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Rheology of rosehip seed oil

Ioana Stanciu*
Department of Physical Chemistry, Faculty of Chemistry, University of Bucharest, 4-12 Elisabeta Blvd, Bucharest, Romania
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Abstract
Rosehip seed oil is a product with diverse applications in the food, cosmetic and pharmaceutical industries, due to its high content of essential fatty acids and antioxidants. The rheological properties of this oil directly influence its processing, stability and performance in finished products. The present study investigates the rheological behavior of rosehip seed oil, evaluating the variation of viscosity as a function of temperature and strain rate. The measurements were performed using a rotational rheometer, and the results indicate a predominantly Newtonian behavior at high temperatures, while at low temperatures slight deviations towards pseudoplastic behavior are observed. The analysis of the viscosity-time and viscosity-shear rate curves highlights the influence of temperature on the fluidity of the oil and suggests the possibility of adjusting the rheological properties through natural mixtures or additives. The data obtained contribute to the optimization of extraction, filtration and packaging processes, providing essential information for the engineering of rosehip oil-based products. In conclusion, the rheological characterization of rosehip seed oil provides a solid basis for its effective use in various industrial and cosmetic applications.

Keywords: rheology, seeds, rose hips, oil

Introduction

The oil extracted from rosehip seeds is a product of high biological and industrial value, recognized for its composition rich in essential fatty acids, vitamins and antioxidant compounds. Recent studies have highlighted the presence of a significant content of polyunsaturated fatty acids, especially linoleic acid (ω-6) and linolenic acid (ω-3), as well as carotenoids and tocopherols, components that give the oil remarkable anti-inflammatory and antioxidant properties. Due to these bioactive characteristics, rosehip oil has attracted the attention of both the food industry and the cosmetic and pharmaceutical sectors, being used for the formulation of nutritional supplements, dermato-cosmetic products and functional preparations.

Within technological processes, the behavior of the oil flow represents a critical parameter, influencing the extraction, filtration, pumping, mixing and packaging stages. Rheology, the field that studies the deformation and flow of materials under the action of external forces, provides the necessary tools to characterize the behavior of oil under different conditions of temperature and shear stress. Rheological properties determine not only the fluidity of the oil, but also the stability of the final products and its interaction with other ingredients in complex formulations. In addition, knowledge of rheological behavior allows for the anticipation of changes during storage and transportation, contributing to maintaining quality and preventing phase separation in emulsions and mixtures.

The rheological behavior of vegetable oils is largely determined by their lipid structure and the minority compounds present. In general, pure oils exhibit Newtonian behavior at high temperatures, characterized by a linear relationship between shear stress and deformation rate, but at low temperatures or in the presence of solid particles, pseudoplastic or viscoelastic deviations can be observed. In the case of rosehip seed oil, such deviations can significantly influence industrial applicability, since antioxidant and organoleptic properties can be affected by thermal or mechanical processing. Therefore, accurate characterization of the rheological behavior is essential for optimizing processing conditions and ensuring consistency and stability of the final product [1-5].

The methodologies used for rheological analysis include viscosity measurements as a function of temperature and strain rate, as well as the determination of shear stress – shear rate curves. These assessments allow the classification of the oil as a Newtonian or non-Newtonian fluid, the estimation of dynamic viscosity and the investigation of its dependence on process parameters. The results obtained have direct implications for the design of technological equipment, for the control of flow in pipelines and for the establishment of optimal mixing and homogenization conditions in cosmetic and food products.

In the cosmetic field, rheological properties determine the texture, degree of absorption and tactile sensation of the oil, thus influencing the user perception and the effectiveness of the product. In the food industry, viscosity and behavior at variable temperatures are critical factors for the formulation of functional products, nutritional supplements and bakery or pastry products containing rosehip oil. Therefore, a detailed rheological analysis allows both the predictability of the behavior of the oil under various processing conditions and the optimization of formulations to obtain superior physicochemical and organoleptic characteristics. In conclusion, the rheological study of rosehip seed oil represents a fundamental tool for understanding its physical behavior and for its optimal utilization in industrial and cosmetic applications. Characterization of rheological

properties provides essential data for the design of technological processes, for ensuring the stability and uniformity of final products and for maximizing the nutritional and therapeutic benefits of the oil. Thus, the rheology of rosehip seed oil constitutes an indispensable component of applied research, contributing to the development of innovative products with significant added value [6-12].

Materials and method

The oil used in the study was obtained by cold pressing of rosehip seeds, without the addition of solvents or preservatives, in order to preserve the natural characteristics of the oil. An Anton Paar rotary rheometer equipped with a thermostat for precise temperature control (±0.1°C) was used. Test tube and pipettes for sample handling.



Fig 1: Coaxial cylinder rheometer produced by Anton Paar

They were not necessary for the direct rheological study, but the oil was filtered through filter paper to remove solid particles. The oil was allowed to reach room temperature and homogenized by gentle shaking. Before measurements, the samples were filtered to remove solid impurities that could influence the rheological results. The oil samples were subjected to viscosity tests at variable temperatures (20°C, 30°C, 40°C and 50°C) to evaluate the effect of temperature on fluidity. Curves were generated in the range 0–100 s^{-1} to determine the type of rheological behavior (Newtonian or non-Newtonian). The oil was maintained for 10 minutes under constant shear rate to evaluate any temporal changes in viscosity. Viscosity values were calculated and plotted as a function of temperature and strain rate. The obtained curves allowed the identification of the Newtonian or pseudoplastic behavior of the oil, as well as the estimation of the dependence of viscosity on processing parameters.

Result and discussions

Figure 2 shows the dependence of shear rate on shear stress for rosehip seed oil.

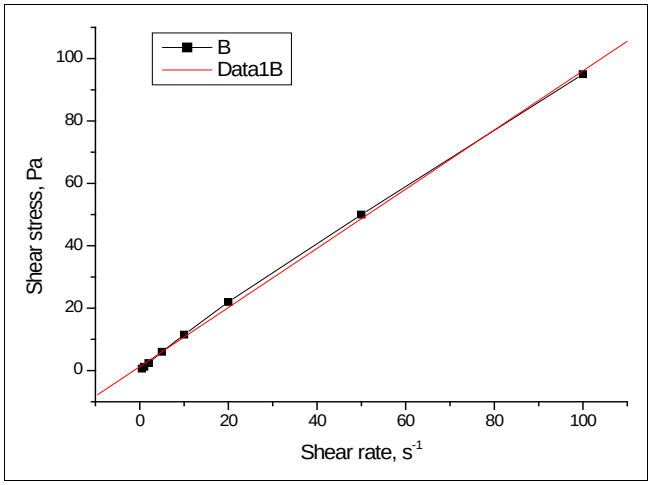

Fig 2: Shear rate dependence on shear stress for rosehip seed oil.

Rheological analysis of rosehip seed oil revealed a clear relationship between shear stress and shear rate, indicating its flow characteristics under different processing conditions. The curves obtained from the measurements demonstrated a predominantly Newtonian behavior at high temperatures, characterized by a linear increase in shear rate with increasing applied stress. This linear relationship suggests that the oil has a constant viscosity under these conditions and behaves as an ideal fluid in technological pumping or mixing processes.

At low temperatures, the oil showed slight deviations from Newtonian behavior, manifesting a pseudoplastic effect, characterized by a slower acceleration of the shear rate at high stress values. This dependence indicates an increase in the internal resistance of the oil to deformation and emphasizes the importance of temperature control during processing to maintain optimal fluidity.

In conclusion, the study of the dependence of shear rate on shear stress provides essential information for the optimization of technological processes and for the development of cosmetic and food formulations. Control of stress and temperature parameters allows maintaining the physicochemical and organoleptic properties of rosehip oil, ensuring performance and stability in industrial applications [13-16].

Figure 3 shows the dependence of dynamic viscosity on temperature for rosehip seed oil.

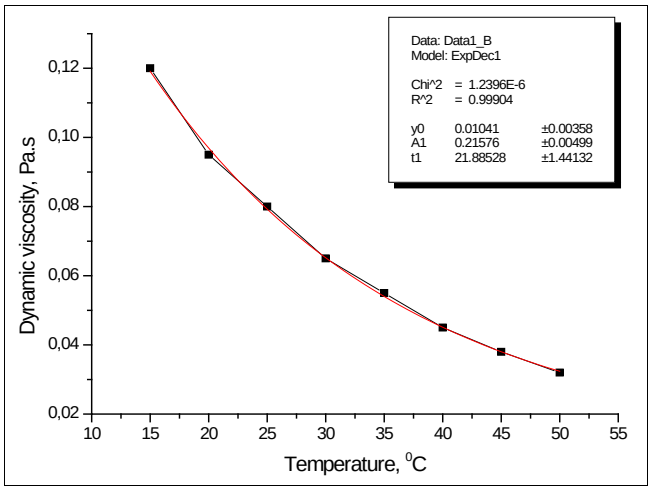

Fig 3: Temperature dependence of dynamic viscosity for rosehip seed oil.

The rheological study of rosehip seed oil revealed a clear temperature dependence of dynamic viscosity, highlighting its influence on fluid behavior during processing and industrial use. Measurements showed that viscosity decreases significantly with increasing temperature, a phenomenon characteristic of vegetable oils, due to the decrease in internal resistance to deformation. At low temperatures (15–20°C), the oil exhibits high viscosity values, which can limit flow and processing, while at higher temperatures (>40°C) fluidity increases, facilitating pumping, mixing and emulsification.

This inversely proportional relationship between viscosity and temperature indicates that temperature is a critical parameter in optimizing technological processes. Knowledge of this dependence allows the establishment of optimal extraction, filtration and packaging conditions, as well as the prevention of undesirable changes in the organoleptic and nutritional properties of the oil. In addition, the information obtained is essential for the formulation of cosmetic and food products, ensuring consistency and stability in use.

In conclusion, the characterization of dynamic viscosity as a function of temperature provides a solid basis for quality control and for the efficient utilization of rosehip seed oil, contributing to the development of optimal industrial and cosmetic applications.

Figure 4 shows the dependence of dynamic viscosity on shear rate for rosehip seed oil.

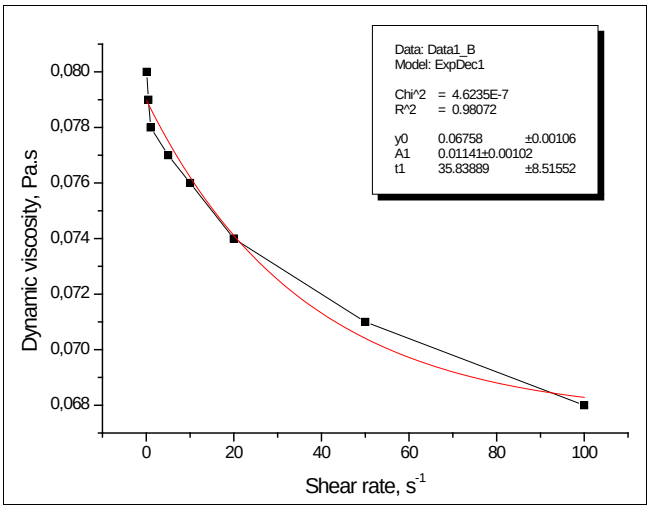

Fig 4: Shear rate dependence of dynamic viscosity for rosehip seed oil.

Rheological analysis of rosehip seed oil revealed the relationship between dynamic viscosity and shear rate, providing important information about the fluid behavior under different processing conditions. The results showed that the oil exhibits a predominantly Newtonian behavior at moderate temperatures and low shear rates, characterized by a constant viscosity independent of the strain rate. This property facilitates the handling and processing of the oil, ensuring a uniform flow in pumping and mixing equipment.

At high shear rates or at lower temperatures, the oil exhibits slight pseudoplastic deflections, indicating a gradual decrease in dynamic viscosity. This behavior suggests that the internal structure of the oil adapts to the applied shear, which can be exploited in industrial processes to optimize flow and reduce energy losses.

In conclusion, the study of the dependence of dynamic viscosity on shear rate provides essential data for equipment sizing and process control. This characterization allows for stable and uniform formulations in cosmetic and food products, contributing to maximizing the nutritional and organoleptic properties of rosehip seed oil [17-20].

Conclusions

The rheological analysis of rosehip seed oil revealed essential characteristics for understanding its behavior under various processing and application conditions. The oil exhibits a predominantly Newtonian behavior at high temperatures, exhibiting a linear relationship between shear stress and strain rate. At lower temperatures, slight deviations towards pseudoplastic behavior are observed, indicating an increase in viscosity and a greater sensitivity to shear rate variations. This temperature dependence emphasizes the importance of controlling processing parameters to maintain product fluidity and stability. The results obtained suggest that the rheological properties of the oil are directly influenced by the lipid composition, the presence of minor compounds, and the extraction and storage conditions. Knowledge of these properties allows the optimization of technological processes, such as filtration, pumping, and packaging, as well as the development of cosmetic and food formulations with superior stability and performance. In conclusion, the rheological characterization of rosehip oil provides a solid basis for industrial exploitation and for the development of functional products, ensuring efficient control over the physicochemical and organoleptic properties of this valuable vegetable oil.

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