A Green Integrated Approach to Extract High-Value Wax and Bioactive Compounds from Sorghum Bran via Supercritical Carbon Dioxide

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INTRODUCTION

Sorghum (*Sorghum bicolor*)

- Gluten-free
- Drought resistance
- Rich in nutritional micro-and macromolecules

Issues

- Although the interest in sorghum kernel is rising, the coating layer, namely sorghum bran, is discarded as waste.
- Current systems to recover lipids and phenolics from the bran require multiple extraction set-ups/steps and petroleum-based organic solvents.

Proposed solution

Using supercritical carbon dioxide (SC-CO_2) based green method to extract wax-rich lipids and phenolic compounds from sorghum bran: An innovative approach

GOAL & OBJECTIVES

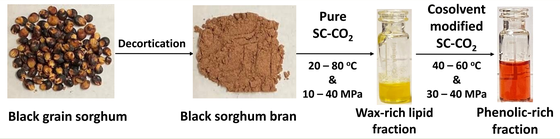
Goal

- To develop a novel and green process utilizing SC-CO_2 and water-ethanol-modified SC-CO_2 to extract both nonpolar (i.e., waxes) and polar compounds (i.e., phenolics) from sorghum bran in a single-step.

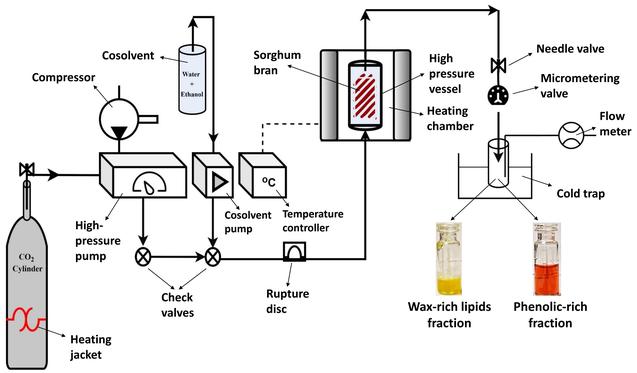
Specific objectives

- Optimize the extraction conditions, namely, temperature, pressure, co-solvent type and concentration, and extraction time for the highest lipid and phenolic yields.
- Characterize the wax-rich lipids and phenolic compounds for their composition.

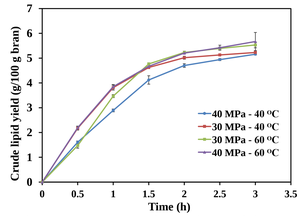
APPROACH

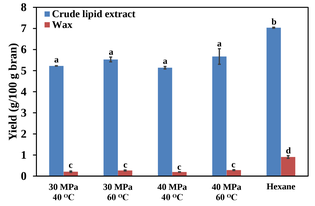


PROCESS SCHEMATIC DIAGRAM

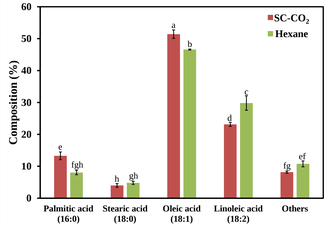


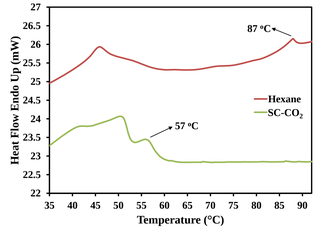
1st PART: EXTRACTION OF WAX-RICH LIPIDS FROM GRAIN SORGHUM BRAN





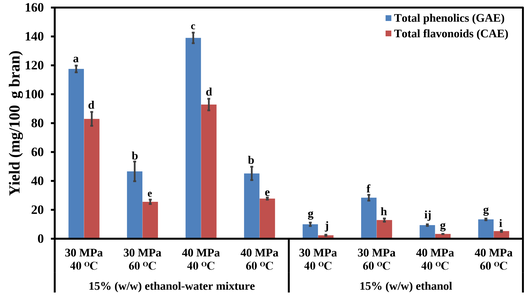
- About 93-95% of crude yield was obtained by pure SC-CO_2 in the first 2 h.
- Temperatures of 40-60 °C and pressures of 30-40 MPa were the optimal conditions.



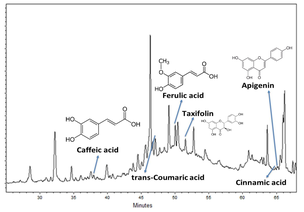


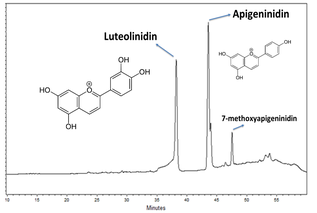
- Oleic (18:1) and linoleic acid (18:2) were the dominant fatty acids (75%).
- SC-CO_2-extracted had a melting point ranging between 57-62 °C.

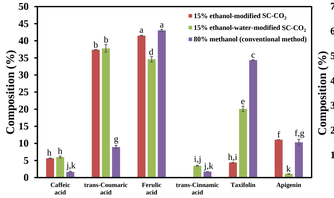
2nd PART: EXTRACTION OF PHENOLIC COMPOUNDS

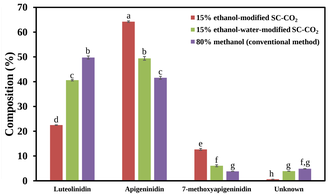


- In the second part of the extraction, using an ethanol-water mixture resulted in significantly higher phenolics recovery compared to using pure ethanol as a cosolvent.
- The highest total phenolic and total flavonoid yields were achieved at 40 MPa and 40 °C using ethanol-water modified SC-CO_2 as 139 ± 3 mg and 92 ± 4 mg in 100 g bran, respectively.



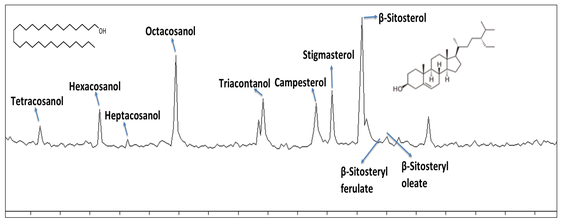






- The phenolic-rich extracts were composed of phenolics acids (i.e., ferulic, caffeic, and coumaric), flavones, flavonols, and 3-deoxyanthocyanins.
- The extraction method significantly altered the phenolic composition of the extracts.

WAX-RICH LIPID COMPOSITION



- β-sitosterol (45%), campesterol (24%) and stigmasterol (17%) were the dominant phytosterols along with policosanols in the lipid extract.

CONCLUSIONS

- Both non-polar (wax-rich lipids) and polar (polyphenols) compounds were extracted using a sequential pure SC-CO_2 and ethanol-water-modified SC-CO_2.
- Nonpolar lipids rich in waxes and phytosterols were selectively extracted in the 1st fraction by neat SC-CO_2.
- The 2nd fraction obtained via ethanol-water-modified SC-CO_2 was concentrated in phenolic compounds.

INDUSTRIAL APPLICATIONS

- A food-grade scalable method to simultaneously extract and fractionate bioactive compounds while eliminating the use of petroleum-based solvents.
- A sustainable source for high-value wax (alternative to carnauba wax).
- Health-promoting phenolic extract for developing functional foods.
- Natural coloring (alternative to synthetic food colorings) for the food industry.

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