

半乳甘露聚糖的酶法降解及理化性质研究

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摘要:【目的】半乳甘露聚糖是广泛分布与于豆科植物种子胚乳中的一种天然多糖。本研究旨在探究酶法降解对半乳甘露聚糖结构及理化性质的影响, 为获得具有特定结构和性质的半乳甘露聚糖提供一种可行的方法, 并扩宽其在日化和医药领域的应用范围。【方法】利用 α -D-半乳糖苷酶和 β -D-甘露聚糖酶的混合酶, 考察了不同酶降解条件(底物浓度、酶解温度、酶浓度和酶解时间)的变化对半乳甘露聚糖分子量和单糖组成的影响。同时, 选取分子量为 1040 kDa、560 kDa、240 kDa、110 kDa、60 kDa 的样品, 通过体外实验评估半乳甘露聚糖的分子量变化对吸湿保湿、抗氧化性及 α -葡萄糖苷酶抑制能力的影响。【结果】通过改变酶降解条件, 半乳甘露聚糖分子量发生不同程度的下降。在 37°C 时, 当酶浓度为 0.15%, 酶解时间为 10 h, 半乳甘露聚糖分子量从 1040 kDa 降至 60 kDa。酶解改变了半乳甘露聚糖中甘露糖和半乳糖的比例, M/G 值最高为 3.01, 最低降至 1.78。分子量的降低显著提高了半乳甘露聚糖的生物活性, 当分子量为 110 kDa 时, 对 DPPH 和 ABTS 自由基的清除率最高, 分别为 46.88% 和 53.36%, 同时, 其对 α -葡萄糖苷酶抑制率可达 81.21%, 表现出良好的生物活性。此外, 在干燥环境中, 不同分子量的半乳甘露聚糖在 2 h 内均表现出较好的保湿性, 优于海藻酸钠。其中, 分子量为 60 kDa 的半乳甘露聚糖可在 24 h 内维持良好的保湿性(90.26%)。【结论】(1) 底物浓度的变化会通过影响溶液的粘度来控制半乳甘露聚糖的酶降解程度, 溶液粘度越高, 半乳甘露聚糖降解程度越小。(2) 酶浓度和酶解时间是影响半乳甘露聚糖降解的主要因素, 延长酶解时间, α -D-半乳糖苷酶将 α -D-半乳糖苷从主链脱除, 为 β -D-甘露聚糖酶充分降解甘露聚糖主链提供了充足的空间和时间, M/G 值逐步下降。(3) 所有分子量级的酶解半乳甘露聚糖的抗氧化和 α -葡萄糖苷酶抑制活性皆具有浓度依赖性。并且半乳甘露聚糖分子量的降低对提高其抗氧化活性和抗糖尿病活性具有显著的增益作用。(4) 通过半乳甘露聚糖的降解可以暴露更多的活性羟基, 增大与水分子的接触面积, 与更多的水分子结合形成氢键, 提高了吸湿保湿能力。

关键词: 半乳甘露聚糖; 酶法降解; 分子量; 抗氧化性; 吸湿保湿

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Enzymatic degradation and physicochemical properties of galactomannan

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Abstract: 【Objective】Galactomannan is a natural polysaccharide widely distributed in the endosperm of legume seeds. The aim of this study was to investigate the effect of enzymatic degradation on the structure and physicochemical properties of galactomannans, to provide a feasible method for obtaining galactomannans with specific structure and properties, and to broaden their application in the fields of daily chemicals and pharmaceuticals. 【Method】Using a mixture of α -D-galactosidase and β -D-mannanase, the effects of variations in different enzyme degradation conditions (substrate concentration, enzymatic temperature, enzyme concentration and enzymatic time) on the molecular weight and monosaccharide composition of galactomannan were investigated. Meanwhile, samples with molecular weights of 1040 kDa, 560 kDa, 240 kDa, 110 kDa, and 60 kDa were selected to evaluate the effects of molecular weight changes of galactomannans on moisture absorption and retention,

antioxidant, and α -glucosidase inhibitory abilities by in vitro experiments. **【Result】** By changing the conditions of enzymatic degradation, the molecular weight of galactomannan undergoes a different degree of decrease. The molecular weight of galactomannan was reduced from 1040 kDa to 60 kDa, at 37°C when the enzyme concentration was 0.15%. Enzymatic digestion altered the ratio of mannose to galactose in galactomannan, with M/G values ranging from a high of 3.01 to a low of 1.78. The reduction of molecular weight significantly improved the biological activity of galactomannan, which showed the highest scavenging rate of 46.88% and 53.36% for DPPH and ABTS free radicals, respectively, when the molecular weight was 110 kDa, and meanwhile, its inhibition rate of α -glucosidase was up to 81.21%, which demonstrated a good biological activity. In addition, galactomannans with different molecular weights showed better moisturizing properties than sodium alginate in dry environments within 2 h. Among them, galactomannan with a molecular weight of 60 kDa maintained good moisture retention (90.26%) for 24 h. **【Conclusion】** (1) Changes in substrate concentration control the degree of enzymatic degradation of galactomannan by affecting the viscosity of the solution; the higher the viscosity of the solution, the less galactomannan is degraded. (2) Enzyme concentration and enzymatic time were the main factors affecting the degradation of galactomannan. By prolonging the enzyme digestion time, α -D-galactosidase removed α -D-galactoside from the main chain, which provided sufficient space and time for β -D-mannanase to fully degrade the mannan main chain, and the M/G value decreased gradually. (3) The antioxidant and α -glucosidase inhibitory activities of enzymatically cleaved galactomannans were concentration-dependent in all molecular weight classes. Moreover, the decrease in molecular weight of galactomannans had a significant gain in improving their antioxidant and antidiabetic activities. (4) More active hydroxyl groups can be exposed through the degradation of galactomannan, increasing the contact area with water molecules, combining with more water molecules to form hydrogen bonds, and improving the ability of moisture absorption and moisturizing.

Key words: galactomannan; enzymolysis; molecular weight; antioxidative activity; moisture absorption and moisturizing.