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TECHNOLOGY OF OBTAINING BIOACTIVE EXTRACTS FROM SILYBUM MARIANUM BY THE MACERATION METHOD

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ABSTRACT

Silybum marianum (milk thistle) is a well-known medicinal plant widely used in pharmaceutical practice due to its pronounced hepatoprotective, antioxidant, and anti-inflammatory properties. These therapeutic effects are mainly attributed to a complex of flavonolignans collectively known as silymarin. The efficiency and quality of herbal medicinal products largely depend on the extraction method employed for isolating bioactive compounds from plant raw materials. Among conventional extraction techniques, maceration remains one of the most commonly used methods due to its simplicity, cost-effectiveness, and suitability for thermolabile compounds.*

The present article is devoted to the technological aspects of obtaining bioactive extracts from Silybum marianum using the maceration method. Special attention is given to the selection and preparation of plant raw materials, choice of extraction solvent, extraction parameters, and factors influencing the yield and quality of the extract. The advantages and limitations of maceration in comparison with other extraction methods are also discussed. The study highlights the relevance of maceration as a rational technological approach for producing high-quality herbal extracts intended for pharmaceutical and nutraceutical applications.

Introduction

Medicinal plants have been used for centuries as a primary source of therapeutic agents, and even in modern pharmaceutical science they remain an important basis for the development of drugs, dietary supplements, and functional products. According to the World Health Organization, a significant proportion of the global population relies on herbal medicines for primary healthcare. In this context, ensuring the quality, safety, and efficacy of plant-derived products is a key task of pharmaceutical technology.

Silybum marianum (L.) Gaertn., commonly known as milk thistle, is one of the most extensively studied medicinal plants due to its proven hepatoprotective activity. The plant

belongs to the Asteraceae family and is widely distributed in Europe, Asia, and other regions with temperate climates. In pharmaceutical practice, the fruits (achenes) of *Silybum marianum* are primarily used as medicinal plant raw material. They contain a complex of biologically active compounds, including flavonolignans (silybin, silydianin, silychristin), flavonoids, fatty oils, sterols, and other phenolic substances.

The main pharmacologically active complex of *Silybum marianum* is silymarin, which exhibits antioxidant, membrane-stabilizing, anti-inflammatory, and hepatoprotective effects. These properties make milk thistle extracts and preparations widely applicable in the prevention and treatment of liver diseases, toxic liver damage, and metabolic disorders. Consequently, the development of effective and reproducible extraction technologies for obtaining high-quality milk thistle extracts is of great scientific and practical importance.

Extraction is a critical stage in the production of herbal medicinal products, as it directly influences the qualitative and quantitative composition of the final extract. Various extraction methods have been developed and applied in pharmaceutical practice, including percolation, Soxhlet extraction, ultrasound-assisted extraction, microwave-assisted extraction, and supercritical fluid extraction. However, despite the availability of modern and intensified techniques, conventional methods such as maceration continue to be widely used, particularly in industrial and semi-industrial settings.

Maceration is a static extraction method based on prolonged contact between plant raw material and an appropriate solvent at room or moderately elevated temperatures. This method is especially suitable for the extraction of thermolabile compounds, as it does not require high temperatures that could lead to degradation of active substances. In addition, maceration is characterized by simple equipment requirements, ease of scaling, and relatively low production costs, making it attractive for pharmaceutical manufacturers.

Nevertheless, the efficiency of maceration depends on several technological factors, including particle size of the raw material, type and concentration of the solvent, extraction time, temperature, and solid-to-liquid ratio. Improper selection of these parameters may result in low extraction yield or insufficient concentration of active compounds in the final product. Therefore, a systematic study of the maceration technology for *Silybum marianum* is essential to optimize the extraction process and ensure the production of standardized, high-quality extracts.

The aim of this article is to analyze and describe the technological process of obtaining bioactive extracts from *Silybum marianum* using the maceration method, with emphasis on critical technological parameters and their influence on extract quality. The findings presented in this work may serve as a scientific basis for further optimization of herbal extraction technologies and for the development of effective hepatoprotective pharmaceutical preparations.

Materials and Methods

Plant Material

The fruits (achenes) of *Silybum marianum* (L.) Gaertn. were used as the primary medicinal plant raw material in this study. The plant material was collected during the period of full maturation, when the content of flavonolignans reaches its maximum. After harvesting, the fruits were cleaned from impurities, dried under controlled conditions at a temperature not exceeding 40 °C, and stored in a dry, dark place until further use.

Prior to extraction, the dried raw material was milled using a laboratory grinder to obtain particles of uniform size. The particle size distribution was selected in accordance

with pharmacopoeial recommendations to ensure optimal solvent penetration and efficient mass transfer during maceration.

Chemicals and Solvents

Ethanol–water mixtures of different concentrations (40%, 60%, and 70% v/v) were used as extraction solvents. Ethanol was selected due to its proven efficiency in extracting flavonolignans and its acceptability for pharmaceutical applications. All solvents used were of analytical or pharmaceutical grade.

Maceration Procedure

Maceration was performed under static conditions in tightly closed glass containers to prevent solvent evaporation. The prepared plant raw material was placed into the extraction vessel, and the solvent was added at a predefined solid-to-liquid ratio. The mixture was thoroughly stirred to ensure complete wetting of the plant particles and then left to stand for a specified extraction period.

The extraction was carried out at room temperature (20–25 °C) to preserve thermolabile compounds. Periodic agitation was applied to enhance diffusion and improve extraction efficiency. After completion of maceration, the extract was separated from the plant residue by filtration. The resulting liquid extract was collected and subjected to further analysis.

Technological Scheme of Maceration

The technological process of obtaining *Silybum marianum* extract by maceration includes several sequential stages:

1. **Preparation of Plant Raw Material**

This stage involves cleaning, drying, and milling of the plant material to achieve optimal particle size. Proper preparation is essential to ensure reproducibility and high extraction yield.

2. **Selection of Extraction Solvent**

The choice of solvent plays a decisive role in the extraction of silymarin complex. Hydroalcoholic solutions are preferred due to their ability to dissolve both polar and moderately non-polar compounds present in milk thistle fruits.

3. **Maceration Process**

The plant material is immersed in the solvent and kept under static conditions for a defined period, typically ranging from 24 to 72 hours. During this time, bioactive compounds diffuse from the plant matrix into the solvent.

4. **Agitation and Diffusion Enhancement**

Periodic stirring promotes solvent penetration and accelerates mass transfer, improving extraction efficiency without increasing temperature.

5. **Separation of Extract**

After maceration, the extract is separated from the exhausted plant material by filtration or pressing.

6. **Clarification and Storage**

The obtained extract may be clarified by settling or fine filtration and stored under controlled conditions to prevent degradation of active compounds.

This technological scheme is simple, scalable, and suitable for both laboratory and industrial applications.

Results and Discussion

The maceration method demonstrated satisfactory efficiency in extracting bioactive compounds from *Silybum marianum* fruits. The qualitative composition of the extracts confirmed the presence of flavonolignans characteristic of the silymarin complex, indicating the suitability of the chosen solvents and extraction conditions.

Extraction efficiency was found to depend significantly on solvent concentration and extraction time. Hydroalcoholic solutions with ethanol concentrations between 60% and 70% showed higher extraction capacity for flavonolignans compared to lower concentrations. This can be explained by the balanced polarity of these solvents, which facilitates the dissolution of phenolic compounds.

One of the main advantages of maceration is the preservation of thermolabile constituents due to the absence of elevated temperatures. This is particularly important for maintaining the biological activity of silymarin components. However, the method is relatively time-consuming and may require large volumes of solvent, which can be considered a limitation.

Despite these drawbacks, maceration remains a rational and widely applicable extraction technique, especially in cases where simplicity, low cost, and product quality are prioritized. When properly optimized, this method allows the production of standardized extracts suitable for pharmaceutical formulation.

Conclusion

The maceration method is an effective and technologically feasible approach for obtaining bioactive extracts from *Silybum marianum* fruits. The method ensures gentle extraction conditions, preservation of thermolabile compounds, and satisfactory yield of the silymarin complex.

Optimization of key technological parameters such as solvent composition, solid-to-liquid ratio, extraction time, and particle size of plant material is essential to achieve high-quality extracts. Given its simplicity and adaptability, maceration can be successfully applied in the production of herbal medicinal products and dietary supplements with hepatoprotective activity.

The results of this study confirm the relevance of maceration as a conventional yet reliable extraction technique and provide a scientific basis for further development and standardization of milk thistle-based pharmaceutical preparations.

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