



TRANSFORMING FOOD ANALYSIS AND CONTROL:

NON-DESTRUCTIVE TECHNOLOGIES AND INNOVATIONS

K. Prasad, S. Shekhar, M. K. Paswan and R. Ahuja



Advancing Food Quality, Safety and Sustainability with
Smart, Innovative and Non-Destructive Technologies



Sant Longowal Institute of Engineering
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Electrical Properties of Jaggery as a Function of Moisture Content: Implications for Quality Control and Shelf-Life Augmentation

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Abstract. Jaggery, an uncentrifuged sugar product rich in essential minerals and bioactive compounds, represents a healthier alternative to refined sugar; however, its hygroscopic behaviour significantly compromises product quality and shelf life through moisture absorption and subsequent microbial degradation. The internal moisture content is the critical quality attribute governing its stability, yet the conventional hot air oven method for moisture determination is time-consuming and unsuitable for real-time industrial monitoring. This study addresses the need for a rapid, non-destructive quality assessment technique by examining the relationship between the physicochemical properties of solid jaggery and its electrical characteristics as a function of varying moisture levels. Plain jaggery samples were analysed using a custom-designed setup to measure electrical conductivity (σ), resistivity (ρ), resistance (R), and conductance (G) across a moisture range of 4.5%–7.58%. The results revealed a complex but consistent relationship between moisture and electrical properties, providing a basis for indirect moisture estimation. Electrical resistance and resistivity generally increased with higher moisture content, attributed to the insulating effect of entrapped air pores. In contrast, conductivity and conductance decreased until 6.67% moisture, beyond which conductivity exhibited an unexpected rise. Additionally, the study established a direct correlation between current flow and temperature elevation in the jaggery matrix, highlighting the influence of ionic resistance and moisture-filled pores on heat dissipation, an important aspect for ohmic heating applications. These findings lay a crucial foundation for developing an electrical resistivity based, real-time moisture measurement system, facilitating improved process control and enhanced shelf-life management of solid jaggery.

Keywords: Jaggery, Moisture content, Electrical conductivity, Resistivity, Non-destructive testing, Quality assessment, Ohmic heating.

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1. Introduction

With the increasing global demand for natural and minimally processed foods, traditional sweeteners such as jaggery have regained importance due to their nutritional richness and sustainability. Jaggery is an uncentrifuged sugar produced by concentrating sugarcane juice without separating molasses, thereby retaining minerals, vitamins, and antioxidants that contribute to its therapeutic value. Jaggery contains essential minerals such as calcium (40–100 mg), magnesium (70–90 mg), potassium (10–56 mg), phosphorus (20–90 mg), sodium (19–30 mg), manganese (0.2–0.5 mg), zinc (0.2–0.4 mg), copper (0.1–0.9 mg), chloride (5.3 mg), and iron (10–13 mg), along with vitamins A (3.8 mg), C (7 mg), and D₂ (6.5 mg). These nutrients make jaggery a healthier alternative to refined sugar and a key component of India's rural economy and export sector (Singh, 2013).

Despite its nutritional and economic value, jaggery exhibits limited storage stability due to its hygroscopic nature, which causes it to readily absorb atmospheric moisture. This results in microbial spoilage, stickiness, and quality deterioration, especially during humid conditions. The major problem in jaggery storage arises from the presence of invert sugars and mineral salts, which absorb moisture during the monsoon season, leading to spoilage losses exceeding 10% of the national production valued at approximately ₹40 crore annually (Mandal et al., 2006). The storage stability of jaggery is strongly influenced by environmental humidity. Their study demonstrated that applying edible coatings of carboxymethyl cellulose (CMC) and hydroxypropyl methylcellulose (HPMC) effectively minimized moisture absorption and microbial growth, thus extending shelf life. These findings underline the crucial role of moisture control in maintaining the quality and marketability of jaggery (Kumar et al., 2017).

Currently, conventional methods such as the hot air oven technique are widely used to measure moisture content; however, these methods are destructive, time-consuming, and unsuitable for real-time industrial monitoring. This limitation highlights the need for a non-destructive, rapid, and reliable method for moisture determination. The electrical measurement techniques can provide a low-cost and effective approach for estimating moisture in agricultural products. Their study found that electrical conductivity and dielectric constant increase with moisture content due to the high dielectric coefficient of water molecules, indicating the potential of electrical properties for indirect moisture assessment (Jafari et al., 2020). Similarly, it was observed that the moisture content of agricultural materials significantly influences their dielectric properties, and that these variations

moisture levels. Electrical conductivity initially decreased with increasing moisture content but showed a sharp rise beyond 6.67% moisture due to the ionization of mineral salts and enhanced ionic mobility within the jaggery matrix. Resistivity and temperature also demonstrated a strong dependence on moisture content, indicating that moisture significantly influences the electrical and thermal behaviour of jaggery. These findings establish electrical conductivity and resistivity as effective indicators for indirect moisture assessment. The study thus provides a scientific foundation for developing an electrical resistivity-based, non-destructive device capable of rapid and accurate moisture determination, which can significantly improve quality control, process monitoring, and storage stability in jaggery production.

References

- Jafari, M., Chegini, G., Rezaeealam, B., Shaygani Akmal, A.A., (2020). Experimental determination of the dielectric constant of wheat grain and cluster straw in different moisture contents. Food Science & Nutrition 8 (1), 629-635. <https://doi.org/10.1002/fsn3.1350>
- Kumar, A., Chand, K., Shahi, N.C., Kumar, A., Verma, A.K., (2017). Optimization of coating materials on jaggery for augmentation of storage quality. The Indian Journal of Agricultural Sciences 87 (10). <https://doi.org/10.56093/ijas.v87i10.75031>
- Mandal, D., Tudu, S., Mitra, S.R., De, G.C., (2006). Effect of common packing materials on keeping quality of sugarcane jaggery during monsoon season. Sugar Tech 8 (2-3), 137-142. <https://doi.org/10.1007/bf02943648>
- Nelson, S.O., (2010). Fundamentals of Dielectric Properties Measurements and Agricultural Applications. Journal of Microwave Power and Electromagnetic Energy 44 (2), 98-113. <https://doi.org/10.1080/08327823.2010.11689778>
- Singh, J., (2013). Manufacturing Jaggery, a Product of Sugarcane, As Health Food. Agrotechnology 01 (S11). <https://doi.org/10.4172/2168-9881.s11-007>