Analysis of carbohydrates in *Saponaria officinalis* L. using GC/MS method

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**Abstract**

*Saponaria officinalis* L. (common soapwort), usually named fuller’s herb, is encountered in most of Europe, in Spain, France, Italy, for example, and also in Syria and North Africa. *Saponaria officinalis* L. is known in most of the world as an introduced species, often a weed, and sometimes as cultivated decorative plant. *Saponaria officinalis* contains a large amount of saponins, which foam during extraction with water. In addition to saponins, common soapwort also contains flavonoids, quillaic acid, fatty acids and different phenolic compounds. There is a lack of information about carbohydrates content of common soapwort. Thus the aim of this study was to determine the content of carbohydrates *Saponaria officinalis* L. herb and roots. The qualitative composition and quantitative content of carbohydrates in herb and roots of *Saponaria officinalis* L. were determined by using GC/MS method. The studies have shown that *Saponaria officinalis* L. herb is mainly composed of free carbohydrates such as D-glucose (3.65 mg/g), D-galactose (0.29 mg/g), D-fructose (0.20 mg/g) and D-saccharose (3.72 mg/g). In common soapwort herb, after acidic hydrolysis and derivatization with acetylated aldononitriles, D-arabinose, D-fucose, D-mannose, D-glucose, D-galactose, D-fructose and Myo-inositol were identified. Free carbohydrates in the roots of *Saponaria officinalis* L., including D-glucose, D-galactose and D-saccharose, were determined with GC/MS method too. D-saccharose was common among free carbohydrates of *Saponaria officinalis* L. in the largest amounts. Its content in herb and roots of the common soapwort was 3.72 mg/g and 25.39 mg/g respectively.

**Keywords**

*Saponaria officinalis* L., common soapwort, carbohydrates, GC/MS

**Introduction**

Plant metabolites are close to the metabolites of the human body, and the main effect of the herbal remedies usage is the regulation of metabolic disorders (Darzuli et al. 2019; Slobodianiuk et al. 2021). The most interesting are medicinal plants that have a long history of use for the treatment and prevention of various diseases (Stoiko and Kurylo 2018; Budniak et al. 2020; Marchyshyn et al. 2021b). Medicinal plants have great tolerability and small side effects (Kurylo et al. 2020; Darzuli et al. 2021). The typical plants for diseases’ treatment are the families of Asteraceae, Lamiaceae, Caryophyllaceae, Rosaceae, Fabaceae, Apiaceae, Poaceae, and Boraginaceae (Slobodianiuk et al. 2020).

*Saponaria* species (family Caryophyllaceae) are perennial, flowering plants, characteristic to Europe and Asia, and usually known as soapworts (Petrović et al. 2018; Budniak et al. 2021b). The most familiar species within the genus is *Saponaria officinalis* L. (common soapwort), usually named fuller’s herb, is encountered in most of Europe, in Spain,
France, Italy, for example, and also in Syria and North Africa. *Saponaria officinalis* L. is known in most of the world as an introduced species, often a weed, and sometimes as cultivated decorative plant (Henry 1989; Petrović et al. 2018).

The various parts of *Saponaria officinalis* have been used in traditional medicine, roots and leaves for skin diseases; roots as diuretic, diaphoretic, blood purifier; sap for scabies, to increase bile flow and hepatic eruptions. In addition, the roots are used as an anti-crystalline cholangitis that cleanses the body for medicinal purposes (Khare 2007; Talluri et al. 2018). A decocation of the herb of *Saponaria officinalis* is applied externally to treat itchy skin (Baytop 1984; Sengula et al. 2011).

*Saponaria officinalis* contains a large amount of saponins, which foam during extraction with water (Moniuszko-Szajwaj et al. 2013). The purified saponin fraction of *Saponaria officinalis* showed hypocholesterolemic effects in vitro, which is believed to be due to the ability of saponins to form an insoluble complex with cholesterol. Saponins also show spermicidal activity, which may be the result of their hemolytic properties (Jia et al. 2002; Böttger and Melzig 2011; Moniuszko-Szajwaj et al. 2013).

In addition to saponins, common soapwort also contains flavonoids, quillaic acid, fatty acids and different phenolic compounds (Cisowski et al. 1995; Lu et al. 2015).

The roots of *Saponaria officinalis* L. contain three oligosaccharides. Two of them were isolated namely gentiobiose and the pentasaccharide saponarose (Bukharov and Shcherbak 1969).

Petrović et al. (2018) confirmed that *Saponaria officinalis* shoots contained essential oil, rich with phytol, tricosane-6,8-dione, patchouli alcohol and tricosane, whereas patchouli alcohol, heneicosane and tricosane were dominant in the flower essential oil.

Czaban et al. (2013) reported antifungal activities of common soapwort’s saponin fraction against *Gaumannomyces graminis var. tritici* and *Fusarium culmorum*, which are pathogens of cereals.

Sengula M. et al. (2011) suggest that the methanol extracts of *Saponaria officinalis* contain compounds with antimicrobial properties. These exhibited properties suppose that such extracts can possibly be used as natural preservatives in the pharmaceutical industries and food.

Extracts from the roots of common soapwort are used as a substitute for existing acaricides, that can enable to achieve a significant reduction in the risks associated with the use of synthetic pesticides (Pavela 2017). The roots of *Saponaria officinalis* have been used for the production of traditional halva and other sweets in the food industry (Korkmaz and Ozcelik 2011).

However, there have been no scientific reports on the content of *Saponaria officinalis* L. carbohydrates. In this regard, this work is carried out to determine the chemical composition of these compounds in the study of raw materials.

### Material and method

#### Plant materials

Herb and roots of *Saponaria officinalis* L. (common soapwort) are collected in Western Ukraine, Chernivtsi region (48°15’33.1”N, 25°12’01.9”E). The aboveground part was collected during a mass flowering period and roots were collected in autumn after the death of the aboveground parts in 2019. The raw material was authenticated by prof. Svitlana Marchyshyn (TNMU, Ternopil, Ukraine).

#### Standards and chemicals

Standard of polysaccharides, including D-mannose, L-rhamnose, D-ribose, D-galactose, D-arabinose, D-fructose, D-xyllose, D-glucose, D-sorbitol, D-saccharose, D-fucose, derived from Sigma-Aldrich (St. Louis, MO, USA) were of analytical grade (> 95% purity) (Figure 1). All other reagents were of analytical grade (≥ 99% purity).

![Figure 1. GC/MS chromatogram of monosaccharides standards.](image-url)
GC/MS determination of monosaccharides

The correlation coefficients ($R^2 > 0.9991$) indicate that all saccharide solution shown in Table 1. As a consequence, versus the concentration of the corresponding monochromatographic peak area of monosaccharide derivatives (D-glucose, D-saccharose, D-fucose) were used for these tests. D-ribose, D-galactose, D-arabinose, D-fructose, D-xylose, D-mannose, D-glucose, D-galactose were determined for these tests. A total of 10 standard sugars (D-mannose, L-rhamnose, D-ribose, D-galactose, D-arabinose, D-fructose, D-xylose, D-glucose, D-saccharose, D-fucose) were used for these tests. Calibration curves had excellent linearity within the test ranges. Furthermore, the limit of detection (LOD) and limit of quantification (LOQ) for individual carbohydrates after GC/MS analysis.

| Carbohydrates | $R^2$ | LOD (µmol/L) | LOQ (µmol/L) |
|---------------|-------|--------------|--------------|
| Ribose        | 0.9998| 0.19         | 0.63         |
| Rhamnose      | 0.9999| 0.83         | 2.76         |
| Arabinose     | 0.9999| 0.22         | 0.73         |
| Fucose        | 0.9998| 0.54         | 1.80         |
| Xylose        | 0.9995| 1.15         | 3.83         |
| Mannose       | 0.9999| 0.37         | 1.23         |
| Glucose       | 0.9999| 0.29         | 0.97         |
| Galactose     | 0.9998| 0.74         | 2.47         |
| Fructose      | 0.9996| 0.57         | 1.90         |
| Saccharose    | 0.9991| 0.78         | 2.60         |

Results and discussion

GC/MS represents an effective, comprehensive and quantitative technique for analysis of carbohydrates. Thus, the qualitative composition and quantitative content of sugars in *Saponaria officinalis* L. was determined by this method. The studies have shown that *Saponaria officinalis* L. herb is mainly composed of free carbohydrates such as D-glucose (3.65 mg/g), D-galactose (0.29 mg/g), D-fructose (0.20 mg/g) and D-saccharose (3.72 mg/g) (Figure 2).

In common soapwort herb, after acidic hydrolysis and derivatization with acetylated aldononitriles, D-arabinose, D-fucose, D-mannose, D-glucose, D-galactose, D-fructose and Myo-inositol were identified too (Figure 3).

Free carbohydrates in the roots of *Saponaria officinalis* L., including D-glucose, D-galactose and D-saccharose, were determined with GC/MS method too (Figure 4).

Various monosaccharides such as D-arabinose, D-fucose, D-xylose, D-mannose, D-glucose, D-galactose and D-fructose were observed at varying degrees in the investigated roots of common soapwort after acidic hydrolysis and derivatization with acetylated aldononitriles (Figure 5).

The quantitative content of carbohydrates is presented in Table 2.
a fast source of energy to the organism (Khowala et al. 2008). Also, among the free carbohydrates in the herb of the common soapwort was determined a highest amount of D-glucose (3.65 mg/g). Glucose is a monosaccharide which is one of the most important carbohydrates in biology. The cell uses it as a source of energy and a metabolic intermediate (Genova et al. 2007). Glucose is synthesized during photosynthesis and serves as the “fuel” and source of energy, accrued as a polymer glycogen in animals and as starch in plants (Niaz et al. 2020). Saponaria officinalis L. roots were dominated by D-galactose among free carbohydrates, the content of which was 2.18 mg/g. Galactose is a nutrient, that is a reducing carbohydrate. D-galactose can be decomposed with glucose to form a lactose disaccharide (Chogtu et al. 2018).

Also, the GC/MS method identified monosaccharides and their derivatives after hydrolysis in the herb and roots of Saponaria officinalis L. (Figures 3, 5). D-arabino-
se, D-fucose, D-xylose and D-mannose were found in the investigated objects only after hydrolysis (Table 1). The amount of D-glucose, D-galactose and D-fructose increased significantly after hydrolysis, compared to its amount as a free sugar.

In the herb of *Saponaria officinalis* L. predominant ones were D-glucose 30.25 mg/g, D-galactose 9.17 mg/g and D-fucose 7.18 mg/g. Fucose is a deoxyhexose, which is present in a wide variety of organisms. In mammals, fucose-containing glycans play serious role in blood transfusion reactions and selectin-mediated leukocyte-endothelial adhesion. Alterations in the expression of fucosylated oligosaccharides have also been observed in several pathological processes, including atherosclerosis and cancer (Becker and Low 2003). In *Saponaria officinalis* L. herb, a great quantity of monosaccharides derivative Myo-inositol was revealed, a content of which was 2.62 mg/g. Inositol is a physiological compound appropriate to the sugar family.
Table 2. The content of monosaccharides, their derivatives after hydrolysis and free monosaccharides of *Saponaria officinalis* L.

| Retention time (min) | The name of the compounds | The content of the carbohydrates, mg/g ±Δx, x̄, n=3, P<0.05 |
|----------------------|---------------------------|----------------------------------------------------------|
|                      | Free carbohydrates        | Monosaccharides and their derivatives after hydrolysis |
|                      | Herb                      | Roots                                                   |
|                      |                      | Herb | Roots |
| 8.61                 | D-arabinose              | 2.93±0.06 | 1.66±0.01 |
| 9.12                 | D-fucose                 | 7.18±0.08 | 5.28±0.04 |
| 9.95                 | D-xyllose                | 0.73±0.01 |          |
| 15.25                | D-mannose                | 1.65±0.03 | 2.25±0.02 |
| 15.57                | D-glucose                | 0.73±0.02 | 30.25±0.14 |
| 16.06                | D-galactose              | 2.18±0.04 | 9.17±0.07 | 33.91±0.16 |
| 18.40                | Myo-inositol             | 2.62±0.02 |          |
| 18.92                | D-Sorbitol internal standard |          |          |
| 23.73                | D-fructose               | 3.68±0.05 | 10.79±0.09 |
| 34.11                | D-saccharose             | 25.39±0.15 |          |

Note: – not found.

The two main stereoisomers of inositol are Myo-inositol and D-chiroinositol, which are present in our body. Myo-inositol is the harbinger of inositol triphosphate, a second messenger regulating variety hormones such as FSH, TSH and insulin (Bizzarri and Carlomagno 2014).

In the roots of common soapwort was defined the higher content of D-galactose 33.91 mg/g, D-glucose 23.08 mg/g and D-fructose 10.79 mg/g among monosaccharides after hydrolysis. Fructose is a simple monosaccharide found in many foods and one of the three very important blood sugars along with galactose and glucose (Genova et al. 2007). Fructose plays a serious role in mammalian metabolism. It is commonly regarded as being 1.73 times sweeter than sucrose (Azmat et al. 2012). D-xylose was found only after hydrolysis in the roots of *Saponaria officinalis* L. D-Xylose is a pentose sugar that is absorbed from the upper small intestinal tract, similar to the sodium-dependent active transport of glucose and amino acids (Doerfler et al. 2000). This aldopentose affects specifically gram-negative organisms. In medical practice it is used as a diagnostic remedy to assess intestinal absorption (Khowala et al. 2008).

**References**

Azmat R, Naz R, Qamar N, Malik I (2012) Kinetics and mechanisms of oxidation of d-fructose and d-lactose by permanganate ion in an acidic medium. Natural Science 4(7): 466–478. [https://doi.org/10.4236/ns.2012.47063](https://doi.org/10.4236/ns.2012.47063)

Baytop T (1984) Türkiyedde Bitkiler ile Tedavi. İstanbul, 444 pp.

Becker DJ, Low JB (2003) Fucose: biosynthesis and biological function in mammals. Glycobiology 13(7): 41R–53R. [https://doi.org/10.1093/glycob/cwg054](https://doi.org/10.1093/glycob/cwg054)

Bizzarri M, Carlomagno G (2014) Inositol: History of an effective therapy for Polycystic Ovary Syndrome. European Review for Medical and Pharmacological Sciences 18: 1896–1903.

Böttger S, Melzig MF (2011) Triterpenoid saponins of the Caryophyllaceae and Illecebraceae family. Phytochemistry Letters 4: 59–68. [https://doi.org/10.1016/j.phytol.2010.08.003](https://doi.org/10.1016/j.phytol.2010.08.003)

Budniak L, Slobodianiuk L, Marchyshyn S, Kostyshyn L, Horoshko O (2016) Determination of composition of fatty acids in *Saponaria officinalis* L. ScienceRise: Pharmaceutical Science 1(21): 25–30. [https://doi.org/10.15587/2519-4852.2021.224671](https://doi.org/10.15587/2519-4852.2021.224671)

Bukharov VG, Shcherbak SP (1969) Oligosaccharides of *Saponaria officinalis*. Chemistry of Natural Compounds 5(6): 391–394. [https://doi.org/10.1007/BF00568572](https://doi.org/10.1007/BF00568572)

Chogtu B, Arivazhahan A, Kunder SK, Tilak A, Sori R, Tripathy A (2018) Evaluation of acute and chronic effects of D-Galactose on memory and learning in wistar rats. Clinical Psychopharmacology and Neuroscience 16: 153–160. [https://doi.org/10.1576/cpn.2018.16.2.153](https://doi.org/10.1576/cpn.2018.16.2.153)

Cisowski W, Zielinska-Stasek M, Stolyhwo A (1995) Raw plant material rich in oils, EFAs and oleic acid. Herba Polonica Journal 41(4): 170–179.

Czaban J, M olecho J, Wróblewska B, Zumuchar-Strzel M, Cieślak A, Oleszek W, Stochmal A (2013) Effect of triterpenoid saponins of field scabious, alflalfa, red clover and common soapwort on growth of *Gaeumannomyces graminis* var. *tritici* and *Fusarium culmorum*. Allolep-athy Journal 32: 79–90.

Darzuli N, Budniak L, Hroshovyi T (2019) Selected excipients in oral solid dosage form with dry extract of *Pyrola rotundifolia* L. International Journal of Applied Pharmaceutics 11(6): 210–216. [https://doi.org/10.22159/ijap.2019v11i6.35282](https://doi.org/10.22159/ijap.2019v11i6.35282)
Darziuli N, Budniak L, Slobodianiuk I (2021) Investigation of the antibacterial and antifungal activity of the Pyrola rotundifolia L. leaves dry extract. Pharmacologyonline 1: In press.

Doerfler RE, Cain LD, Edens FW, Parkhurst CR, Qureshi MA, Havenstein GB (2000) D-Xylose Absorption as a Measurement of Malabsorption in Poul Enteritisand Mortality Syndrome. Poult Science 79: 656–660. https://doi.org/10.1093/ps/79.5.656

Genova J, Zheliaskova A, Mitov MD (2007) Monosaccharides (fructose, glucose) and disaccharides (sucrose, trehalose) influence the elasticity of SOPC membranes. Journal of Optoelectronics and Advanced Materials 9(2): 427–430.

Henry M (1989) XXIV Saponaria officinalis L.: In vitro culture and the Henry M (1989) XXIV Saponaria officinalis L.: In vitro culture and the treatment of various diseases. Int J Biotechnol Agric Sci 300(3): 112–116. https://doi.org/10.5530/pj.2018.6s.24

Husak L, Dakhym I, Marchyshyn S, Nakonechna S (2018) Determination of carbohydrates and fructans content in Cyperus esculentus. International Journal of Pharmacology 68(1): 211–216. https://doi.org/10.3897/pharmacia.68.e54762

Marchyshyn S, Budniak L, Skrynchuk O (2021b) Analysis of anticancer activity of the roots of Saponaria officinalis L. Pharmacia 68(1): 15–21. https://doi.org/10.3897/pharmacia.68.e66715

Moniuszko-Szajwaj B, Pecio L, Kowalczyk M, Simonet AM, Maciasb FA, Szumacher-Strabel M, Cieslak A, Oleszek W, Stochmal A (2013) New triterpenoid saponins from the roots of Saponaria officinalis. Natural Product Communications 8(12): 1687–1690. PMID: 24552523. https://doi.org/10.1177/1934578X1300801207

Niaz K, Khan F, Shah MA (2020) Analysis of carbohydrates (monosaccharides, polysaccharides). Recent Advances in Natural Products Analysis 18: 621–633. https://doi.org/10.1016/B978-0-12-816455-6.00018-4

Pavela R (2017) Extract from the roots of Saponaria officinalis as a potential acaricide against Tetranychus urticae. Journal of Pest Science 90: 683–692. https://doi.org/10.1007/s10340-016-0828-6

Petrovic GM, Ilic MD, Stankov-Jovanovic GS, Jovanovic SC. (2018) Phytochemical analysis of Saponaria officinalis L. shoots and flowers essential oils. Natural Product Research 32(3): 331–334. https://doi.org/10.1080/14786419.2017.1350668

Pigman W (2012) The Carbohydrates: Chemistry and Biochemistry Physiol. Elsevier, Academic Press, 920 pp.

Sengula M, Ercisli S, Yildiz H, Gunorg N, Kavaz A, Cetin B (2011) Antioxidant, antimicrobial activity and total phenolic content within the aerial parts of Artemisia absinthium, Artemisia santonicum and Saponaria officinalis. Iranian Journal of Pharmaceutical Research 10(1): 49–56.

Slobodianiuk L, Budniak L, Marchyshyn S, Basaraba R (2019) Determination of amino acids and sugars content in Antennaria dioica. Gaertn. International Journal of Applied Pharmaceutics 11(5): 39–43. https://doi.org/10.22159/ijap.2019v11i5.33909

Slobodianiuk L, Budniak L, Marchyshyn S, Basaraba R (2020) Investigation of the hepatoprotective effect of the common cat’s foot herb dry extract. Pharmacologyonline 3: 310–318.

Slobodianiuk L, Budniak L, Marchyshyn S, Sinchenko A, Denydiak O (2021) Determination of amino acids of cultivated species of the genus Primula L. Biosurface Interface Research in Applied Chemistry 11(2): 8969–8977. https://doi.org/10.33263/BRIAC11.2.89698977

Stoilow L, Kurylo Khr (2018) Development of optimal technology of alcohol extract Centaurium erythraea Raunf. herb. Archives of the Balkan Medical Union 53: 523–528. https://doi.org/10.31688/ABMU2018.53.4.06

Talluri MR, Gummadi VP, Battu GR (2018) Chemical composition and hepatoprotective activity of Saponaria officinalis on paracetamol-induced liver toxicity in rats. Pharmacognosy Journal 10(6): s129–s134. https://doi.org/10.5530/pj.2018.6s.24

Saponaria officinalis L.: In vitro culture and the treatment of various diseases. Int J Biotechnol Agric Sci 300(3): 112–116. https://doi.org/10.5530/pj.2018.6s.24

Saponaria officinalis L. shoots and flowers essential oils. Natural Product Research 32(3): 331–334. https://doi.org/10.1080/14786419.2017.1350668

Saponaria officinalis L. shoots

Saponaria officinalis L. (Caryophyllaceae) taxa of Saponaria Fenzl and Saponaria L. (Caryophyllaceae) family. In: Rahman A-U (Ed.) Studies in Natural Products Chemistry. Vol. 26. Elsevier, Amsterdam, 3–61. https://doi.org/10.1016/S1572-5995(02)80004-7

Saponaria officinalis L. herb. ScienceRise: Pharma- cologyonline 3: 310–318.

Saponaria officinalis L. (Caryophyllaceae) taxa of Turkey. African Journal of Biotechnology 10: 9533–9541. https://doi.org/10.7754/AJB.2010.2500

Saponaria officinalis L. (Caryophyllaceae) taxa of Turkey. African Journal of Biotechnology 10: 9533–9541. https://doi.org/10.5897/AJB10.2500

Saponaria officinalis L. (Caryophyllaceae). In: Rahman A-U (Ed.) Studies in Natural Products Chemistry. Vol. 26. Elsevier, Amsterdam, 3–61. https://doi.org/10.1016/S1572-5995(02)80004-7