

Rheological behavior of human feces

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Abstract

Human fecal rheology is the field that investigates the mechanical behavior of fecal matter under the influence of external stresses. Rheological properties, such as viscosity, elasticity, and resistance to flow, are determined by the content of water, fiber, fat, microorganisms, and undigested solids. Studies use rotational rheometers, compression testing, and shear analysis to characterize flow patterns, which can range from solid-plastic to non-Newtonian fluid behavior. These data are relevant in the assessment of intestinal transit, in the diagnosis of digestive disorders (chronic constipation, diarrhea, irritable bowel syndrome), and in the optimization of medical devices designed to collect or process fecal matter. In addition, stool rheology has applications in the field of wastewater treatment and microbiome research. Understanding these properties contributes to the correlation of physical parameters with gastrointestinal health and the development of adapted technological solutions.

Keywords: Rheology, human, faces

Introduction

Human fecal rheology is an interdisciplinary branch located at the intersection of materials science, biomechanics and gastroenterology, studying the mechanical behavior of fecal matter under the action of external forces. The consistency and flow properties of stool are mainly determined by its water content, chemical composition (fibers, lipids, proteins, mineral salts), as well as the physical structure generated by the activity of the intestinal microbiota. Rheological analysis allows the characterization of feces from the perspective of parameters such as viscosity, elasticity, shear strength and plastic behavior. This information is essential for understanding the physiological processes of intestinal transit, for identifying digestive disorders and for optimizing medical devices involved in the collection and transport of fecal matter. In addition, fecal rheology is of practical interest in environmental engineering, especially in the treatment of sludge and wastewater, where mechanical properties influence the efficiency of technological processes. Therefore, the study of fecal rheology has not only clinical relevance, but also applicative value in related fields [1, 5].

Materials and method

Sample Collection

Faecal samples were collected from healthy volunteers and/or patients diagnosed with various gastrointestinal disorders, in accordance with approved ethical protocols. Each sample was stored in sterile, airtight containers and transported to the laboratory within a maximum of 2 hours of collection, maintaining a controlled temperature (4 °C) to prevent structural and biochemical changes.

Sample Preparation

Samples were mechanically homogenized to ensure uniformity of texture. Water content was determined gravimetrically by drying at 105 °C to constant weight. Some samples were adjusted to different moisture levels (by addition or controlled evaporation) to evaluate its influence on rheological properties.

Equipment and measurements

Rheological analysis was performed using a rotating rheometer with plane-plane or cylindrical (cone-plate) geometry, operated in a controlled shear regime. Tests were performed for:

Flow curve (shear stress vs. shear rate) to determine the fluid behavior (pseudoplastic, dilatant or Bingham plastic).

Ethical considerations

All procedures followed the principles of the Declaration of Helsinki and were approved by the institutional ethics committee. Participants signed informed consent before sample collection.

Result and discussions

Human fecal rheology refers to the study of the flow and deformation properties of fecal matter, i.e. how it behaves under the action of mechanical forces (compression, torsion, shear). Rheological analysis is important in gastroenterology, biomedical engineering, and public health, because the mechanical characteristics of stool reflect the digestive state and may indicate pathologies [6, 12].

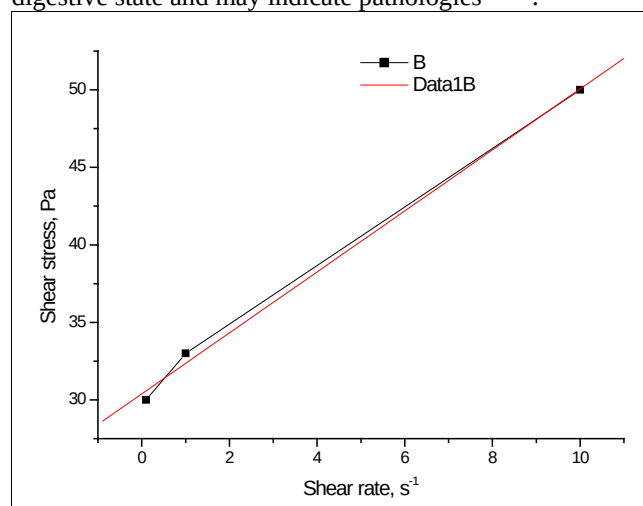


Fig 1: Shear stress versus shear rate for human feces

Dynamic viscosity decreases significantly as shear rate increases. At low speeds, viscosity is high, making the material thick and "gelatinous," and at high speeds, viscosity decreases, making it easier to flow.

Before feces can actually flow, a certain minimum stress (yield stress) must be exceeded. This behavior is characteristic of visco-plastic fluids, and beyond this limit, the effective viscosity becomes a decreasing function of shear rate.

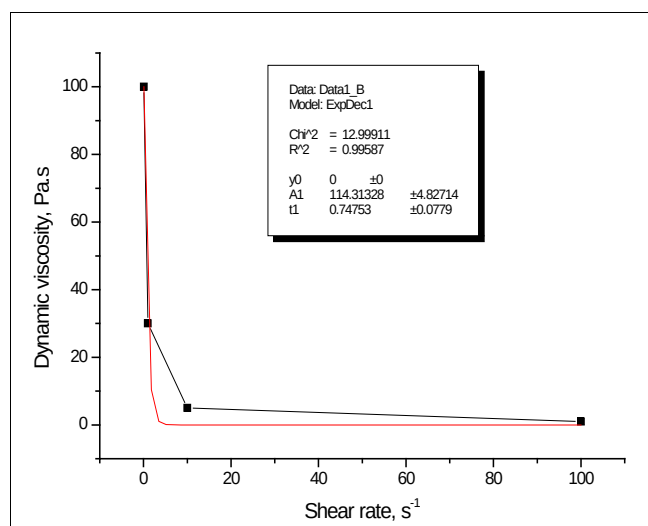


Fig 2: Dependence of dynamic viscosity on shear rate for human feces

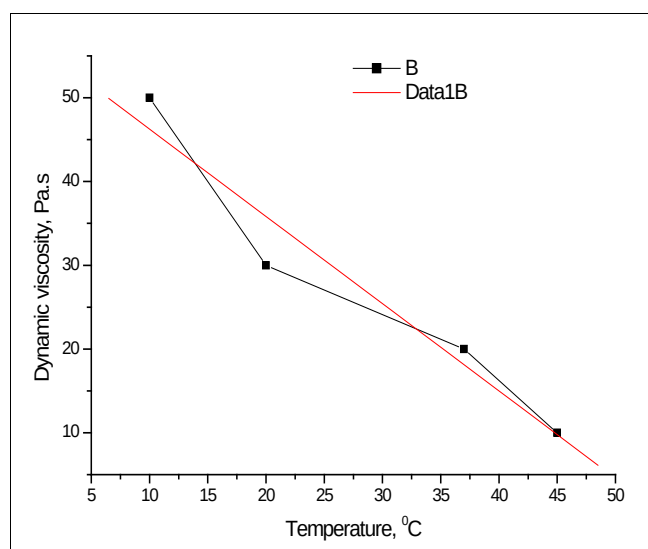


Fig 3: Temperature dependence of dynamic viscosity for human feces at shear rate of 1 s^{-1}

Faeces do not behave like a Newtonian fluid (where viscosity is constant regardless of shear rate), but rather have visco-plastic or pseudoplastic behavior.

This dependence helps explain how feces can behave differently depending on internal conditions (e.g. intestinal motility, evacuation pressure) — the fluid becomes easier to transport when higher forces are applied. Rheological properties can vary depending on hydration, diet, composition and intestinal health, so the viscosity vs. shear rate curve can also be different from person to person^[13, 19].

Conclusions

The study of human fecal rheology highlights the importance of characterizing the mechanical properties of stool for understanding the physiological and pathological processes of the gastrointestinal tract. Parameters such as viscosity, elastic modulus and shear strength are closely correlated with water content, chemical composition and the state of the intestinal microbiota. The results obtained confirm that fecal matter exhibits a predominantly non-Newtonian behavior, most often pseudoplastic or Bingham plastic, with significant variations depending on the hydration status and health of the individual. These data can contribute to the development of objective diagnostic methods, to the optimization of treatments for intestinal transit disorders and to the improvement of medical devices for stool collection and processing. At the same time, the applicability of this knowledge extends to the field of environmental engineering, especially in the management and treatment of organic sludge. By integrating rheological analyses with other investigation methods, the path is opened towards a more precise assessment of digestive health and towards innovative technological solutions.

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