



## Review

# Plant/algal polysaccharides extracted by microwave: A review on hypoglycemic, hypolipidemic, prebiotic, and immune-stimulatory effect

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## ABSTRACT

Microwave-assisted extraction (MAE) is an emerging technology to obtain polysaccharides with an extensive spectrum of biological characteristics. In this study, the hypoglycemic, hypolipidemic, prebiotic, and immunomodulatory (e.g., antiinflammatory, anticoagulant, and phagocytic) effects of algal- and plant-derived polysaccharides rich in glucose, galactose, and mannose using MAE were comprehensively discussed. The *in vitro* and *in vivo* results showed that these bioactive macromolecules with the low digestibility rate could effectively alleviate the fatty acid-induced lipotoxicity, acute hemolysis, and dyslipidemia status. The optimally extracted glucomannan- and glucogalactan-containing polysaccharides revealed significant antidiabetic effects through inhibiting  $\alpha$ -amylase and  $\alpha$ -glucosidase, improving dynamic insulin sensitivity and secretion, and promoting pancreatic  $\beta$ -cell proliferation. These bioactive macromolecules as prebiotics not only improve the digestibility in gastrointestinal tract but also reduce the survival rate of pathogens and tumor cells by activating macrophages and producing pro-inflammatory biomarkers and cytokines. They can effectively prevent gastrointestinal disorders and microbial infections without any toxicity.

## 1. Introduction

In recent year, a substantial interest in the extraction process of polysaccharides has been paid because the obtained extracts can be applied to formulate different nutraceutical, pharmaceutical, cosmetic, food, and beverage products. The conventional extraction using hot water as a solvent is not considered as an appropriate procedure for bioactive polysaccharides because prolonged times and high temperatures can highly destroy or change their structure and functionality

(Rostami & Gharibzahedi, 2017). Several alternative methods are suggested to facilitate the release of intracellular polysaccharides without any change in their inherent characters during processing. These extraction techniques include enzyme-assisted extraction (EAE), ultrasound-assisted extraction (UAE), microwave-assisted extraction (MAE), and pressurized water extraction (PWE) (Guo et al., 2019; Rostami & Gharibzahedi, 2017; Wei et al., 2019; Yuan et al., 2019). MAE is one of the most efficient techniques to obtain target bioactive compounds. Electric and magnetic fields in microwaves in terms of

**Abbreviations:** ACC, acetyl-CoA carboxylase; AIP, atherogenic index of plasma; AKT, serine/threonine-specific protein kinase; AMPK, adenosine monophosphate (AMP)-activated protein kinase; APTT, activated partial thromboplastin time; BABA, bile acid-binding ability; CAE, cold alkaline extraction; CAT, catalase; CBA, cholesterol-binding ability; CRP, C-reactive protein; EAE, enzyme-assisted extraction; ERK, extracellular-signal-regulated kinase; EY, extraction yield; FBA, fat binding ability; GGT, gamma-glutamyl transpeptidase; GIT, gastrointestinal tract; GLUT4, glucose transporter 4; GS, glycogen synthase; GSH-Px, glutathione peroxidase; GSK3, glycogen synthase kinase 3; HAE, hot alkaline extraction; HDL-C, high-density lipoprotein-cholesterol; HMG-CoA, 3-hydroxy-3-methylglutaryl coenzyme A; HWE, hot water extraction; IL-6, and -8, interleukin-6 and -8; iNOS, nitric oxide synthase; JNK, c-Jun N-terminal kinase; PLIA, pancreatic lipase inhibition activity; LDL-C, low-density lipoprotein-cholesterol; LPO, lipid peroxide; LPS, lipopolysaccharide; LTs, leukotrienes; MAE, microwave-assisted extraction; MAPK, mitogen-activated protein kinase; MDA, malondialdehyde; MW, molecular weight; NO, nitric oxide; NSAIDs, nonsteroidal anti-inflammatory agents; PGs, prostaglandins; PWE, pressurized water extraction; PRG I-P, potato rhamnogalacturonan I polysaccharide; RSM, response surface methodology; SOD, superoxide dismutase; SREBP1c, sterol regulatory element-binding protein 1c; STG, serum triglyceride; TNF- $\alpha$ , tumor necrosis factor- $\alpha$ ; TT, thrombin time; IRS, insulin receptor substrate; PI3K, phosphoinositide 3-kinase; PDK, phosphoinositide-dependent protein kinase; TSC, total serum cholesterol; PT, prothrombin time; SCFAs, short-chain fatty acids; UAE, ultrasound-assisted extraction; VLDL-C, very-low-density lipoprotein-cholesterol.

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