Research progress selects on RBO in the last three years

Xuebing Xu

Outline

Enzyme assisted extraction of rice bran oil

Rice bran oil bodies

Physicochemical properties, fatty acid compositions, bioactive compounds, antioxidant activity and thermal behavior of rice bran oil obtained with aqueous enzymatic extraction

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Rice Bran Oil: Emerging Trends in Extraction, Health Benefit, and Its Industrial Application

CrossMark

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Aqueous extraction processing: An innovative and sustainable approach for recovery of unconventional oils

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Cell structure

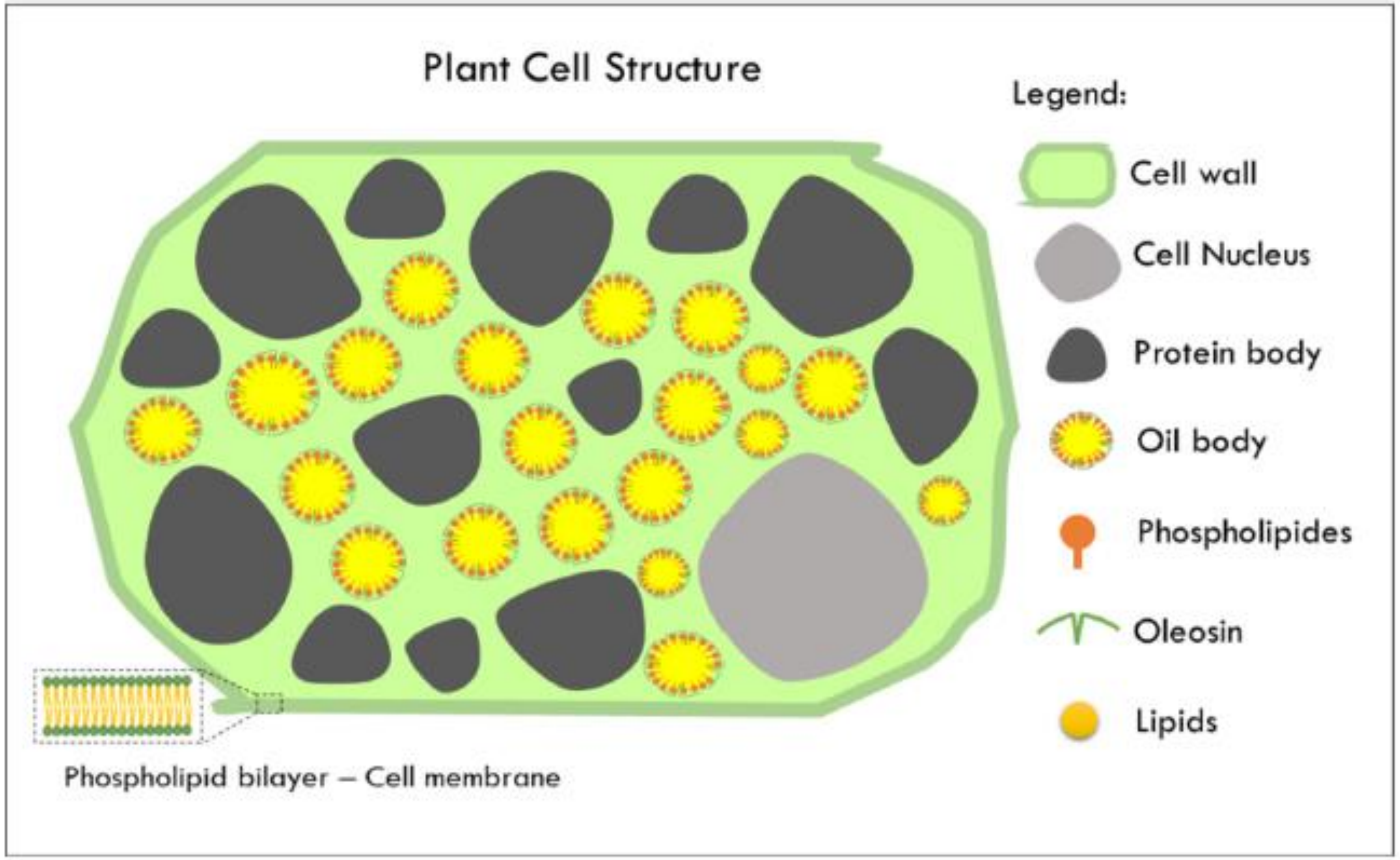
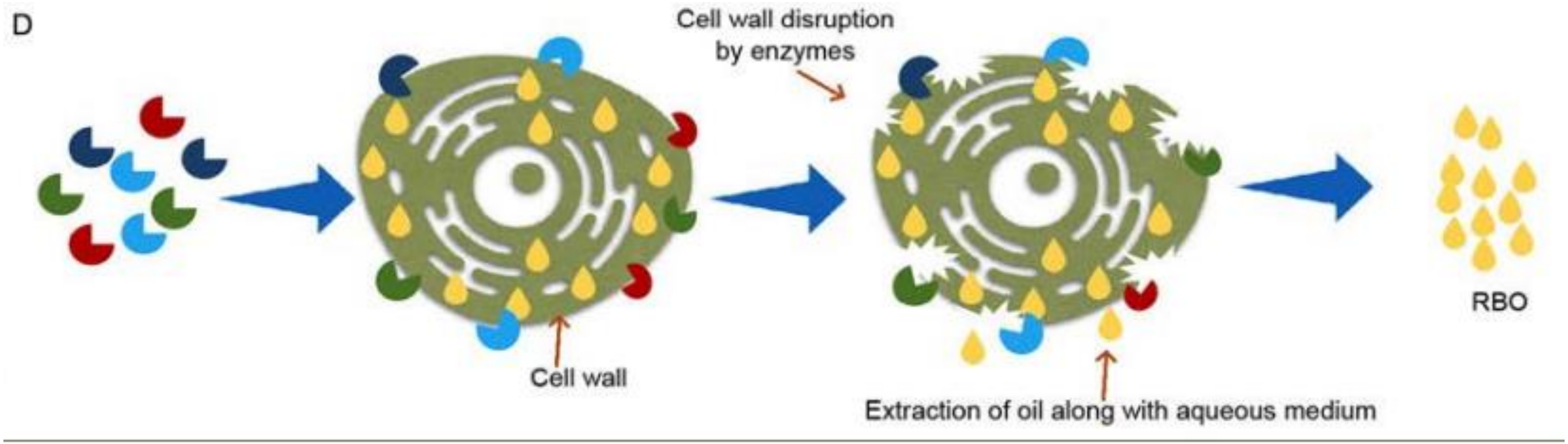


Fig. 1. Plant cell structure (Adapted from Nikiforidis et al. (2014)).

Illustration of enzyme assisted aqueous extraction



Oil difference

Table 3

Content of bioactive compounds of RBO obtained by different methods. AEEO, AEE-extracted oil; SEO, SE-extracted oil. All values are the mean of three replications ± SD. Different letters mean statistically significant differences between treatments ($P < 0.05$).

Compounds	AEEO	SEO
Sum of tocopherols and tocotrienols (mg/kg)	1004 ± 17.94^{a}	839 ± 19.78^{b}
α-tocopherol	316 ± 7.39^{a}	261 ± 6.09^{b}
γ-tocopherol	44.88 ± 1.11^{a}	31.00 ± 0.01^{b}
α-tocotrienol	235 ± 1.39^{a}	230 ± 6.36^{a}
γ-tocotrienol	408 ± 8.05^{a}	317 ± 7.32^{b}
Sterols (mg/100 g)	7749 ± 23.44^{a}	6956 ± 59.98^{b}
Campesterol	1893 ± 4.21^{a}	987 ± 4.06^{b}
Stigmasterol	846 ± 8.76^{a}	670 ± 3.97^{b}
β-sitosterol	4143 ± 4.69^{a}	4095 ± 21.66^{b}
Stigmastanol	867 ± 5.78^{b}	1204 ± 30.29^{a}
Squalene (mg/kg)	2962 ± 6.02^{a}	2479 ± 103.53^{b}
Oryzanol (g/100 g)	2.43 ± 0.06^{a}	2.31 ± 0.02^{b}

Rice brans after different treatments

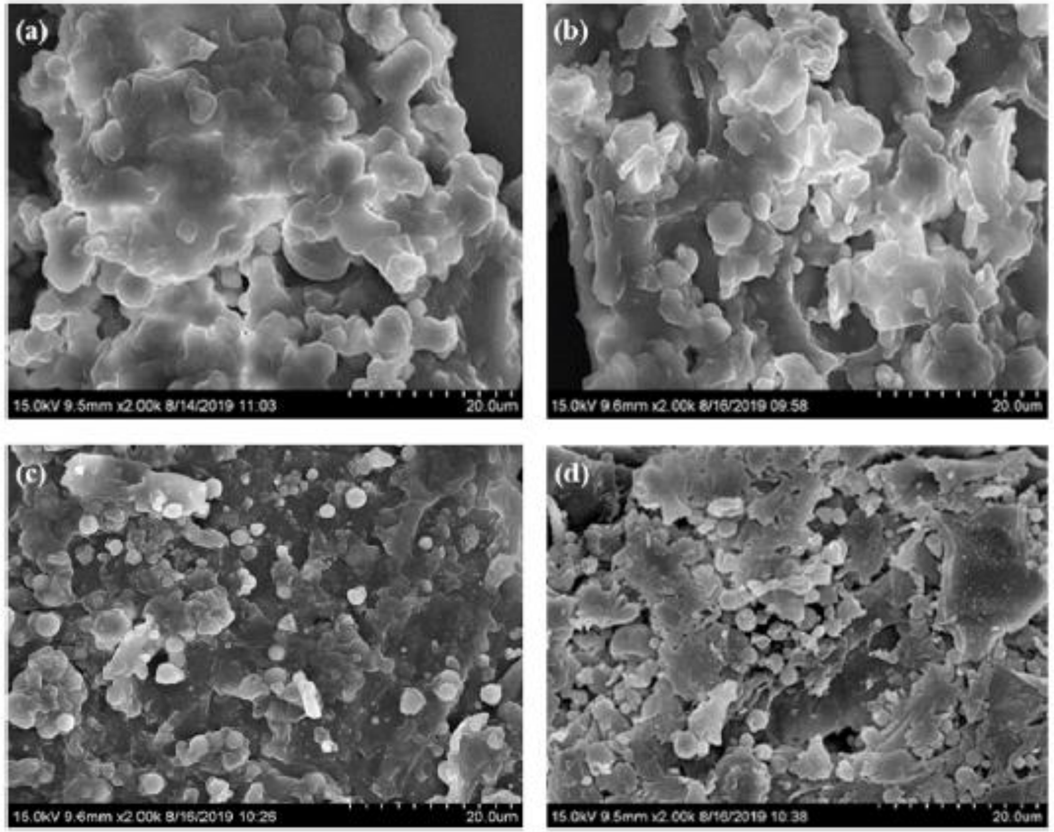


Fig. 4. SEM of rice bran samples: natural rice bran (a), expanded rice bran (b), after AEE (c), and after SE (d). The samples were systematically viewed at 2000× magnification.

Beneficial aspects for the technology

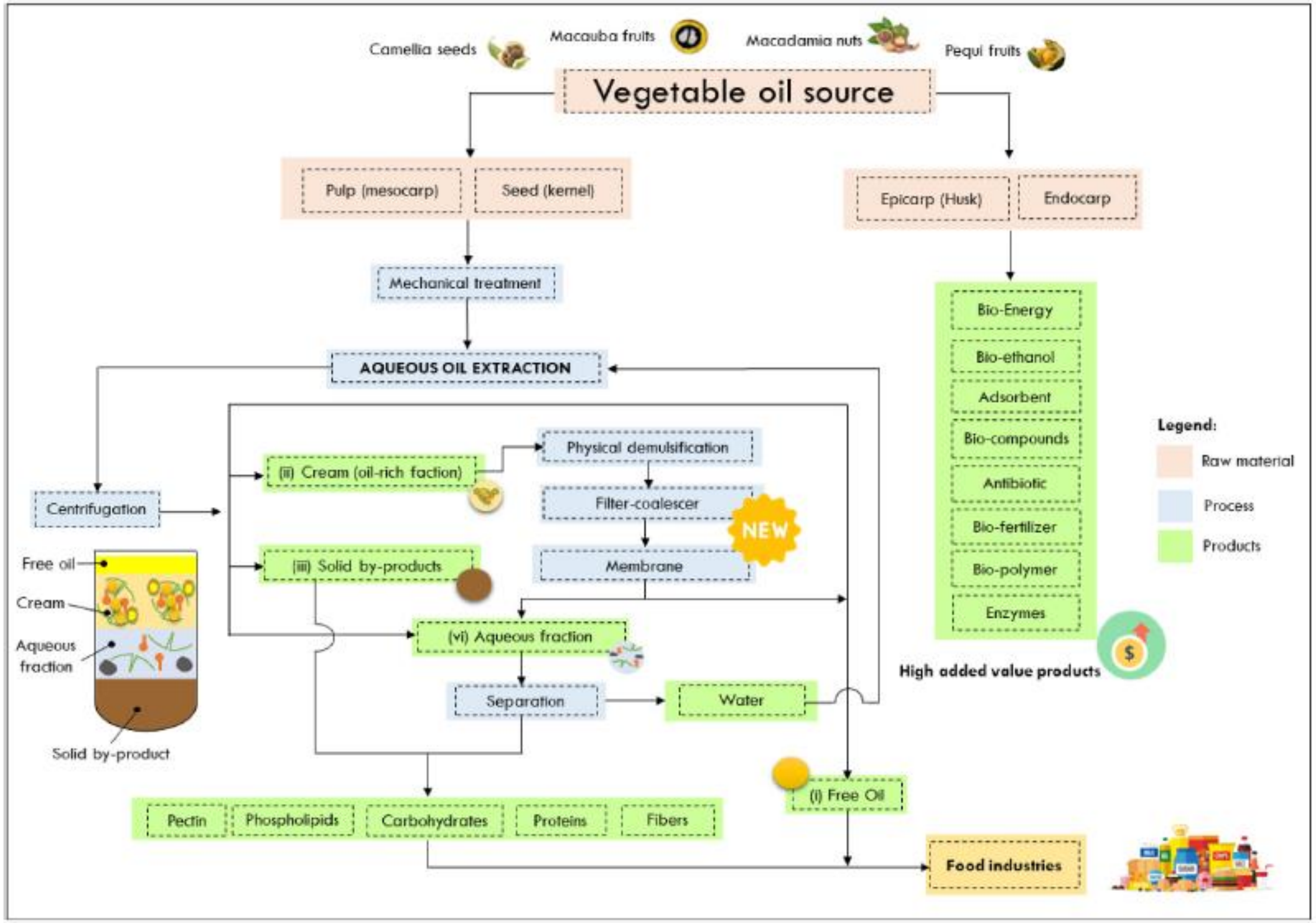
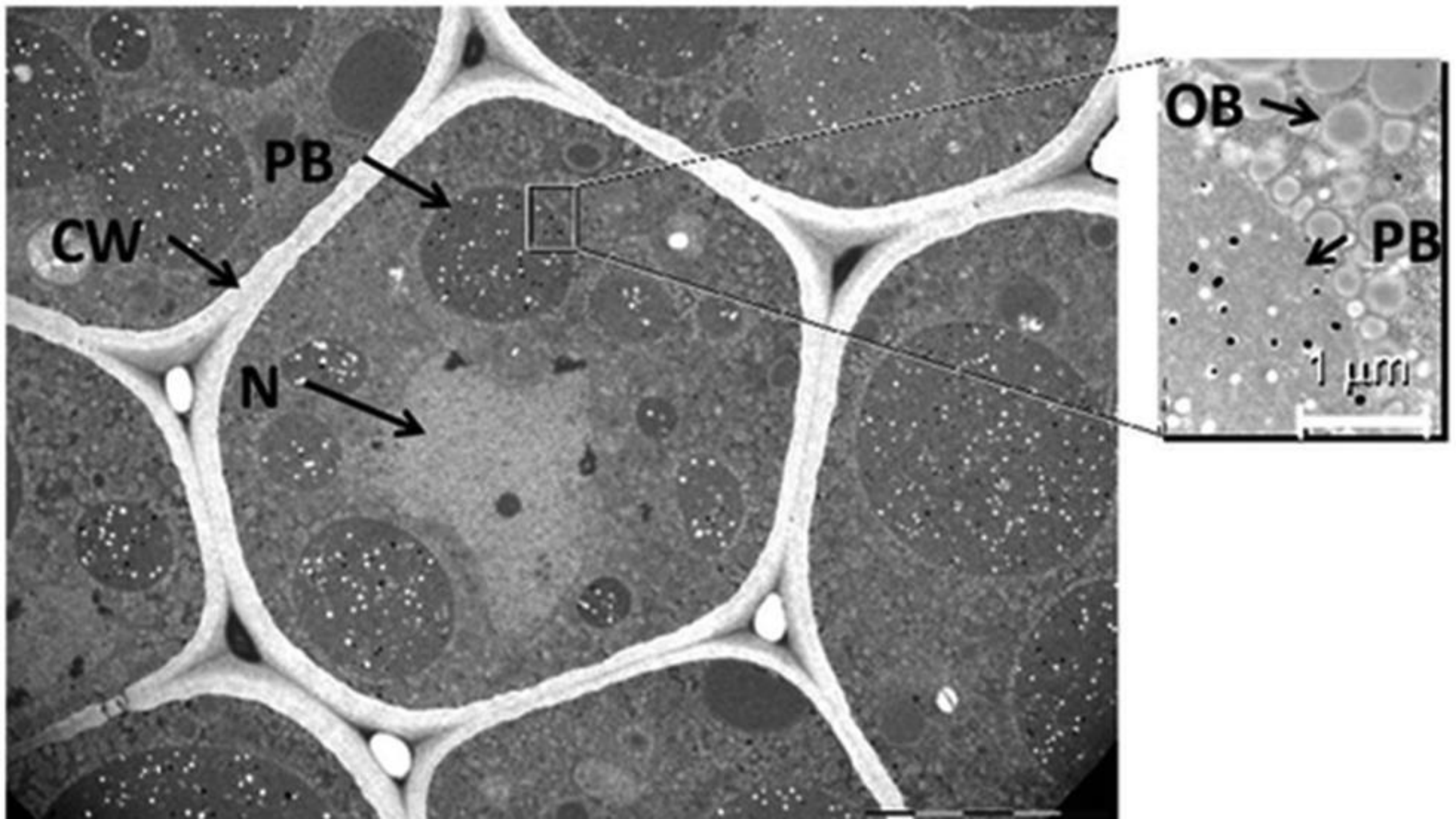


Fig. 3. Generic biorefinery design for industrial oil production by aqueous oil extraction based on physical demulsification methods.


PB
CW
N
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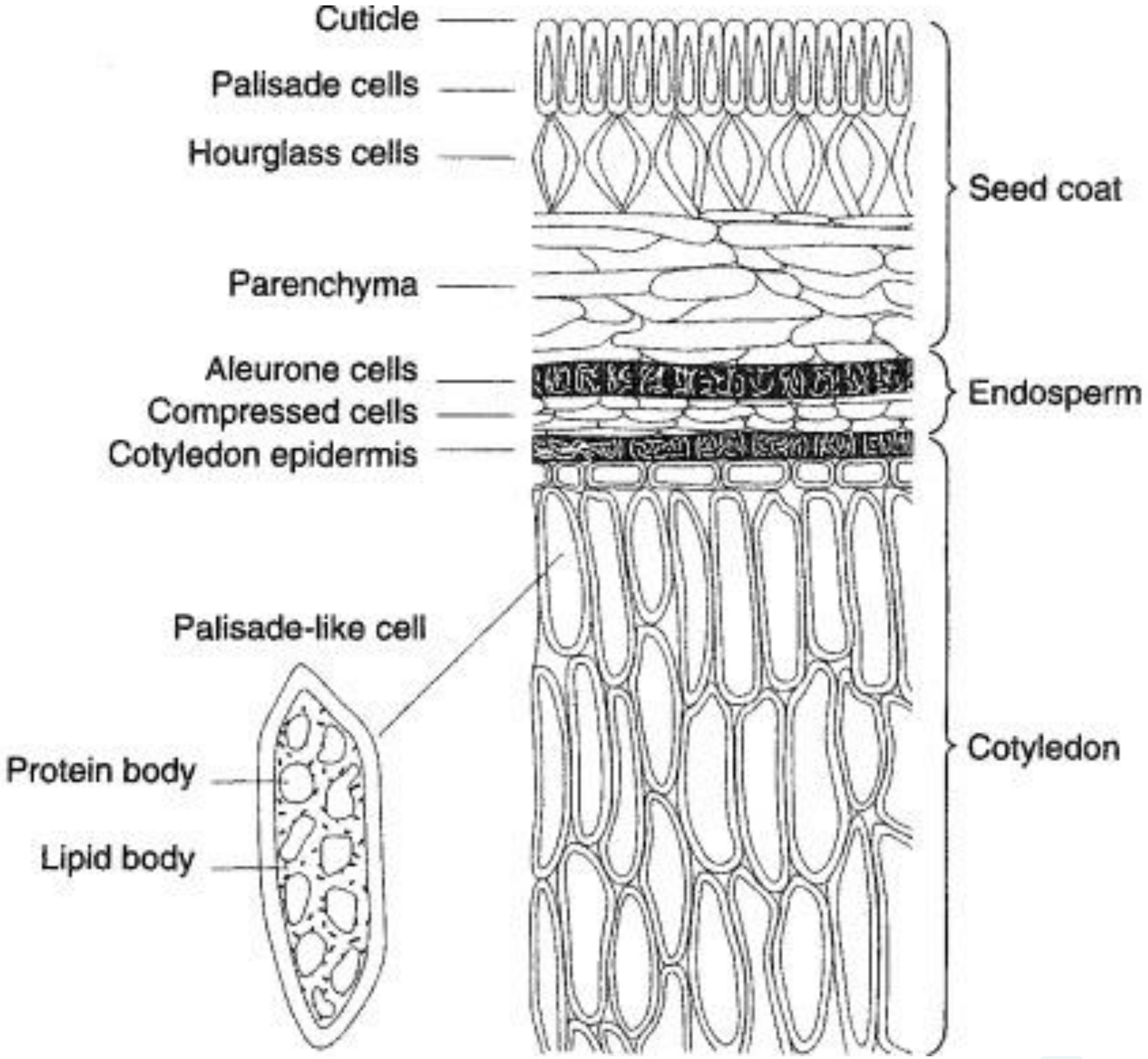
PB
1 μm


Cuticle
Palisade cells
Hourglass cells
Parenchyma
Aleurone cells
Compressed cells
Cotyledon epidermis
Palisade-like cell
Protein body
Lipid body
Seed coat
Endosperm
Cotyledon

Rice bran cells

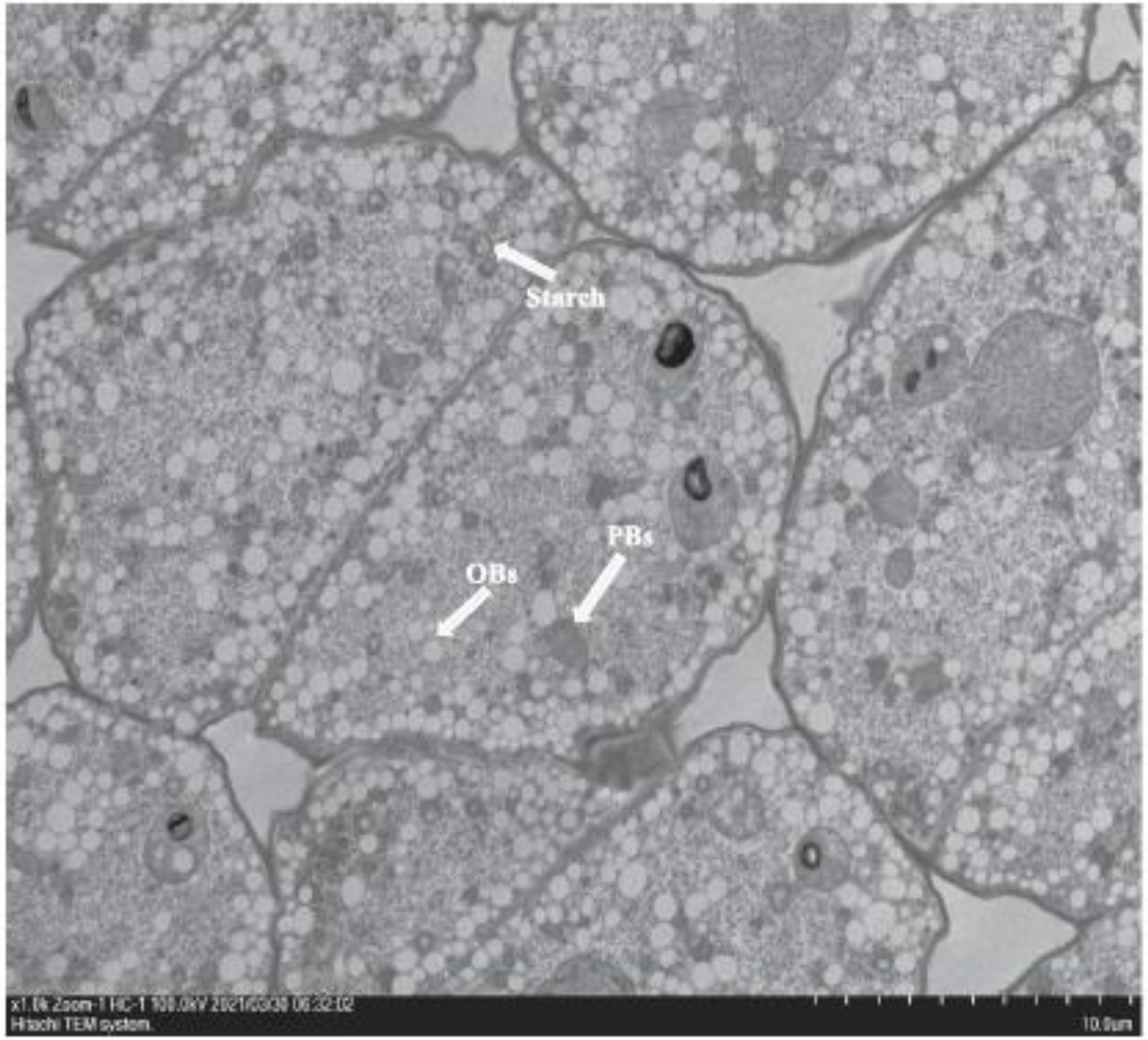


Fig. 2. TEM images of rice bran cells. PBs, protein bodies.

Oil body

Soybean oil bodies: A review on composition, properties, food applications, and future research aspects

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Studies in the last three years on rice bran oil bodies

Structures and physicochemical characterization of enzyme extracted oil bodies from rice bran

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Extraction of structurally intact and well-stabilized rice bran oil bodies as natural pre-emulsified O/W emulsions and investigation of their rheological properties and components interaction

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School of Food and Health, Beijing Advanced Innovation Center for Food Nutrition and Human Health (BTBU), Beijing Engineering and Technology Research Center of Food Additives, Beijing Higher Institution Engineering Research Center of Food Additives and Ingredients, Beijing Key Laboratory of Flavor Chemistry, Beijing Laboratory for Food Quality and Safety, Beijing Technology and Business University, 100048 Beijing, China

Formation, digestion properties, and physicochemical stability of the rice bran oil body carrier system

Han Wang [a], Lu Chen [a], Qiaoyu Cai [a], Shuang Wu [a], Wangyang Shen [a,b], Zhongze Hu [a,b], Wenjing Huang [a,b,*], Weiping Jin [a,b,*]

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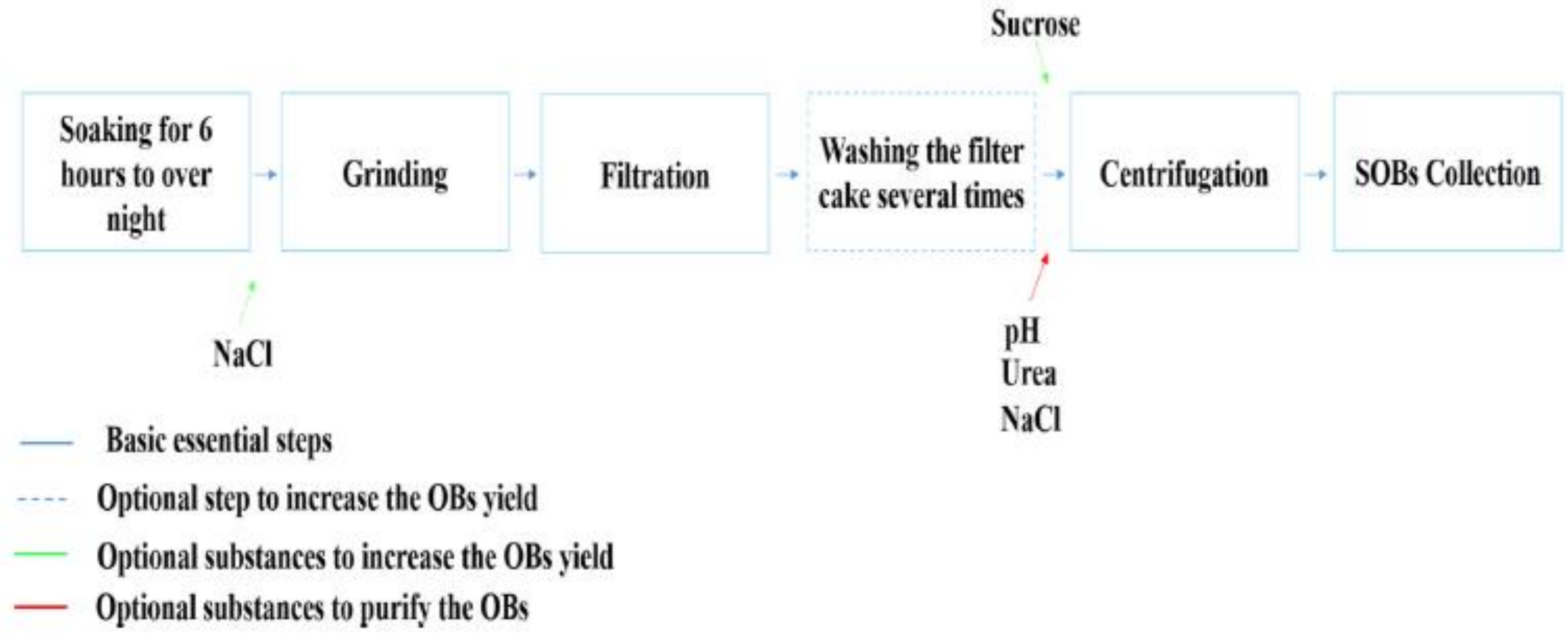
Extraction of oil bodies



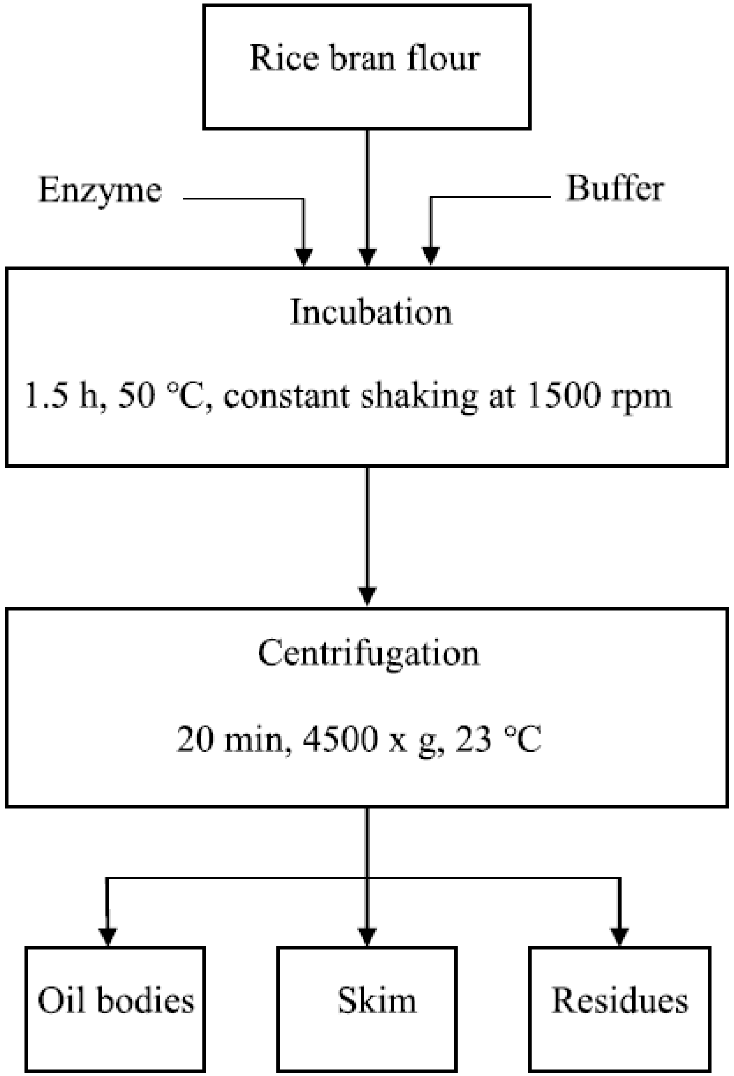


Fig. 1. Flow diagram for the enzyme-assisted aqueous extraction (EAAE) of rice bran oil bodies.

Characteristics of rice bran oil bodies

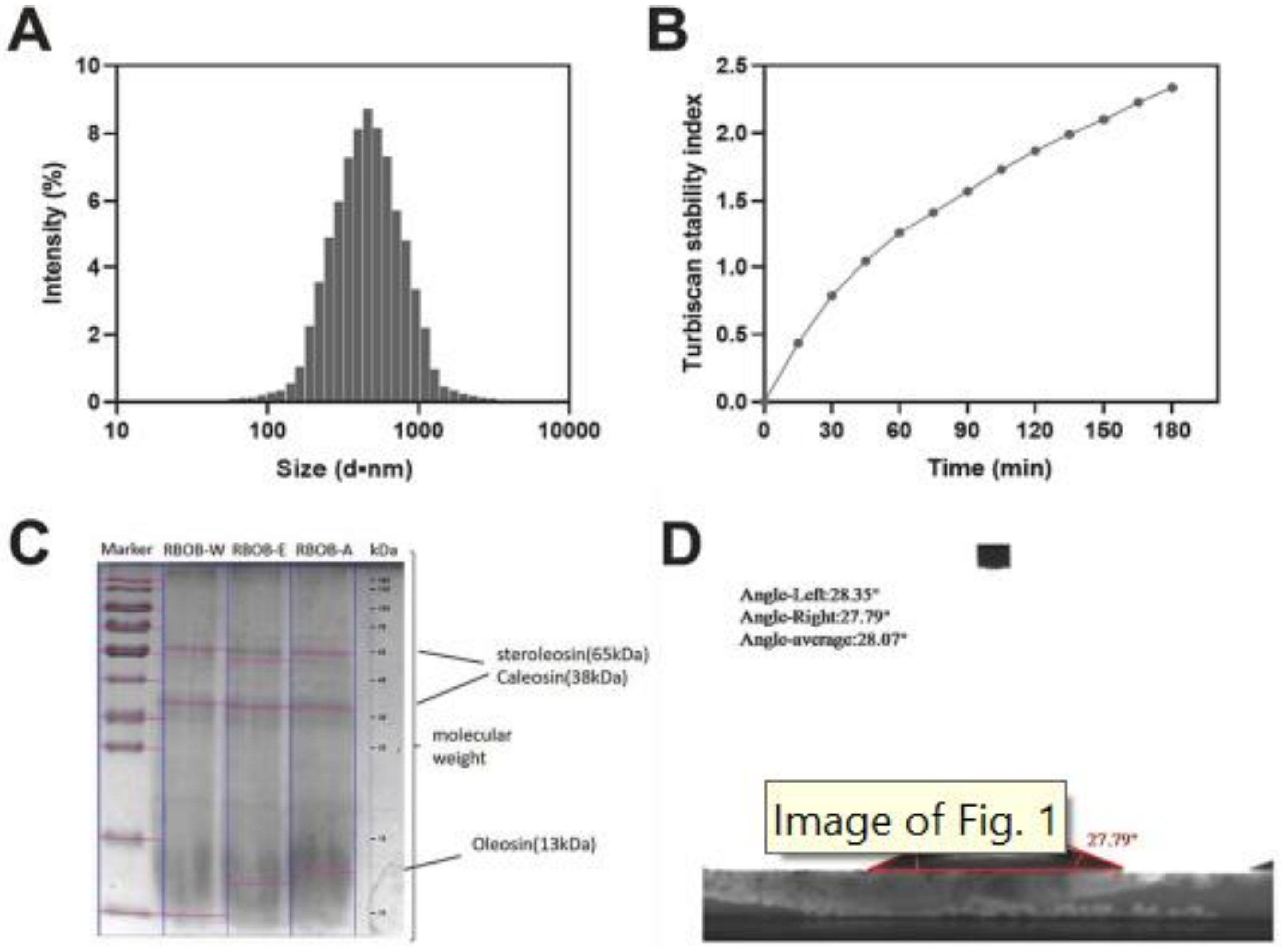


Fig. 1. Characterization of rice bran oil bodies (RBOBs). (A) Particle sizes of RBOBs, (B) Turbiscan stability index (TSI) values of RBOBs, (C) Sodium dodecyl sulphate–polyacrylamide electropherogram (SDS-PAGE) of the rice bran oil body (RBOB) proteins obtained using different extraction methods, and (D) θ_{wa} of the glass slide with RBOB particles film.

Characteristics of rice bran oil body based emulsion

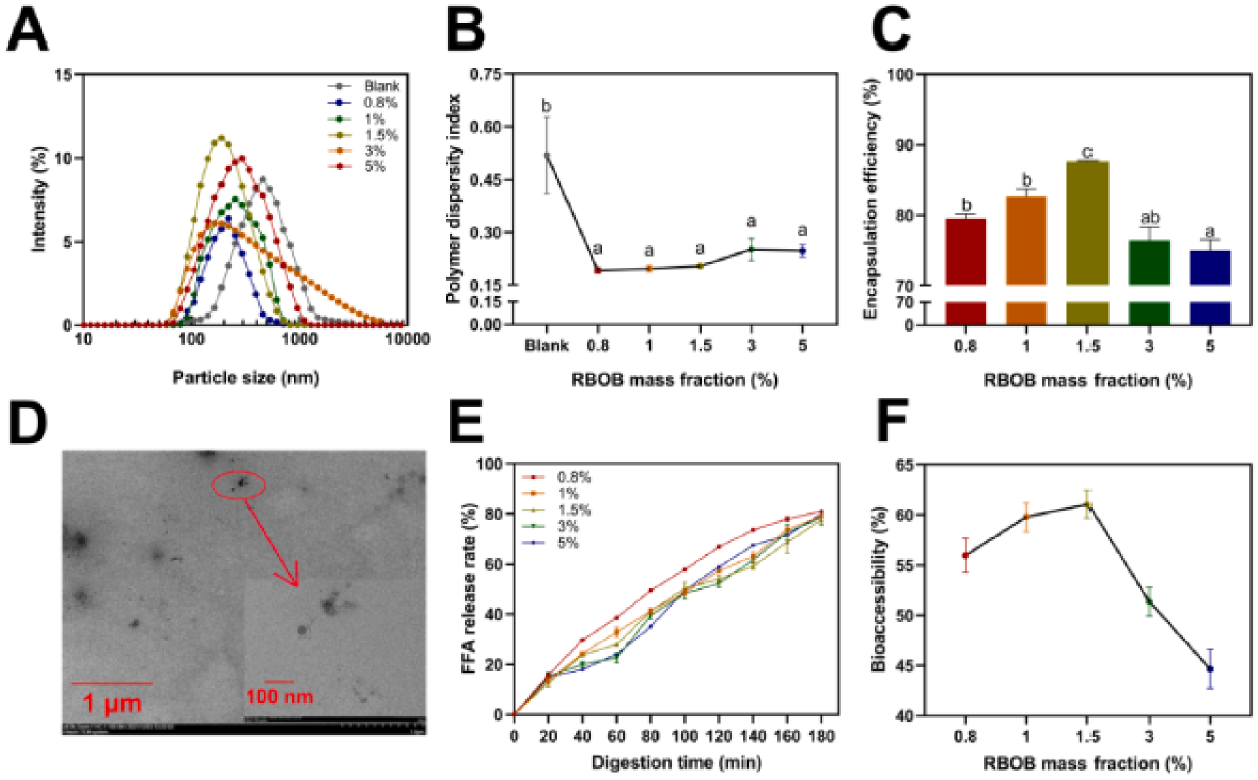


Fig. 2. Characterization of rice bran oil body (RBOB)-based emulsions. (A) Particle sizes, (B) Polymer dispersity index (PDI) values, (C) Encapsulation efficiencies of RBOB-based curcumin (CUR) emulsions (containing 10% medium chain triglycerides (MCT), the carrier system is named RBOB@CUR-MCT) with different mass fractions of RBOBs, (D) Transmission electron microscopy (TEM) images of RBOB@CUR-MCT nanoparticles with sizes of 1 μm and 100 nm (inserted figure is RBOB@CUR-MCT nanoparticle under higher magnification), (E) Free fatty acid (FFA) release rates of curcumin emulsions prepared from RBOB at different mass fractions, and (F) Bioaccessibility of curcumin emulsions prepared from RBOB at different mass fractions.

Structural characteristics of rice bran oil body based emulsion

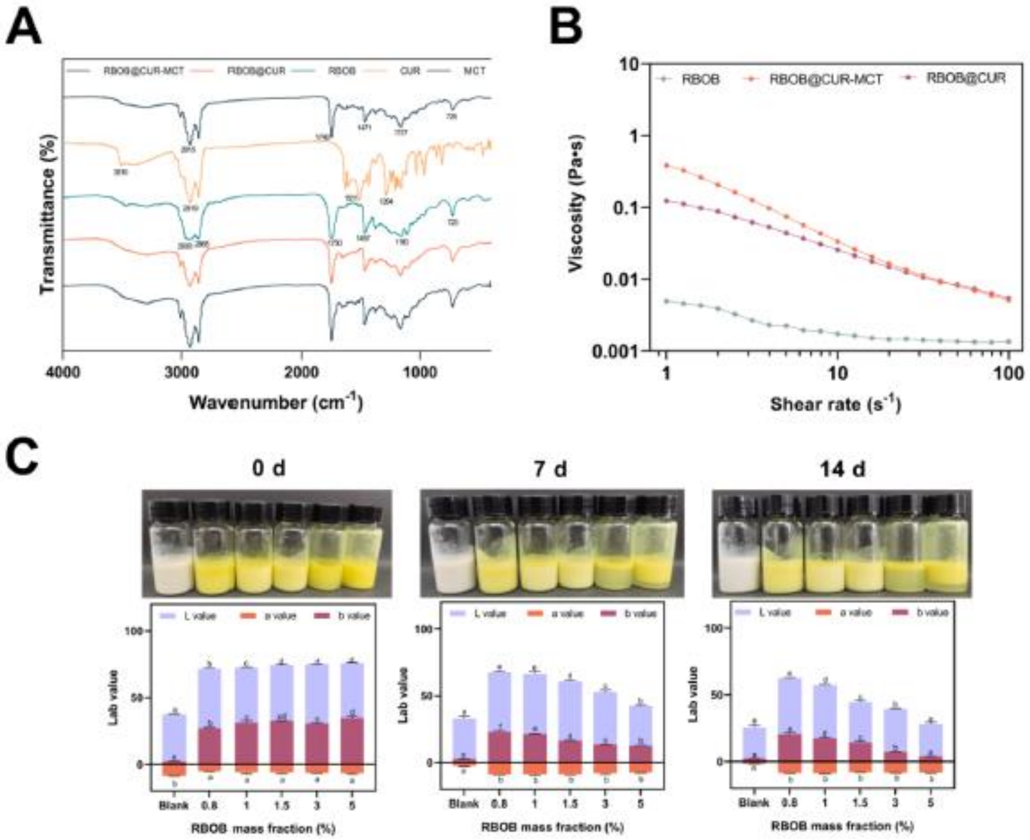


Fig. 4. Structural characterization of rice bran oil body (RBOB)-based emulsions and relevant components. (A) Fourier transform infrared spectroscopy (FT-IR) spectra of RBOB, curcumin (CUR), medium chain triglycerides (MCT), RBOB-based emulsions (RBOB@CUR and RBOB@CUR-MCT), (B) Apparent viscosities of RBOB, RBOB@CUR, and RBOB@CUR-MCT, (C) Storage stability and lab values of curcumin emulsions prepared with RBOB at different mass fractions.

In vitro activity evaluation

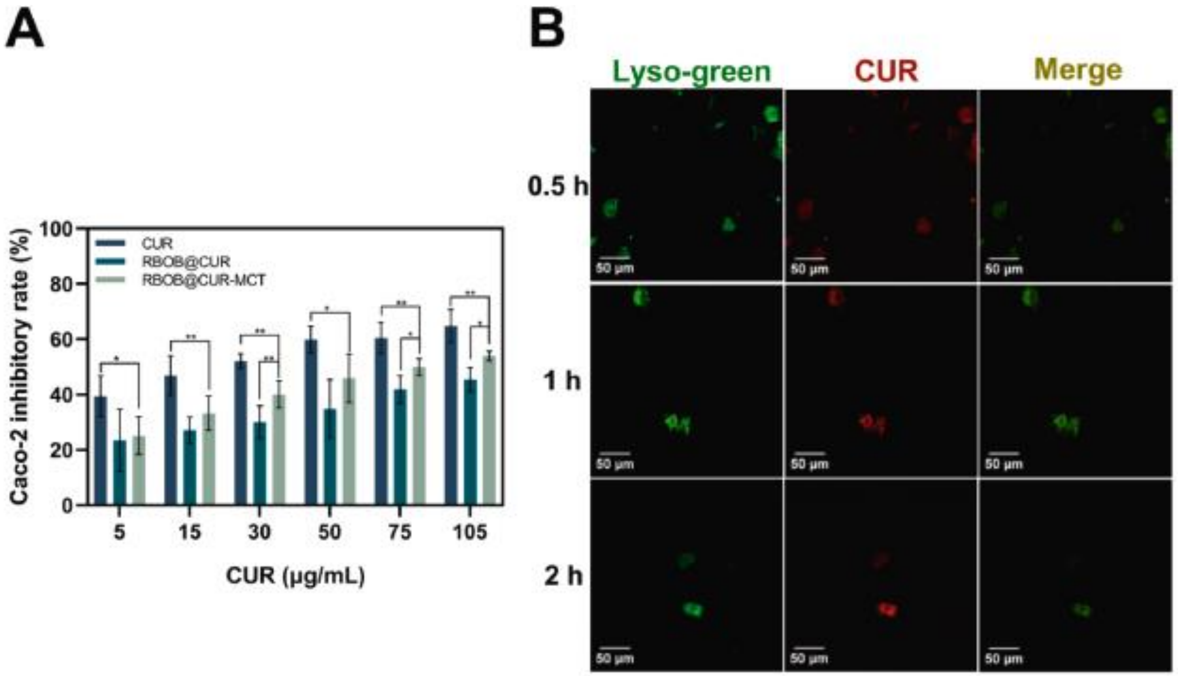


Fig. 6. *In vitro* activity evaluation of rice bran oil body (RBOB) based emulsions. (A) Inhibition rates of Caco-2 cells by RBOB carriers containing varying concentrations of curcumin (CUR), (B) Confocal microscopy images of the intracellular localization of RBOB-based carrier system (curcumin concentration is 30 μg/mL) in Caco-2 cells (Caco-2 cells lysosomes were stained with Lyso-green). The scale bar = 50 μm. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Oil body imagines

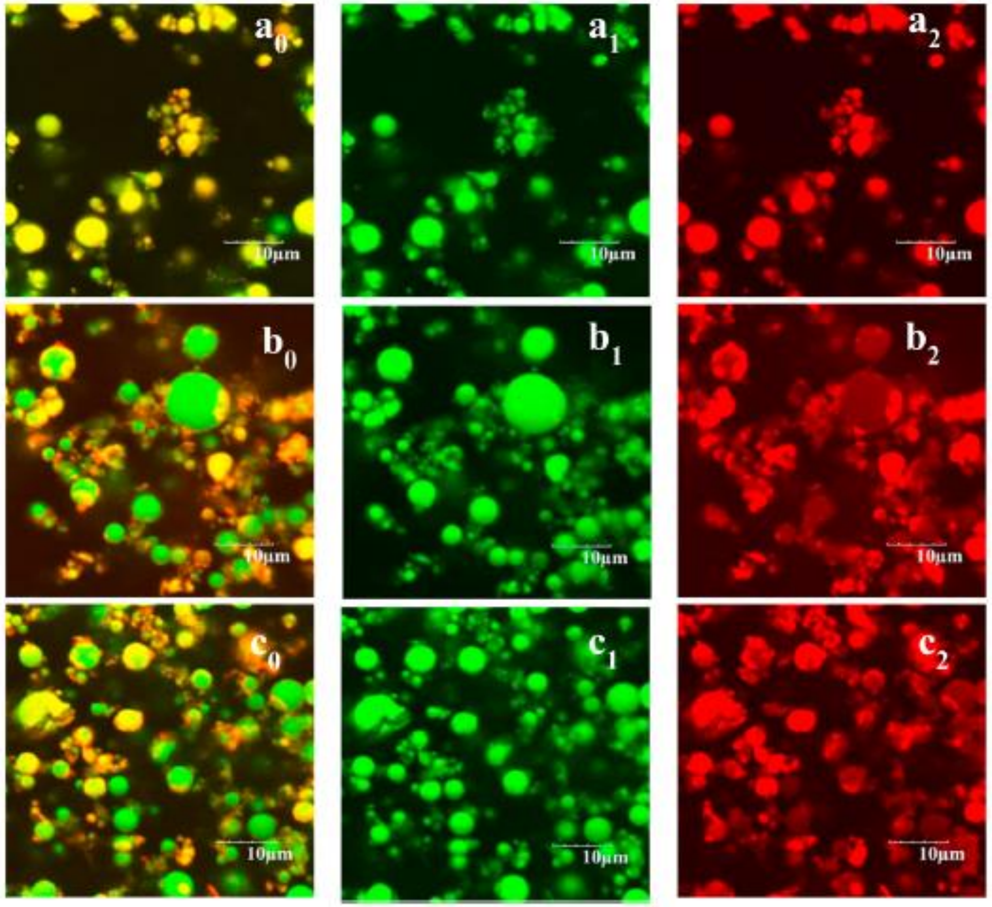


Fig. 6. CLSM images of OBs obtained from rice bran by Plant extracted enzyme, Xylanase and their mixture (a_0-a_2, RBOBP, b_0-b_2, RBOBX, c_0-c_2, RBOBM. The graphs of a_0, b_0 and c_0 were oil bodies with oil and proteins, a_1, b_1 and c_1 were oil stained green, a_2, b_2 and c_2 were proteins stained red). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Oil bodies in food applications

Researches of food based on soybean oil bodies and their interaction with other components.

Product	Objective of the study	Procedure	Fundamental finding of the research	Reference
Tofu	Evaluating the relationship between the proportion of glycinin to -conglycinin in soymilk and the lipid incorporation into the coagulum during addition of CaCl2.	• Two types of soybeans were used for soymilk preparation with different proportions. • $CaCl_2$ was used as coagulant for tofu formation	✓ In Tofu, SOBs found to be wrapped with triple layers of proteins; oleosin, protein particles, and new -conglycinin-rich particles.	Guo et al. (2002)
	The effect of the 11S/7S ratio, $MgCl_2$ concentration in the distribution of lipids and proteins	• Soybean milk was made from swollen beans. • Crude Tofu was made of heated soymilk using $MgCl_2$ as coagulant	✓ Concentration of OBs in the coagulum increased with the increase of 11S/7S ratio and the coagulant $MgCl_2$ ✓ OBs concentration in the coagulum significantly affect the texture of tofu.	Toda, Yagasaki, and Takahashi (2008)
	The effect of 5 different soybean varieties on the soymilk properties and Tofu texture	• Soybeans milk was made of five different varieties	✓ Variation of 11S/7S ratio affect the OBs Concentration in the coagulum and significantly affect the texture of tofu ✓ Soymilk with more calcium, polysaccharides, and 7S basic globulin also showed more protein particulate content and an increase in the breaking stress of tofu	Toda et al. (2010)
Soybean milk	Studying the possible consequences of freezing on organoleptical quality of soybean milk.	• Soybeans were socked in DI water for 10 h; then placed in a freezer at −5 °C for different days. • The forzen soybeans were dried at 45 °C in an air-dryer. • Soymilk was prepared by grinding the frozen dryer soybeans	✓ Freezing could affect the soybean oil bodies size and therefore the soymilk qualities ✓ Freezing increased protein, lipid and solid contents in soymilk.	Lili, Yeming, and Zaigui (2013)
Soybean milk and Tofu	Studying the consequence of heating on soymilk OBs, their interactions with soymilk proteins and the effect of heated soymilk OBs on the quality of Tofu.	• .Crude Tofu was made of defatted soymilk and isolated heated soymilk oil bodies at pH recovery 11.0 (protein, 2.4%; lipid, 1.0%) • CaSO4 was used as coagulant with a concentration of 0.3% (w/w). The tofu curds were formed in 70 °C water bath for 1 h.	✓ Heat treatment caused a strong association between OBs and β-conglycinin and glycinin ✓ Heat treatment inhibit the oleosin hydrolysis which is considered to improve the sensory qualities of soymilk and its related products ✓ Tofu curds containing heated soymilk OBs showed lower breaking stress and Young's modulus than those containing raw	Chen, Zhao, et al. (2014)
Soybean milk	The effect of milling and pressing soybeans at high temperatures (50–90C) on soymilk physicochemical properties	• Soybeans were milled at temperatures between 50 and 90C for 8 min with hot water and immediately filtered giving raw soymilk.	✓ Milling and pressing at high temperatures induced the formation of more precipitate, accelerate protein denaturation and dispersibility of the protein aggregates and oil bodies	Shimoyamada, Mogami, Tsuzuki, and Honda (2014)
	relationship between viscosity and lipid content was examined in order to predict soymilk viscosity during the production process	• Four soymilk with different lipid content were prepared and oil bodies were isolated using aqueous extraction method.	✓ The oil body suspension showed a Krieger-Dougherty-like dependency on volume fraction.	Idogawa and Fujii (2015)
Soybean milk cream	Preparation of soymilk cream at the industrial level	• Soymilk were centrifuged then aggregated by inducing with the treatment of papain digestion followed by heat treatment	✓ Soymilk cream (oil bodies'cream) was successfully isolated using papain digestion, heat treatment, and low-speed centrifugation	Abe, Wu, Kim, Fujii, and Abe (2015)
Soybean milk	Effects of heating (70–100 °C; 0–30 min) on particle size and bound proteins of isolated oil bodies and soymilk	• Soybean Oil bodies were isolated using aqueous extraction method from heated soymilk.	✓ Heat treatment stopped 24 and 18 kDa oleosins hydrolyzing due to the proteases denaturizing, ✓ extrinsic proteins were unfolded and P34 and α′/α-SS-P34 complex was released	Yan et al. (2016)
	Effect of blanching on the interaction of oil bodies and proteins in soymilk	• Soybean milk was made from blanched beans	✓ The blanching process has caused protein/oil bodies interaction and formation of an aggregation of particles in the traditional soymilk	Peng et al. (2017)
	Effect of oleosins on the stability of oil bodies in the production of soymilk different stages of the soymilk manufacturing process	• Oil bodies were isolated from heated soymilk using aqueous extraction method and the oil bodies were washed twice using 0.1 M Na2CO3.	✓ Oil bodies' stability in soymilk dependent on the presence of a hydrophobic protein coat (Oleosin) ✓ SOBs were remarkably stable and did not aggregate or coalesce throughout the soymilk production process	Idogawa et al. (2018)
Soybean OBs-gel	Studying the tribology, structure, rheological properties of κ-carrageenan gels filled with soybean OBs	• OBs were isolated using aqueous extraction method and • OBs emulsion was prepared. κ-carrageenan solution of 2.0 wt%.	✓ Gel formed due to the electrostatic interaction between the κ-carrageenan and the oleosins on the surface of OBs at different pHs. ✓ At pH 4, the electrostatic interaction between the matrix and protein-coated OBs facilitated gelation of κ-carrageenan and the elastic modulus of the emulsion-gels increased with increase of oil concentration ✓ At neutral pH, the electrostatic repulsion delayed gel formation and the elastic modulus	(Yang, Feng et al., 2020)

General summary

- Non-conventional production technology received attentions including enzyme assisted aqueous extraction.
- Oil bodies received attention including rice bran oil bodies.
- Nutritional concerns are attracting evaluation as always.
- A wide application studies have been conducted in industry including performance in frying.

THANK YOU FOR YOUR ATTENTION！