Supplementary Material

1. Physicochemical and gelatinization property of FDP/DDP

Degree of esterification or acetylation (DE, DAc): Weigh samples and perform pretreatment according to GB 25533-2010. In brief, 100 mg of dry pectin was wetted by 1 mL of absolute ethanol, then 100 mL of CO_2-free water was added to dissolve the pectin. Subsequently, the solution was titrated with 0.02 mol·L^{-1} sodium hydroxide (NaOH) standard solution after 3 drops of phenolphthalein indicator was added. The consumed volume of NaOH was recorded as V_1.

20 mL of 0.5 mol·L^{-1} NaOH solution was added to generate the saponification, then 20 mL of 0.5 mol·L^{-1} HCl solution was submitted until the pink color completely disappeared. The final solution was divided into two parts, one was directly titrated with NaOH, and the other went through ethanol precipitation, centrifugation to give the supernatant, recorded the volume of 0.02 mol·L^{-1} NaOH consumed as V_2 and $V_{2\text{-}1}$, the calculation formula of saponification titration and esterification degree:

$$DE = \frac{V2 - V2\text{-}1}{V1 + V2 - V2\text{-}1} \times 100\%$$

$$DAc = \frac{V2\text{-}1}{V1 + V2 - V2\text{-}1} \times 100\%$$

Viscosity: 2 mg·mL^{-1} pectin solution was poured into the internal cavity of Ukrainian viscometer at 30°C for 15 minutes. the viscometer, the time from the upper line to the lower line was recorded. All results were the average of three experiments, and each measurement error was maintained within 30 s. Use the following formula to calculate the viscosity:

η = Kt (η—the viscosity of the liquid to be measured/ (m Pa·s);

K—the Ukrainian viscometer constant/ (mm^2/s^2); t—the liquid flow time/s).

Particle size: The emulsion was measured in a laser particle size analyzer (Malvern Instruments Ltd, Malvern, UK) as shown in **Fig. 1S**. 2 mg·mL^{-1} pectin solution (2 mL)

were pipetted into the beaker filled with 800 mL of deionized distilled water, 10-15% obscuration was achieved to minimize scattering effects, the particle size distribution was calculated from the scattered light using the instrument software (Mastersizer 2000, version 5.40).

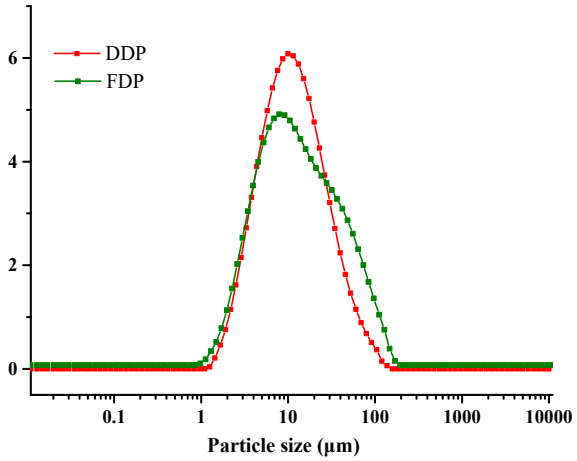

Fig. 1S Particle size of FDP and DDP

Turbidity: 2 mg·mL^{-1} pectin solution was poured into a quartz cuvette, and an ultraviolet-visible spectrophotometer was measured the absorption value at a wavelength of 480 nm. Turbidity of pectin was positively correlated with absorbance.

Table 1S Physicochemical properties of FDP and DDP

Sample	DE	DAc	Viscosity (m Pa·s)	Particle size (μm)	Turbidity
FDP	80.1 ± 3.55	16.4 ±1.1	1.14 ± 0.08	12.6 ± 0.14	0.65 ± 0.05
DDP	74.2 ± 2.36	12.7 ± 1.6	0.93 ± 0.07	8.6 ± 0.15	0.54 ± 0.07

FDP/DDP was submitted to the determination of DE and DAc, presenting the hypermethoxy pectin with high acetylation. If a comparison was made between FDP and DDP, the value of GalA and DE were in the order FDP>DDP (Table 1S). The similar order was present in the gelation property, FDP demonstrated a higher viscosity level than that of DDP ($p < 0.05$). Besides, the turbidity was affected by particle size (**Fig. 1S**) of molecules, and reflected the stability of the system as well, [1] therefore, the aqueous solution of DDP may be more stable.

2. Monosaccharide composition of FDP/DDP

FDP and DDP (10 mg) were fully hydrolyzed into monosaccharide with 2 mol·L^{-1} trifluoroacetic acid (TFA) by incubation at 110 °C for 8 h, then the system was submitted to evaporate after adding the methanol. This process was repeated more than three times for removing TFA completely. Then the hydrolysates solution was mixed with 100 μL 0.6 mol·L^{-1} NaOH solution and 200 μL 0.5 mol·L^{-1} 1-phenyl -3-methyl-5- pyrazolone (PMP) in a sealed tube at 70 °C for 100 min. Next, 200 μL of 0.3 mol·L^{-1} HCl solution was added to neutralize the NaOH. Chloroform was then added to extract the excess PMP and this process was repeated four times. The final sample was filtered through 0.22 μm membrane for the further HPLC analysis. Eight monosaccharide standards were carried out the same derivatization and the corresponding calibration curves were established.

3. Methylation analysis of FDP/DDP

The main process of methylation was divided into four parts.

(a) Methylation: Approximately 10 mg FDP/DDP was dissolved in dimethyl sulfoxide. Adding 100 mg NaOH and 1mL CH_3I to the above solution and the methylation was repeated for three times to gain completely methylated pectin. The methylation process was monitored by the disappearance of absorption peak between 3200~3700 cm^{-1} in the FT-IR spectrum.

(b) Hydrolysis: The methylated pectin was hydrolyzed with 3 mL of 2 mol·L^{-1} TFA at 120°C for 2 h in a sealed ampoule. Then methanol was added and evaporated to remove the TFA.

(c) Reduction: 0.6 mL NaOH solution (0.05 mol·L^{-1}) and 5 mg $NaBH_4$ were successively added to the above intermediate and the reduction was carried out for 6 h, then neutralized with 4 mol·L^{-1} acetic acid.

(d) Acetylation: The reduced product was acetylated under the action of acetic anhydride and anhydrous pyridine. The final product was extracted by CH_2Cl_2 with three times and filtered through a 0.22 μm membrane to give the suitable derivative

for the further GC-MS analysis. The corresponding spectra were shown in **Fig. 2S**.

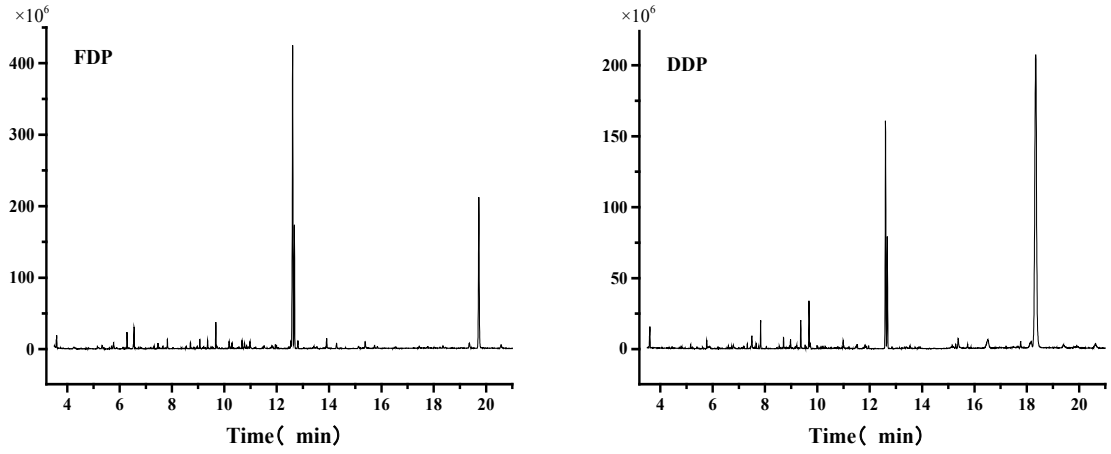

Fig. 2S The GC-MS of methylation of FDP/DDP

4. Establishment of alcoholic liver damage mice

Before the hepatoprotection assay was performed, a preliminary alcohol-induced liver model dosage was selected according to the ALT value. As shown in Fig. 3S, 50% alcohol with the dosages of 12 mL·kg^{-1} for 12 h was appropriate for establishing liver injury model mice, where the ALT value was about 350% of the NC group (**Fig. 3S**).

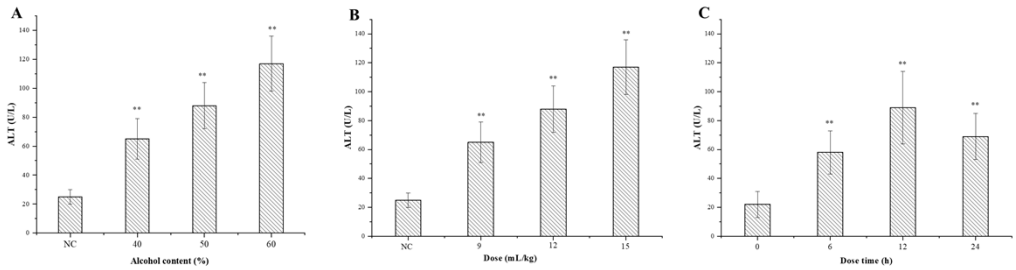

Fig. 3S Serum ALT level in different alcohol content (A), dose (B) and dose time (C)-treated mice. ** $p < 0.01$, compared with NC or the initial point (0 h)

[1] M. A. Razzak, M. Kim and D. Chung, Elucidation of aqueous interactions between fish gelatin and sodium alginate, *Carbohydr. Polym.*, 2016, **148**, 181.