection of resins

25 mL of absolute ethanol was mixed with aqueous filtrate (5 mL) with stirring. The formation of a cloudy or white precipitate is positive for the presence of resins.

Test for tannins

A few drops of 0.1% ferric chloride were added to 3 mL of the filtrate and observed for brownish green or a blue-black coloration.

Test for alkaloids

Mayer's test: to a few mL of filtrate, add 2 drops of Mayer's reagent and form a creamy or white precipitate.

Test for polyphenols

To 1 mL of extract, a few drops of 5% solution of lead acetate form a yellow.

Test for flavonoids

Ferric chloride test: A few milliliters of the extract were treated with a few drops of ferric chloride solution, resulting in the formation of a blackish-red precipitate.

Test for saponins

0.5 mg of extract was shaken with a few mL of distilled water. The formation of frothing is positive for saponins.

Detection of catechin

A few drops of Ehrlich reagent and concentrated HCl were added to a few mg of the extract in alcohol and the pink color developed indicates the presence of catechin.

Test for phytosterols

The extract is dissolved in 2 mL of acetic anhydride to which 1 or 2 drops of concentrated H_2SO_4 is added along the sides of the tube and an array of color changes indicates the presence of phytosterols.

Test for terpenes

Salkowski test: 3 mL of the extract was used and 1 mL of chloroform and 1.5 mL of concentrated H_2SO_4 were added in a tube. The reddish-brown color formed at the interface is positive for terpenoids.

Test for diterpenes

Copper acetate test: Extracts are dissolved in water and treated with a few drops of copper acetate solution. The formation of an emerald green color indicates the presence of diterpenes.

Test for triterpenoids

10 mg of extract was dissolved in 1 mL of chloroform and there were added 2 mL of concentrated H_2SO_4 followed by 1 mL of acetic anhydride. The formation of a reddish violet color is positive for triterpenoids.

Test for glycosides

Borntrager's test: to 2 mL of filtrate, 3 mL of chloroform is added and shaken. The chloroform layer was separated and 10% ammonia solution was added. The pink color indicates the presence of glycosides.

Detection of coumarins

3 mL of 10% NaOH solution was added to 2 mL of aqueous extract. The formation of yellow color indicates the presence of coumarins.

Test for xanthoproteins

A few drops of nitric acid and ammonia are added to 1 mL of extract. A reddish-brown precipitate indicates the presence of xanthoproteins.

Test for anthocyanins

2 mL of aqueous extract was added to 2N HCl and it was followed by the addition of ammonia. The conversion of pink-red turns blue-violet indicates the presence of anthocyanins.

Test for steroids

2 mL of an extract with 2 mL of chloroform and 2 mL of concentrated H_2SO_4 are added, the appearance of red color and yellowish-green fluorescence indicates the presence of steroids.

Determination of the density of natural rubber latex

The density of latex samples was measured by using a pycnometer with a volume (Vp) of 50 cm^3 according to International Standard (ISO) [16].

Determination of total solids content (TSC) of latex

The TSC of natural rubber latex was determined according to International Standard (ISO) [17].

$SC = „m - 1.\text{-},m\text{-}$

Determintion of alkalinity of latex

A test portion of latex concentrate is titrated with hydrochloric acid to pH 6 in the presence of a stabilizer to prevent coagulation, with methyl red as a visual indicator. The alkalinity is calculated from the quantity of acid required from International Standard (ISO) [18].

Determination of latex conductivity

The latex conductivity was determined using the Five Easy F30 laboratory conductometer at 25°C. Approximately 150 mL of latex was added to a Berzelius beaker into which the electrode of the conductometer is inserted until the surface of the latex is at the specified point on the electrode. The conductivity value is expressed in $\mu S\ cm^{-1}$.

Determination of total polyphenol content in latex

The total polyphenol content of the latex was determined by the procedure described by Dumitru, 2016 [19] The total content of polyphenols was estimated using the gallic acid standard curve ($y = 0.0134x + 0.0171$, $R^2 = 0.9981$) where x is the absorbance and the result was expressed in mEq gallic acid (GAE) mL^{-1} extract.

Determination of total flavonoid content from latex

Aluminium chloride colorimetric method was used for flavonoids determination [20]. Total flavonoid content was calculated as catechin (mg g^{-1}), using the following equation based on the calibration curve: $y = 0.002x + 0.0314$, $R^2 = 0.9984$, where x was the absorbance and the result was expressed as catechin equivalent (mg g^{-1}). The total flavonoid content was showed in mg CE g^{-1}.

Determination of the antioxidant activity of latex

DPPH free radical scavenging assay

The antioxidant activity by DPPH method was evaluated by the procedure described by Dumitru, 2017 [21]. The sample to be analyzed contained 1 mL latex and 4 mL 0.1 mmol L^{-1} of methanolic DPPH solution. After 30 min of incubation in the dark at room temperature, the absorbance of the sample was read in a Cary 50 UV-Vis spectrophotometer manufactured by Varian Inc. at 517 nm against the control sample (4 mL of 0.1 mmol L^{-1} of methanolic DPPH solution and 200 µL deionised distilled water). The inhibition of free radicals by DPPH was determined by the formula:

$I\% = (A_{blanc} - A_{sample})/A_{blanc}\ 100.$

where: A_{blanc} = absorbance of control sample and A_{sample} = absorbance of a tested sample after the reaction.

ABTS radical scavenging assay

The antioxidant activity by ABTS radical scavenging assay was evaluated by the procedure described by Shahinuzzaman, 2020 [22]. TEAC was calculated by preparing a Trolox curve for ABTS assay (the standard curve equation: $y = 159.8X - 0.813$, $R^2 = 0.9992$), and the results were presented as µg TE mL^{-1} sample. The percentages of inhibition of ABTS was calculated using:

$\%\ \text{Inhibition} = (1 - A_S/A_B) \times 100\%$

where: A_B = absorbance of control sample (t = 0 h) and A_S = absorbance of a tested sample after the reaction (t = 1 h).

Determination of natural rubber

30 mL of latex was added to a 100 mL Berzelius beaker over which ethanoic acid was dropped with stirring until the latex became acid. Following coagulation, the mixture was filtered through Whatman paper no. 1 on the Buchner funnel and the rubber mass obtained was dried at a temperature of 50°C in a Memmert type oven.

Determination of natural rubber moisture

The moisture content of the rubber extracted from latex following the separation process was determined by the MX-50 moisture analyzer, based on the principle of thermogravimetric analysis, drying a sample using a halogen lamp, obtaining the moisture content in %.

FTIR spectrum of rubber extracted from *Ficus carica*

The infrared spectroscopy study was carried out with the help of an ALFA-BRUKER spectrometer with the Fourier transform in the spectral range 3500–500 cm^{-1}.

3. Results and discussions

Rubber (cis-1,4-polyisoprene) is one of the most important polymers produced naturally by plants. *Hevea brasiliensis* was the only resource for commercial production of natural rubber. The lack of biodiversity in the production of natural rubber makes the search for new alternative sources for its production imperative. In the specialized literature, there are works in which potential sources of natural rubber production are studied, Table 1 [23].

The development of *Ficus carica* culture in Romania as an alternative rubber culture may be promising because it generates a large volume of latex, has fast growth, and has a long life expectancy [24].

Phytochemical screening is the scientific process of analyzing, examining, extracting, and identifying different classes of bioactive nutritive chemicals from fruits, vegetables, grains, and other plant products. The obtained results reveal the presence of a variety of compounds (primary and secondary metabolites)

in the latex of *F. carica*. Table 2 shows the bioactive compounds identified in the latex extracted from *Ficus carica*.

Table 1. Alternative sources of poly-*cis*-isoprene

Plant species	Plant species
Artocarpus heterophyllus	*Lactuca sativa*
Ericameria nauseosa	*Lactuca serriola*
Euphorbia characias	*Parthenium argentatum*
Euphorbia heterophylla	*Pycnanthemum incanum*
Euphorbia lactiflua	*Scorzonera tau-saghyz*
Euphorbia tirucalli	*Scorzonera uzbekistanica*
Ficus bengalensis	*Solidago altissima*
Ficus carica	*Solidago graminifolia*
Ficus elastica	*Solidago rigida* L.
Helianthus sp.	*Taraxacum brevicorniculatum*
Hevea brasiliensis	*Taraxacum kok-saghyz*

Table 2. The bioactive compounds identified in the latex extracted from *Ficus carica*

Phytochemical constituents	*Ficus carica*	Phytochemical constituents	*Ficus carica*
Proteins	+	Catechins	−
Amino acids	+	Phytosterols	+
Fatty acids	+	Terpenes	+
Carboxylic acids	+	Diterpenes	+
Resins	+	Triterpenoids	+
Tannins	+	Glycosides	−
Alkaloids	+	Coumarins	+
Polyphenols	+	Xanthoproteins	−
Flavonoids	+	Anthocyanins	−
Saponins	+	Steroids	+

Note: '+' indicates positive and '−' indicates negative.

From the data presented in Table 2, the presence of various secondary metabolites can be noticed, which are a diversified class of compounds produced by plants. Secondary metabolites are not essential for the metabolism of the plant, but they still have important functions that allow the plant to adapt to the environment. Plant extracts are of major importance in various fields of activity (medicine, pharmacy, food industry, cosmetics, etc.).

Determining the latex density is an important characteristic in the process of reducing the water content and increasing the percentage of latex rubber. Reducing the water content is carried out by three methods: evaporation, concentration by creaming, and centrifugation.

In concentration by creaming the density difference between rubber and water is used to remove water excess. This difference is achieved by adding creaming agents (sodium alginate) that have the role of increasing the volume of the rubber particles and, therefore, the density decreases, achieving an adequate separation [25]. The density of the latex was determined by the pycnometer at the temperature of 25°C and had a value of 0.977 g cm^{-3}.

Determination of total solid content (TSC) from latex

The total solid content (TSC) of latex is the mass percentage of the solid material (both in suspension and dissolved), measured by the evaporation of a known mass of latex up to dryness at a temperature of 70°C (International Standard (ISO)) [17]. The value of the total solid content is mainly given by the primary constituents of the latex, which are carbohydrates, protein, resinous substances, lipids, and inorganic constituents that contribute to the higher value of the total solid content. The value of the total solid content from latex is 43.5%.

Determination of latex alkalinity

Alkalinity refers to the total alkali present in the latex and it is often expressed in the amount of ammonia added to the latex. The change in acidity that occurs in the latex immediately after harvesting under the bacterial and enzymatic action on the non-rubber constituents leads to the destabilization of the latex by acidification and to its coagulation. To prevent these inconveniences, ammonia is added to latex, which has the role of bacterial and enzymatic inhibition. The presence of ammonia determines colloidal stability through the formation of fatty acid surfactants.

If latex is preserved with ammonia, then the free alkali is ammonia, and the same is true for latex preserved with potassium hydroxide. The alkalinity test used to indicate whether enough preservatives have been added to properly preserve the latex measures the percentage of preservatives in the latex, either ammonia or potassium hydroxide [25]. The latex extracted from *Ficus carica* presented an alkalinity value of 0.53%.

Determination of conductivity

Latex is a colloidal dispersion consisting of polymer particles dispersed in water. Latex consists of at least two phases: the dispersed phase and the continuous phase. The dispersed phase, also known as the discontinuous phase, consists of latex particles and non-latex particles, while the dispersion medium, also known as the continuous phase, is aqueous in nature. The continuous phase, being of an aqueous nature, contains dissolved substances such as a series of constituents (carbohydrates, protein substances, inorganic substances) with a role in the formation of conductivity. After determining the conductivity, a value of 21 µS cm^{-1} was found.

Determination of total polyphenol content in latex

Polyphenols are very important plant constituents, playing a fundamental role in the strategies adopted by plants. In addition, epidemiologically, studies have established that polyphenols may provide benefits to human health due to their antioxidant activity [26] by neutralizing free radicals that cause cell damage. The content of total polyphenols in *Ficus carica* latex extracted with 100% methanol had a value of 349.7 µg GAE/mL, a value in agreement with the highest result obtained by Shahinuzzaman et al., 2020 (354.32 µg GAE mL^{-1}) [22] upon the determinations made on latex extracted with 100% methanol from 18 crops of *Ficus cari*ca.

Determination of total flavonoid content in latex

Flavonoids are an important class of natural products; in particular, they belong to a class of plant secondary metabolites having a polyphenolic structure and have various biochemical and antioxidant effects. The result of the spectrophotometric determination of the *Ficus carica* latex extract presented a value of 13.4 mg CE g^{-1} latex, a value that is in agreement with that obtained by Abdel-Aty et al. 2019 of 12.5, mg CE g^{-1} latex [27].

Antioxidant activity of latex

To determine the antioxidant capacity of the extracts, we used the ABTS and DPPH tests [28].

The DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging assay is based on the reduction of this free radical with an antioxidant whereby the DPPH radical with a maximum absorption of 515 nm is converted to a colorless compound after reduction. The use of DPPH provides an easy and rapid way to assess antioxidant activity [29].

Any substance that can donate a hydrogen radical (antioxidant) to the DPPH solution can reduce the stable free radical and change the color of its solution from purple to pale yellow. The high antioxidant

activity indicated that the latex extract might contain polyphenols, as it was reported by Ozer [30]. The result obtained when determining the antioxidant activity of the latex extract by the DPPH method had a value of 59.75%, comparable to the result previously obtained on the DPPH radical scavenging activity from the determinations made on the latex extracted with 100% methanol from 18 crops of *Ficus carica* (66.67%) by Shahinuzzaman et al., 2020 [22].

The free radical scavenging capacities of the extracts were also analyzed using the ABTS radical scavenging assay. The method is based on the reduction of ABTS radicals by the antioxidants of the tested extracts. In the ABTS radical scavenging assay (an electron transfer-based assay), the 2,2′-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) radical cation (ABTS), which has a dark blue color, is reduced by an antioxidant into colorless ABTS, which can be measured spectrophotometrically. The result obtained when determining the antioxidant activity of the latex extract by the ABTS method was expressed as a percentage of TEAC inhibition with a value of 511 µg TE mL^{-1}, comparable to the result obtained previously (528.78 µg TE mL^{-1}) by Shahinuzzaman et al., 2020 [22].

Phenolic compounds, especially flavonoids, have an ideal free radical scavenging structure and have been shown to be excellent antioxidants, mainly due to the ease with which a hydrogen atom of an aromatic hydroxyl can be donated to a free radical, breaking the generation cycle by new radicals [31].

Studies have shown that the antioxidant activity of the latex extracted from *Ficus carica* is higher than that of the fruits [32]. This antioxidant activity of *Ficus carica* latex could be anticipated from the results of the preliminary phytochemical screening of the latex, where compounds with antioxidant activity (phenolic compounds, organic acids) were identified.

Determination of latex rubber

By separating the rubber from the latex extracted from *Ficus carica* and coagulated with ethanoic acid, it resulted in a content of 3.78%, a value that is in agreement with the approximate value of 4% obtained by Kang et al., 2000 [24].

The rubber moisture obtained following the analysis of the rubber sample with the MX-50 moisture analyzer based on the principle of thermogravimetric analysis was 0.95%.

*FTIR spectrum of rubber extracted from Ficus car*ica.

The infrared spectroscopy study was carried out with the help of an ALFA-BRUKER spectrometer with the Fourier transform in the spectral range 3500–500 cm^{-1}. Fourier transform infrared spectroscopy spectrum recorded in transmission for the rubber sample is presented in Figure 2.

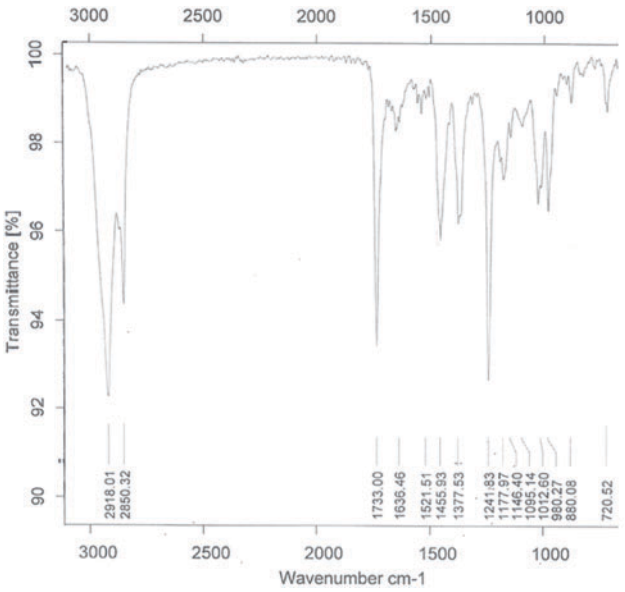

Figure 2. FTIR spectrum of the rubber extracted from *Ficus carica*

FTIR spectroscopy is a technique that uses mid-infrared energy to analyze the molecular structure and composition of substances by measuring the absorption of specific frequencies of infrared light, providing a unique fingerprint for identification and analysis. The infrared spectroscopy study was carried out with the help of an ALFA-BRUKER spectrometer with the Fourier transform in the spectral range 3500–500 cm^{-1}. Fourier transform infrared spectroscopy spectrum recorded in transmission for the rubber sample is presented in Figure 2.

Characteristic bands for cis-1,4-polyisoprene are indicated with their wave numbers (2918.01, 2850.32, 1733.00, 1455.90, 1377.53, 1177.9 and 720.52 cm^{-1}). The functional groups present were CH, C=C, CH_2 and CH_3.

The corroboration of the experimental data obtained and the consultation of the specialized bibliographic material highlight the role played by *Ficus carica* not only in being an alternative source of natural rubber but also in having, through the content of active principles, a major role in the treatment of certain human disorders [33,34].

4. Conclusions

In order to expand the sources of natural rubber and to avoid the hazards of limited production, we should look for new plants containing rubber and improve those already known to try to make them economically competitive. Although the experimentally obtained rubber content of *Ficus carica* latex (3.78%) is not as high as that of the rubber tree, its content is comparable to other plants that biosynthesize rubber and accumulate 1% to 3% rubber. The multitude of bioactive components identified through the phytochemical screening of latex present potential therapeutic values on the human body, making it an essential source for the pharmaceutical industry. Since the latex analysis was performed from samples collected during the summer, it is not known if this represents the maximum rubber content from latex.

Acknowledgement: Not applicable.

References

1. DELL, B., MCCOMB, A. J.. Plant resins—their formation, secretion and possible functions. *Adv. Botan. Res.*, 6(8), 1977, 277–316. https://doi.org/10.1016/S0065-2296(08)60332-8.
2. KOTARO, K., Plant latex and other exudates as plant defense systems: roles of various defense chemicals and proteins contained therein. *Phytochemistry*, 72(13), 2011, 1510–1530. https://doi.org/10.1016/j.phytochem.2011.02.016.
3. DA CAMARA, A. G. C., MARSAIOLI, A. J., BITTRICH, V., Chemical constituents of apolar fractions from fruit latex of twelve *Clusia species* (Clusiaceae). *An. Acad. Bras. Cienc.*, 90(2 suppl 1), 2018, 1919–1927. https://doi.org/10.1590/0001-3765201820170257.
4. ANTONY, V. S., CHUA, Y. M., NG, X. Q., SAIGEETHA, S. W., VINOD, V. R. et al., Plant latex: phytochemistry, medicinal properties and application—a review. *J. Pharma. Negat.*, 13(7), 2022, 5351–5375. https://doi.org/10.47750/pnr.2022.13.S07.658.
5. JIN, S. K., YEON, O. K., HYUN, J. R., YEON, S. K., JI, Y. L. et al., Isolation of stress-related genes of rubber particles and latex in fig tree (*Ficus carica*) and their expressions by abiotic stress or plant hormone treatments. *Plant Cell. Physiol.*, 44(4), 2003, 412–414. https://doi.org/10.1093/pcp/pcg058.
6. MAWA, S., HUSAIN, K., JANTAN, I., *Ficus carica* L. (Moraceae): Phytochemistry, traditional uses and biological activities. *Evid. Based Complement. Alternat. Med.*, 2013(3), 2013, 1–8. https://doi.org/10.1155/2013/974256.
7. CRISTIANA, F., Smochine. Perioadă de coacere, cultivare și secretul pe care puțini îl știu despre fructul de smochin. [Internet]. [cited 2023 Jun 6]. Available from: https://agromedia.ro/unde-se-cultiva-smochinul-in-romania.

8. SREENITHI, V., VISHNU, B., Phytochemical comparison of alcoholic extract of fresh and dry *Curcuma longa*. *Int. J. Adv. Res. Innov. Ideas Educ.*, 5(3), 2019, 419–428.
9. RAJINIKANTH, M., SAMATHA, T., SRINIVAS, P., SHYAMSUNDARACHARY, R., RAMA, S. N., Preliminary phytochemical analysis of leaf, stem, root and seed extracts of *Arachis hypogaea*. L. *Int. J. Pharm. Sci. Rev. Res.*, 20(1), 2013, 134–139.
10. GOPINATH, S. M., VIDYA, G. M., SUNEETHA, T. B., ISMAIL SHAREEF, M., NARASIMHA MURTHY, T. P. et al., Screening of major bio-active compounds of few medicinal plants for anti-HIV properties. *Int. J. Innov. Sci. Eng. Technol.*, 3(6), 2014, 13785–13791.
11. MORSY, N., Phytochemical analysis of biologically active constituents of medicinal plants. *Main Group Chem.*, 13(1), 2014, 7–21. https://doi.org/10.3233/MGC-130117.
12. VELAVAN, S., Phytochemical techniques—a review. *World J. Sci. Res.*, 1(2), 2015, 80–91.
13. RATHER, A. A., KIRTI, J., Preliminary phytochemical screening and *in vitro* antioxidant activity of *Nigella sativa* and *Allium cepa* oil. *UK J. Pharm. Biosci.*, 6(1), 2018, 25–32. https://doi.org/10.20510/ukjpb/6/i1/173527.
14. VISHNU, B., SHEERIN FATIMA, M. A., SREENITHI, V., A guide to phytochemical analysis. *Int. J. Adv. Res. Innov. Ideas Educ.*, 5(1), 2019, 236–245. https://doi.org/16.0415/IJARIIE-9430.
15. ABU, O. D., ONOAGBE, I. O., OBAHIAGBON, O., Qualitative phytochemical screening and proximate analysis of *Dialium guineense* stem bark. *IAR J. Agri. Res. Life Sci.*, 1(4), 2020, 108–112.
16. International Standard (ISO) 705. Geneva, Switzerland: ISO—International Organization for Standardization; 2015.
17. International Standard (ISO) 124. Geneva, Switzerland: ISO—International Organization for Standardization; 1997.
18. International Standard (ISO) 125. Geneva, Switzerland: ISO—International Organization for Standardization; 2011.
19. DUMITRU, M. G., Increasing the oxidative stability of oil extracted from *Jatropha curcas* L. seeds by adding oil extracted from roasted *Vitis vinifera* seeds. *Rev. Chim.*, 67(6), 2016, 1127–1130. https://doi.org/10.37358/rc.18.6.6329.
20. CHANG, C., YANG, M., WEN, H., CHERN, J., Estimation of total flavonoid content in propolis by two complementary colorimetric methods. *J. Food Drug. Anal.*, 10(3), 2002, 178–182. https://doi.org/10.38212/2224-6614.2748.
21. DUMITRU, M. G., GANESCU, A., Obtaining natural biopolymers films of *Quercus robur* L. and roasted seeds of *Vitis vinifera* grapes. *Mater. Plast.*, 54(2), 2017, 316–320. https://doi.org/10.37358/MP.17.2.4842.
22. SHAHINUZZAMAN, M., YAAKOB, Z., ANUAR, F. H., AKHTAR, P., KADIR, N. H. A. et al., *In vitro* antioxidant activity of *Ficus carica* L. latex from 18 different cultivars. *Sci. Rep.*, 10(1), 2020, 10852. https://doi.org/10.1038/s41598-020-67765-1.
23. SALEHI, M., CORNISH, K., BAHMANKAR, M., NAGHAVI, M. R., Natural rubber-producing sources, systems, and perspectives for breeding and biotechnology studies of *Taraxacum kok-saghyz*. *Ind. Crops Prod.*, 170(229–230), 2021, 113667. https://doi.org/10.1016/j.indcrop.2021.113667.
24. KANG, H., KANG, M. Y., HAN, K. H., Identification of natural rubber and characterization of rubber biosynthetic activity in fig tree. *Plant Physiol.*, 123(3), 2000, 1133–1142. https://doi.org/10.1104/pp.123.3.1133.
25. EXPERIMENT 3: TO TEST ALKALINITY AND MST OF LATEX CONCENTRATE. [Internet]. [cited 2023 Jun 6]. Available from: https://www.coursehero.com/file/38793031/EXPERIMENT-3docx/.

26. PETRUCCELLI, R., IERI, F., CIACCHERI, L., BONETTI, A., Polyphenolic profiling and chemometric analysis of leaves from Italian *Ficus carica* L. varieties. Polyphenol compounds in common fig. *Eur. J. Hortic. Sci.*, 83(2), 2018, 94–103. https://doi.org/10.17660/eJHS.2018/83.2.5.
27. ABDEL-ATY, A. M., HAMED, M. B., SALAMA, W. H., ALI, M. M., FAHMY, A. S. et al., *Ficus carica*, *Ficus sycomours* and *Euphorbia tirucalli* latex extract: phytochemical screening, antioxidant and cytotoxic properties. *Biocatal Agric. Biotechnol.*, 20(6), 2019, 101199. https://doi.org/10.1016/j.bcab.2019.101199.
28. ILYASOV, I. R., BELOBORODOV, V. L., SELIVANOVA, I. A., ROMAN, T. R. P., ABTS/PP decolorization assay of antioxidant capacity reaction pathways. *Int. J. Mol. Sci.*, 21(3), 2020, 1131. https://doi.org/10.3390/ijms21031131.
29. SILVA, C. G., HERDEIRO, R. S., MATHIAS, C. J., PANEK, A. D., SILVEIRA, C. S. et al., Evaluation of antioxidant activity of Brazilian plants. *Pharm. Res.*, 52(3), 2005, 229–33. https://doi.org/10.1016/j.phrs.2005.03.008.
30. OZER, H. K., Phenolic compositions and antioxidant activities of Maya nut (*Brosimum alicastrum*): comparison with commercial nuts. *Int. J. Food Prop.*, 20(11), 2017, 2772–2781. https://doi.org/10.1080/10942912.2016.1252389.
31. ROSS, J. A., KASUM, C. M., Dietary flavonoids: bioavailability, metabolic effects, and safety. *Annu. Rev. Nutr.*, 22(1), 2002, 19–34. https://doi.org/10.1146/annurev.nutr.22.111401.144957.
32. MOHAMMAD, H., ALZWEIRI, M., Phytochemistry and pharmacological activities of *Ficus carica* latex: a systematic review. *J. Chin. Pharm. Sci.*, 31(2), 2022, 81–96. https://doi.org/10.5246/jcps.2022.02.007.
33. SHAHRAJABIAN, M. H., WENLI, S., QI, C., A review of chemical constituents, traditional and modern pharmacology of fig (*Ficus carica* L.), a super fruit with medical astonishing characteristics. *Pol. J. Agron.*, 44, 2021, 22–29. https://doi.org/10.26114/pja.iung.452.2021.452.04.
34. HEGAZY, M. M., MEKKY, R. H., AFIFI, W. M., MOSTAFA, A. E., ABBASS, H. S., Composition and biological activities of ficus carica latex, cap. In: M. F. RAMADAN, (ed). *Fig (Ficus carica): Production, Processing, and Properties*. Cham, Switzerland: Springer; 2023. p. 597–641. https://doi.org/10.1007/978-3-031-16493-4.

Received: 22 June 2023; Accepted: 27 June 2025; Published: 18 July 2025