Generating Nanoporous Protein Aerogels from Defatted Rice Bran via Supercritical Carbon Dioxide

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RICE PROCESSING BYPRODUCTS

- Rice is a major cereal food crop (>500 MT).
- Arkansas is the leading producer of rice production in the nation.
- Rice processing byproduct, i.e., rice bran, is ~8-10% of total rice weight.
- Rice bran contains high-value starch and proteins.
- Rice proteins are albumin, globulin, glutenin, and prolamin.

Issues

- Used as animal feed
- Underutilized/restricted applications
- Disposal and economic loss concerns

GOAL & OBJECTIVES

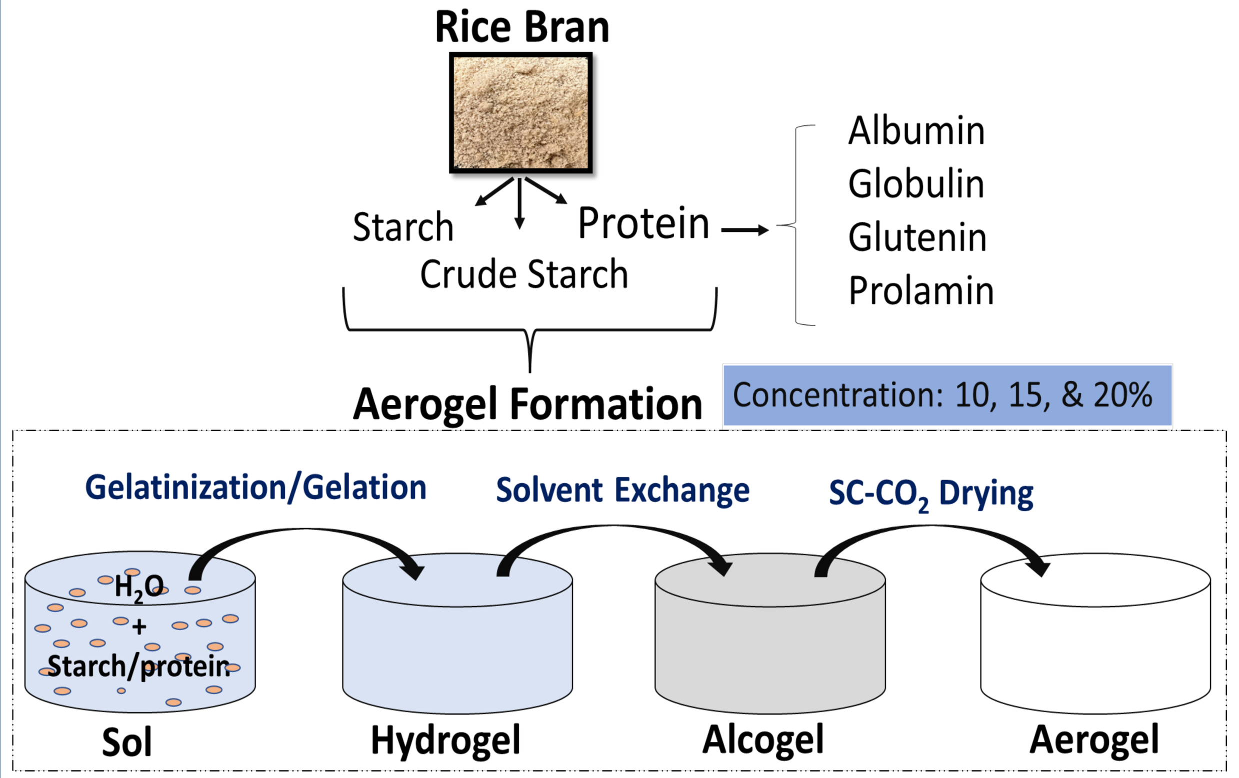
Goal

- To convert defatted rice bran into high-value aerogels (i.e., nanoporous high-value materials for the delivery of bioactive compounds) using supercritical carbon dioxide (SC-CO_2) drying.

Specific objectives

- To form aerogels from the starch, crude starch, and proteins extracted from defatted rice bran using SC-CO_2 drying.
- To characterize the generated aerogels and investigate the effect of the composition on their properties.

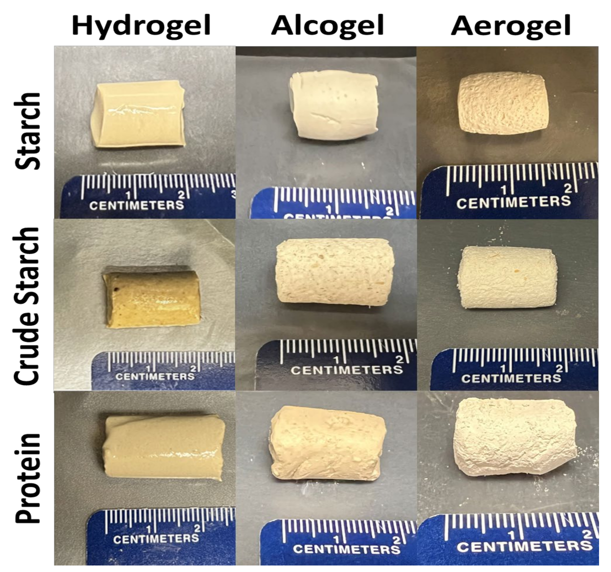
AEROGEL FORMATION FROM BYPRODUCTS



Characterization: Chemical composition; morphology; crystallinity; chemical interactions; stability; solubility.

FABRICATION OF NANOPOROUS AEROGELS FROM DEFATTED RICE BRAN FRACTIONS

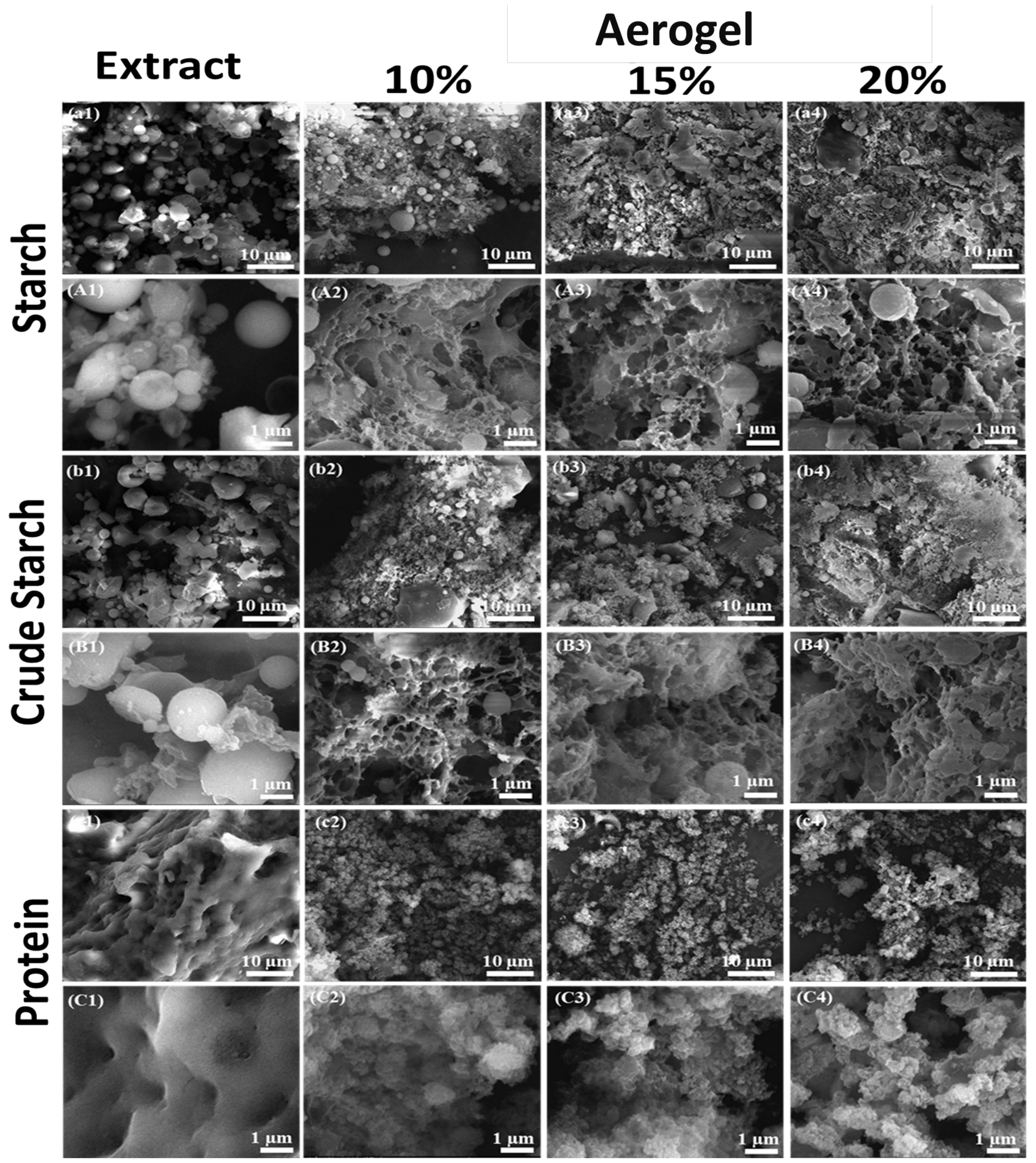
Rice Bran	Composition (%, w/w)
Protein	13.84 ± 0.11[b]
Starch	34.63 ± 2.93[a]
Oil	12.32 ± 2.23[b]
Moisture	2.52 ± 0.15[c]
Ash	14.60 ± 0.42[b]
Total dietary fiber	36.15 ± 0.21[a]



Pictures of rice bran starch, crude starch, and protein hydrogels, alcogels, and aerogels.

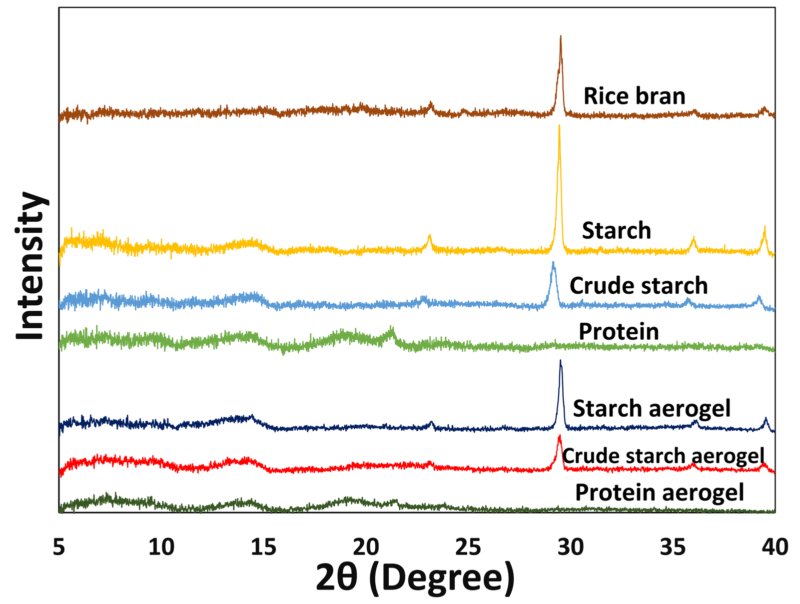
Aerogel	Surface area (m^2/g)	Pore size (nm)	Pore volume (cm^3/g)	Density (g/cm^3)	Porosity (%)
Starch	36.46 ± 1.01[b]	19.02±0.76[b]	0.18±0.01[c]	0.27±0.02[b]	85.28±1.52[b]
Crude starch	46.54 ± 2.19[a]	16.48±0.14[c]	0.21±0.01[b]	0.29±0.02[a]	83.31±1.27[c]
Protein	34.56 ± 7.12[b]	24.93±8.30[a]	0.27±0.08[a]	0.19±0.01[c]	86.94±1.00[a]

- Stronger hydrogels were formed via rice bran proteins compared to starches.
- Protein aerogels had lower density with higher porosity compared to starch aerogels.

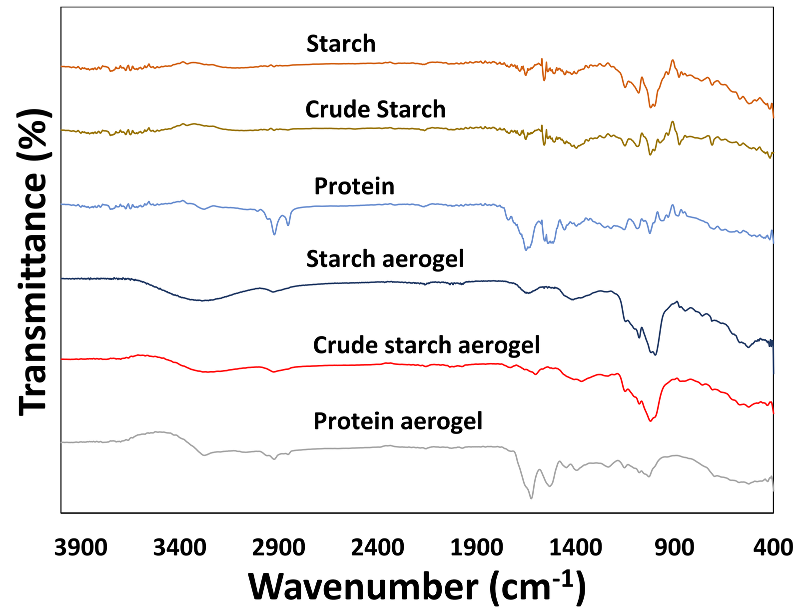


SEM images of rice bran starch, crude starch, and protein extracts and aerogels (10, 15, and 20% concentration).

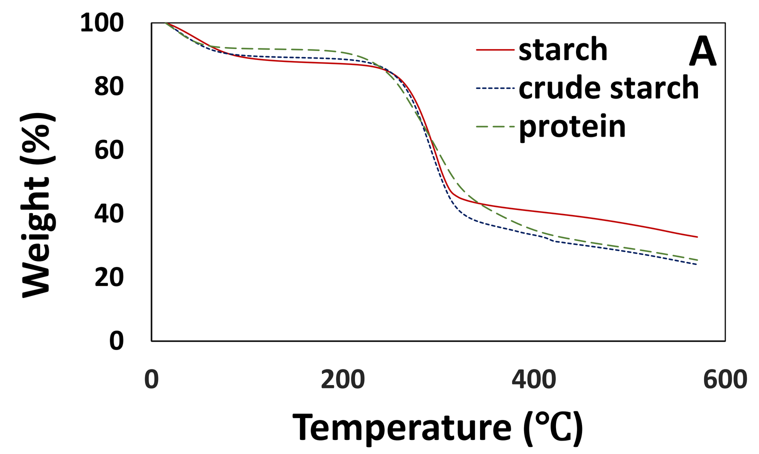
- All aerogels revealed open porous structures with interconnected fibrils.

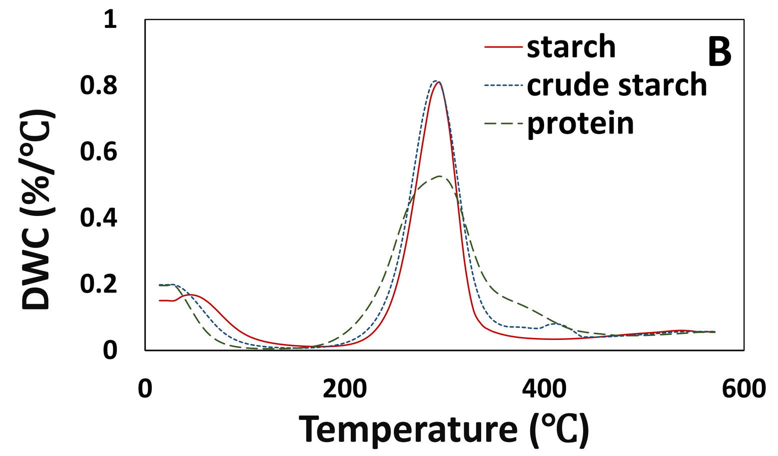


XRD patterns of the rice bran starch, crude starch, and protein extracts and aerogels.

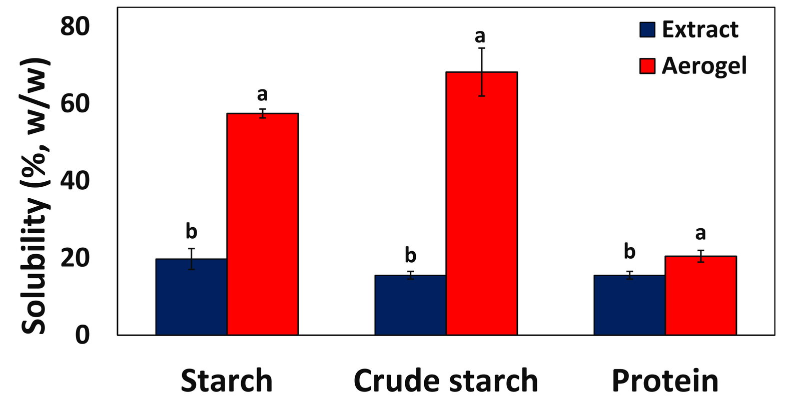


ATR-FTIR spectra of the rice bran starch, crude starch, and protein extracts and aerogels.

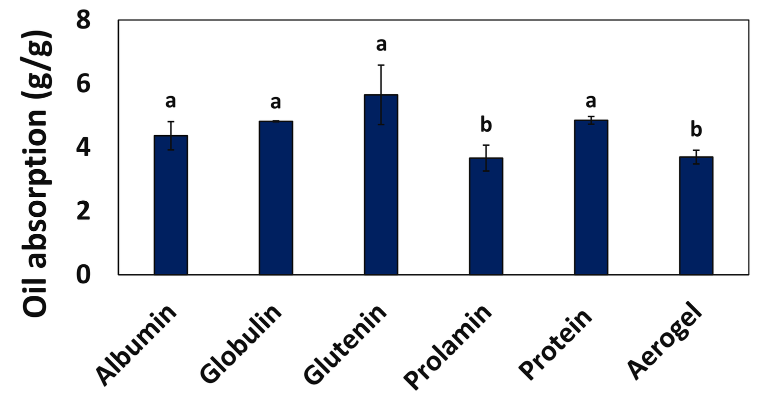




Thermogravimetric analysis (A) weight loss and (B) derivative weight of starch, crude starch, and protein aerogels produced using 15% concentration.



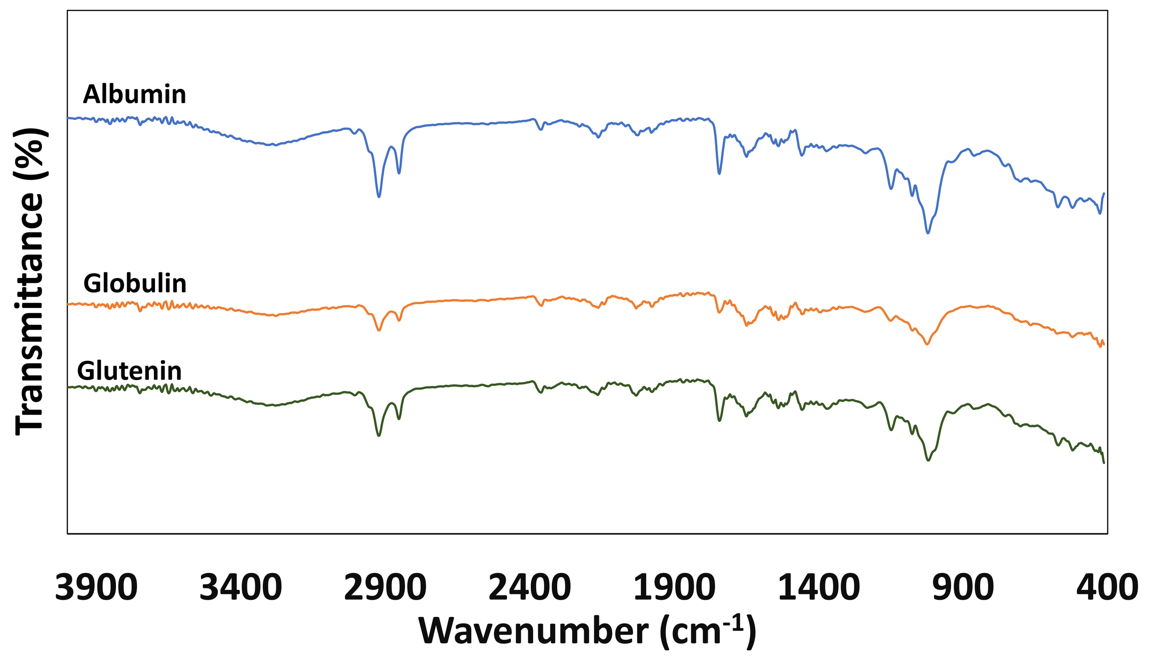
Water solubility of starch, crude starch, and protein extract and aerogels.



Oil absorption of protein fractions, extract and aerogel.

- The aerogels showed higher solubility compared to extracts while they revealed lower oil absorption capacity.

ATR-FTIR OF THE PROTEIN FRACTIONS



ATR-FTIR spectra of the protein fractions extracted from defatted rice bran.

CONCLUSIONS

- Nanoporous starch and protein aerogels were successfully produced from defatted rice bran.
- Stronger hydrogels were formed via rice bran proteins.
- The protein aerogels demonstrated the highest porosity and the lowest density.
- A 15% protein/starch concentration generated the best 3D network structure.
- The aerogel formation increased the water solubility of proteins and starches from defatted rice bran.

INDUSTRIAL APPLICATIONS

- Produce new health-promoting food ingredients for developing functional foods.
- Generate high-value porous materials from defatted rice bran for bioactive compound delivery.
- Propose new avenues for the utilization of rice bran.
- Improve the sustainability of rice production by reducing waste generation.

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