Developing a Green Biorefinery Approach for Rural Processing of High-Value Camelina and Sorghum Co-Products

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Problem

Camelina

Oil

Energy

Jet fuel

Ethanol

Starch

Sorghum

Waste

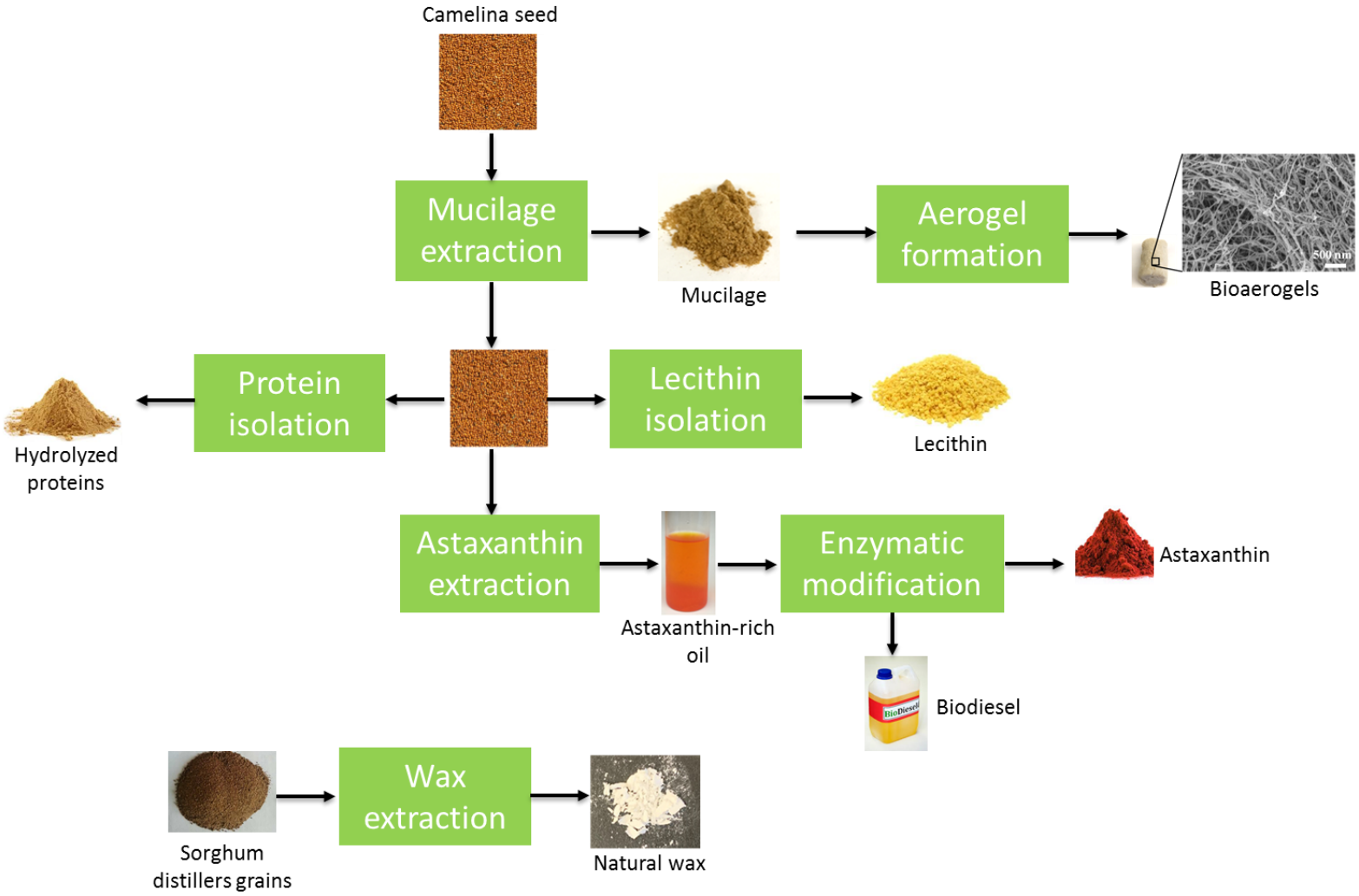
Waste

Innovative approaches

High value products and fractions for food and industrial applications

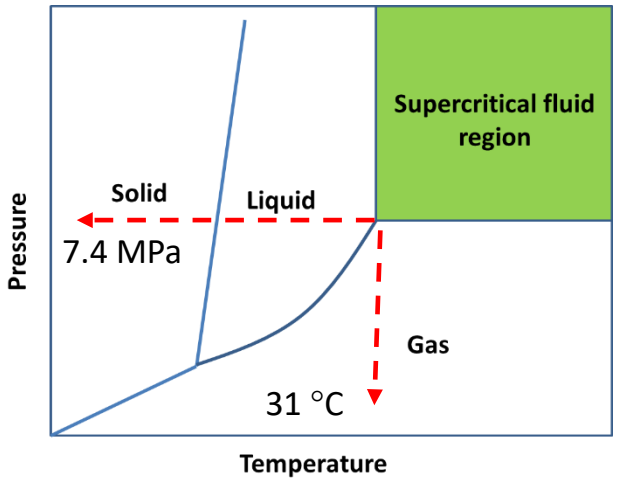
Goal

To develop an innovative integrated green biorefinery approach based on supercritical fluid technology to utilize wastes obtained from the processing of camelina seed and sorghum for biofuel production for several high value-added fractions and products to be used for food, industrial, and nutraceutical applications.



Global trends signal “green” opportunities

Supercritical carbon dioxide (SC-CO_2): A green fluid with many advantages

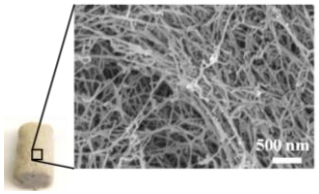


- Fluid above its critical pressure and temperature.
- Liquid-like density to enhance solubility, gas-like viscosity, compressibility and diffusivity, allowing higher mass-transfer rates or penetration.

- Inexpensive, non-toxic, abundant.
- Moderate critical pressure and temperature (31 °C, 7.4 MPa).
- Ease of separation from solute.
- No solvent residue in products.
- Environmentally friendly process.
- Selective and nondisruptive technology.
- No oxidation in CO_2 environment.
- No degradation of heat labile components.
- “Clean” products.

Novel high value products and fractions from camelina seed and sorghum distillers grains

Mucilage: Novel food thickening agent



Bioaerogels:
Novel drug and bioactive delivery systems, bioabsorbent,
insulation material

Astaxanthin:
Nutraceutical,
natural food colorant
(~$7,000/kg)

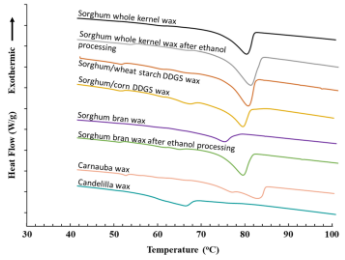
Lecithin: Food emulsifier and ingredient for various foods – alternative to soy lecithin

Emulsions

Biodiesel

Hydrolyzed proteins:
Functional food ingredients

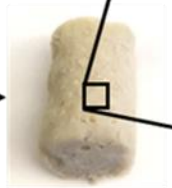
Natural wax: Alternative to carnuba and candelilla waxes



Novel nanoporous mucilage aerogels

Camelina seed

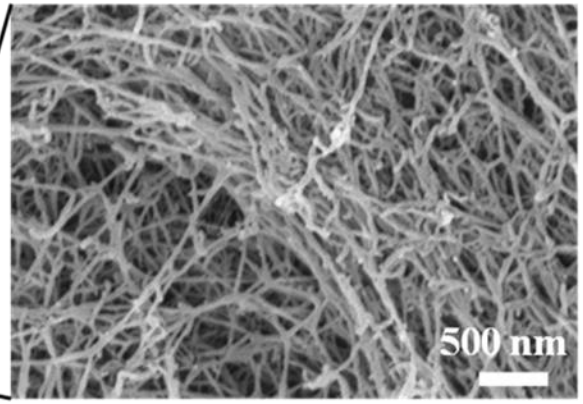
Camelina mucilage



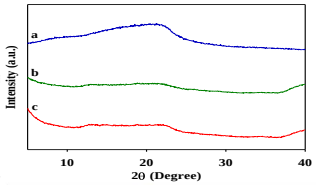
Camelina mucilage aerogel

From concentrate (CMA)
From powder (PMA)

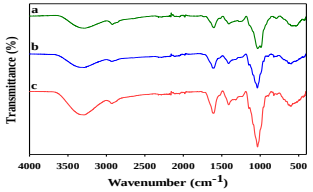
Morphology
Surface area, pore size, pore volume



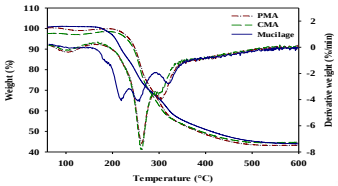
Crystallinity



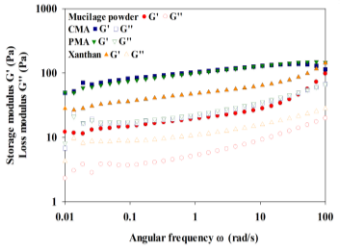
Chemical structure



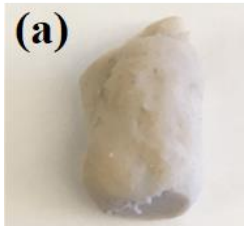
Thermal stability

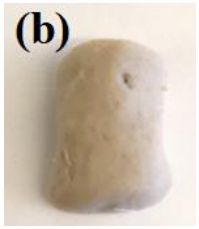


Rheological properties



Camelina mucilage aerogels have outstanding properties



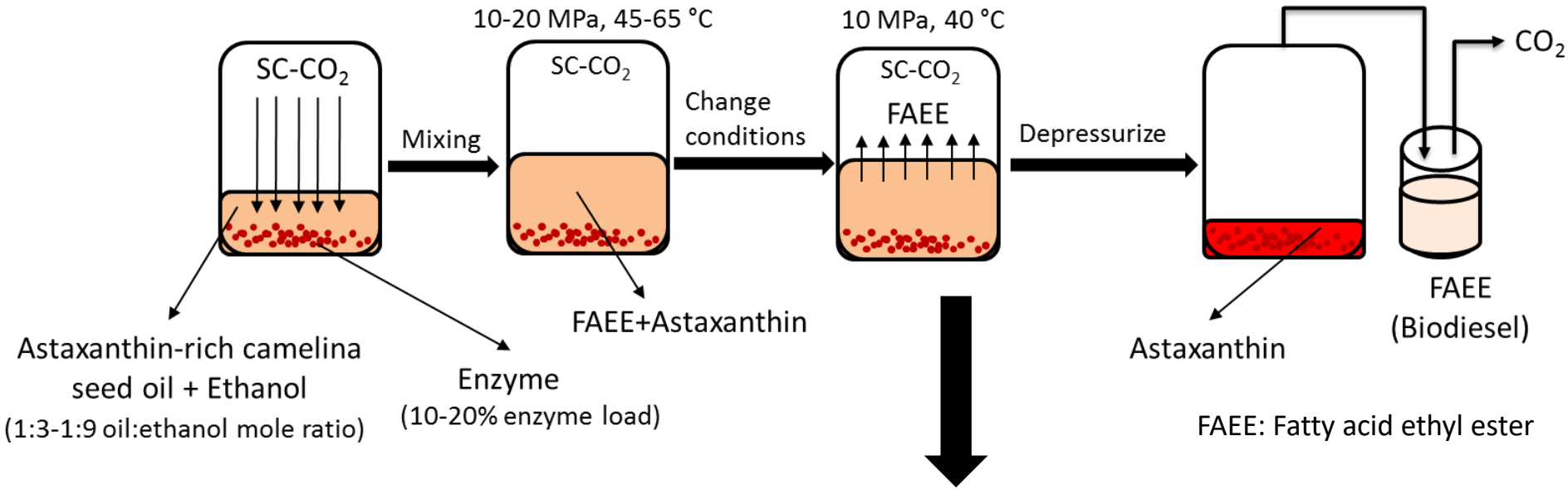


	CMA	PMA
BET surface area (m^2/g)	228.7 ± 7.0^a	239.5 ± 4.6^a
BJH pore size (nm)	5.6 ± 0.1^b	6.0 ± 0.2^a
Pore volume (cm^3/g)	0.28 ± 0.01^b	0.32 ± 0.01^a
Density (g/cm^3)	0.05 ± 0.01^b	0.08 ± 0.01^a
Porosity (%)	94.3 ± 0.5^a	91.0 ± 0.9^b

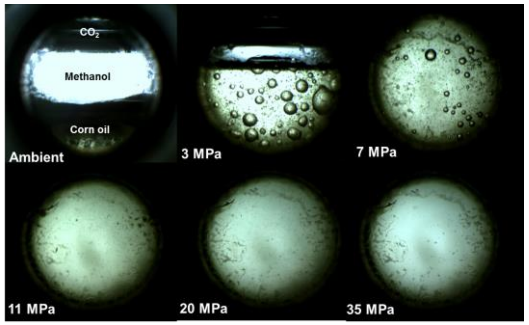
From concentrate (CMA)
From powder (PMA)

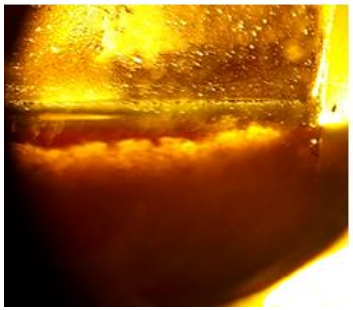
Isolation of astaxanthin from camelina seed oil by enzymatic modification in SC-CO_2: A novel green separation and purification process

Process development and optimization using a model system:

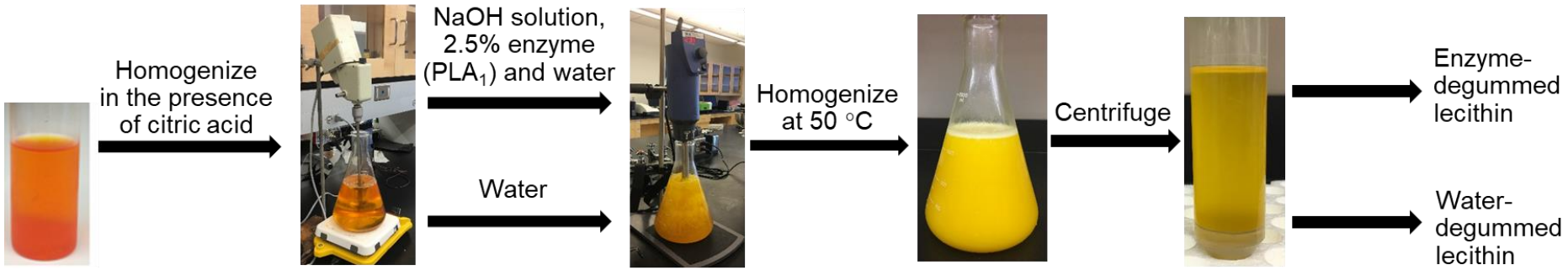


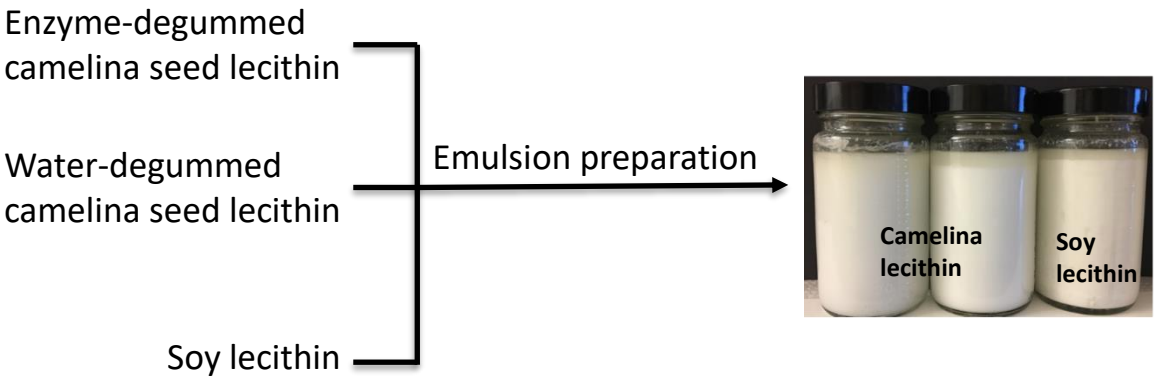
FAEE: Fatty acid ethyl ester





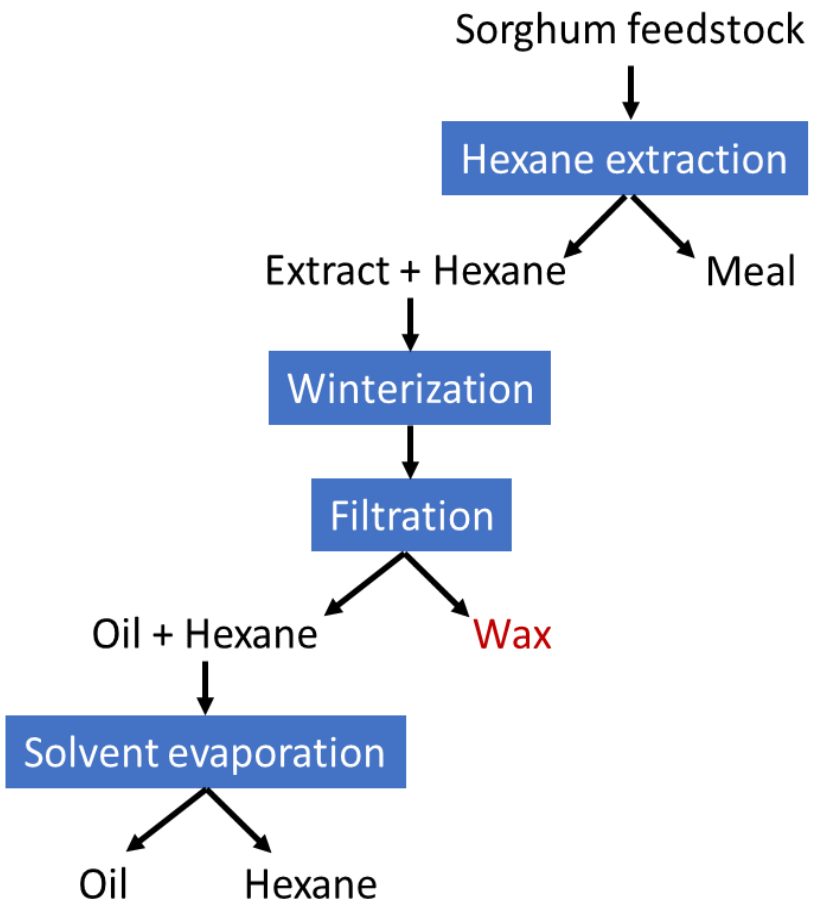
Camelina seed is a new promising lecithin source



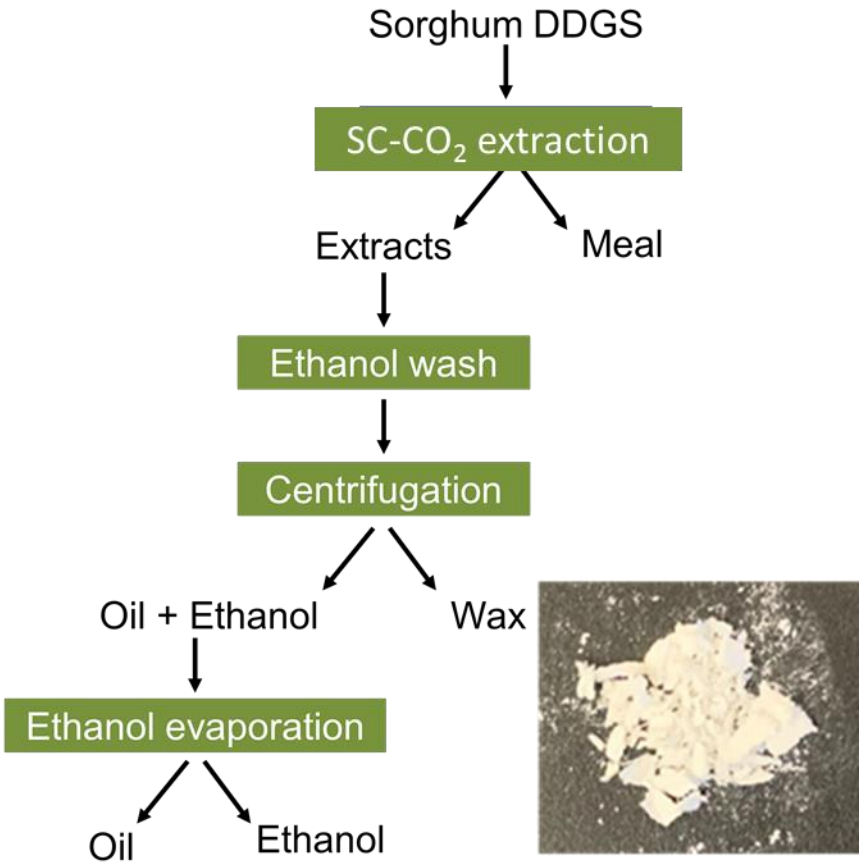


Extraction and purification of wax from sorghum by-products using SC-CO_2: A new simple and clean purification process

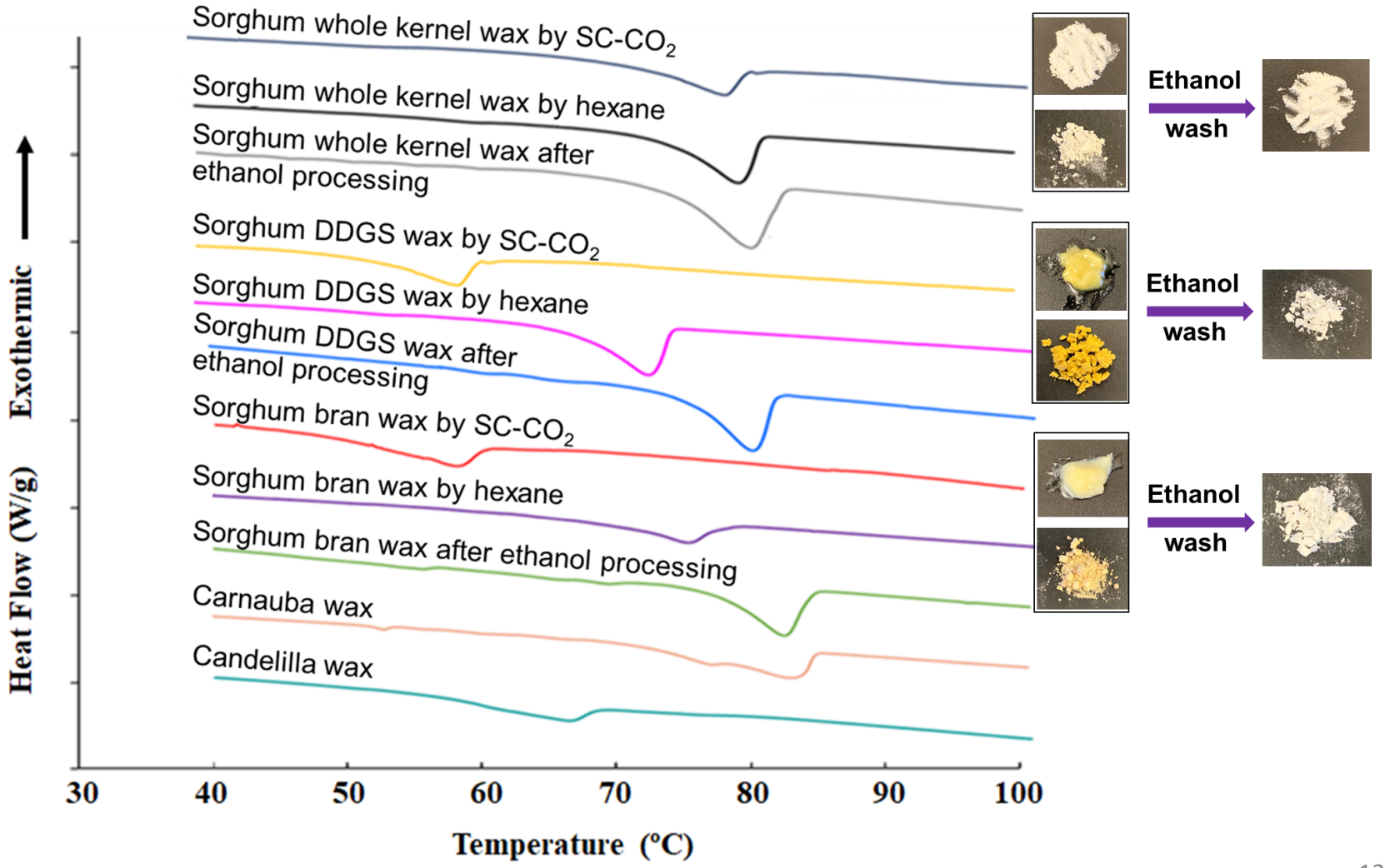
Conventional industrial process



Our green process



Sorghum wax is alternative to industrial carnauba and candelilla wax



Oleogel formation using sorghum DDGS wax: Novel fat replacers

Sorghum DDGS wax (2-10 wt.%)
+
camelina seed oil

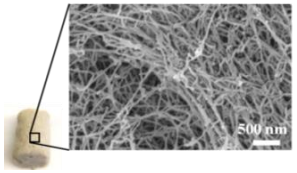
Ultrasonication

Oleogels:
Novel solid fat replacers to produce low-calorie foods and reduced fat intake in diet

Novelty & Innovation

Camelina mucilage

- A novel food thickening agent.
- Similar properties to xanthan gum - great potential for food applications.



Camelina mucilage aerogel

- First-of-its-kind novel bioaerogel.
- First time reported.
- Potential food grade biomaterial for drug and bioactive delivery, bioabsorbent, and insulation material.

Astaxanthin

- First natural astaxanthin generated in an oilseed.
- Ethanol-modified SC-CO_2 extraction of astaxanthin is innovative.

Camelina Lecithin

- First time reported.
- An alternative to soy lecithin - the major lecithin on market. Industry is looking for alternatives to soy lecithin due to allergenicity.

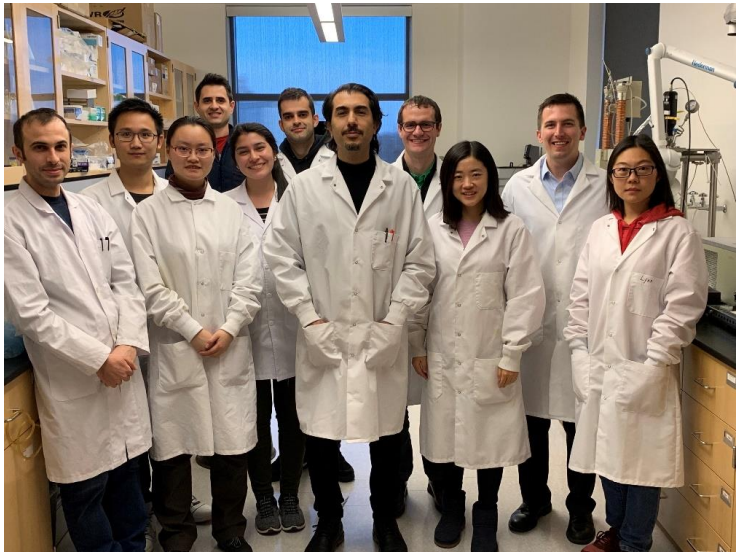
Sorghum wax

- A new natural wax.
- USA is dependent on natural waxes imported from Brazil. Demand for natural wax is growing.
- Wax purification process is novel.

Expected Outcomes and Estimated Impact

- Foundation for efficient utilization of energy crops and co-products to enable profitable camelina and sorghum production and utilization for biofuel production.
- Several novel and high value products from sorghum and camelina that will enhance the sustainability and economic value of these crops as energy crops.
- The products will have great commercialization potential - technology will be green, the products will be natural and clean, and the processing technology can be implemented at relatively low cost and scaled as needed.
- Stimulate job creation and additional market opportunities for Nebraska farmers.

Thank you



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