*Article*

# Isolation, Structural Elucidation, Antioxidant and Hypoglycemic Activity of Polysaccharides of *Brassica rapa* L.

**Wenyang Cao [1], Chenxi Wang [1], Xiayidan Mayhesumu [1], Le Pan [1], Yan Dang [1], Abulimiti Yili [2], Aytursun Abuduwaili [1,*] and Sanawar Mansur [1,*]**

[1] College of Chemistry and Chemical Engineering, Xinjiang Agricultural University, Urumqi 830052, China; caoziye88@163.com (W.C.); w18129196969@163.com (C.W.); xiayidanms@sina.com (X.M.); inmail911@sina.com (L.P.); mg20000330@163.com (Y.D.)

[2] Key Laboratory of Plants Resources and Chemistry of Arid Zone, Xinjiang Technical Institute of Physics and Chemistry, Chinese Academy of Sciences, Urumqi 830011, China; abu@ms.xjb.ac.cn

* Correspondence: aytursun11@126.com (A.A.); sanam0405@163.com (S.M.); Tel.: +86-152-7667-9155 (A.A.); +86-139-9921-2592 (S.M.)

# Supporting Information

**Table S1. The BBD design and predicted values for the content of BRP.**

| No. | Variables | | | | Yield (%) | | |
|---|---|---|---|---|---|---|---|
| | A: Ratio of water to material (mL/g) | B: Extraction temperature (◦C) | C: Microwave-ultrasound time (min) | D: Ultrasound power (W) | Actual | STDE_V | Predicted |
| 1 | 20 | 70 | 9 | 300 | 16.8124 | 0.0572 | 16.3700 |
| 2 | 30 | 70 | 9 | 300 | 17.0450 | 0.0610 | 16.2700 |
| 3 | 20 | 80 | 9 | 300 | 17.5870 | 0.0458 | 17.7800 |
| 4 | 30 | 80 | 9 | 300 | 18.5480 | 0.0458 | 18.4100 |
| 5 | 25 | 75 | 7 | 250 | 17.0603 | 0.0381 | 16.8200 |
| 6 | 25 | 75 | 11 | 250 | 19.3715 | 0.0153 | 19.4400 |
| 7 | 25 | 75 | 7 | 350 | 19.4940 | 0.5721 | 18.8400 |
| 8 | 25 | 75 | 11 | 350 | 18.7920 | 0.0610 | 18.4500 |
| 9 | 20 | 75 | 9 | 250 | 19.0816 | 0.0763 | 19.5400 |
| 10 | 30 | 75 | 9 | 250 | 18.2235 | 0.0130 | 17.3200 |
| 11 | 20 | 75 | 9 | 350 | 16.8850 | 0.0534 | 17.5600 |
| 12 | 30 | 75 | 9 | 350 | 21.0040 | 0.0458 | 20.3200 |
| 13 | 25 | 70 | 7 | 300 | 16.9310 | 0.0229 | 16.9400 |
| 14 | 25 | 80 | 7 | 300 | 16.2136 | 0.0305 | 15.7700 |
| 15 | 25 | 70 | 11 | 300 | 14.8940 | 0.0839 | 15.1100 |
| 16 | 25 | 80 | 11 | 300 | 20.0580 | 0.0229 | 19.8200 |
| 17 | 20 | 75 | 7 | 300 | 18.4370 | 0.0038 | 18.2500 |
| 18 | 30 | 75 | 7 | 300 | 17.9070 | 0.0610 | 19.4200 |
| 19 | 20 | 75 | 11 | 300 | 20.9580 | 0.0458 | 20.2600 |
| 20 | 30 | 75 | 11 | 300 | 18.6240 | 0.0153 | 19.6200 |
| 21 | 25 | 70 | 9 | 250 | 14.8940 | 0.4500 | 15.3000 |
| 22 | 25 | 80 | 9 | 250 | 16.3814 | 0.0229 | 16.6000 |
| 23 | 25 | 70 | 9 | 350 | 14.7500 | 0.3509 | 15.3400 |
| 24 | 25 | 80 | 9 | 350 | 17.1750 | 0.3966 | 17.5800 |
| 25 | 25 | 75 | 9 | 300 | 21.8730 | 0.0610 | 21.8700 |
| 26 | 25 | 75 | 9 | 300 | 21.8730 | 0.0610 | 21.8700 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 27 | 25 | 75 | 9 | 300 | 21.8730 | 0.0610 | 21.8700 |
| 28 | 25 | 75 | 9 | 300 | 21.8730 | 0.0610 | 21.8700 |
| 29 | 25 | 75 | 9 | 300 | 21.8730 | 0.0610 | 21.8700 |

**Table S2. ANOVA for response surface quadratic model.**

| Source | Sum of Squares | DF | Mean Square | F -Value | P-value |
|---|---|---|---|---|---|
| Model | 130.48 | 14 | 9.32 | 15.82 | < 0.0001 |
| A- Ratio of water to material | 0.21 | 1 | 0.21 | 0.36 | 0.5593 |
| B- Extraction temperature | 9.43 | 1 | 9.43 | 16 | 0.0013 |
| C- Microwave-ultrasound time | 3.69 | 1 | 3.69 | 6.26 | 0.0253 |
| D- Ultrasound power | 0.79 | 1 | 0.79 | 1.35 | 0.265 |
| AB | 0.13 | 1 | 0.13 | 0.23 | 0.6425 |
| AC | 0.81 | 1 | 0.81 | 1.38 | 0.2596 |
| AD | 6.19 | 1 | 6.19 | 10.51 | 0.0059 |
| BC | 8.65 | 1 | 8.65 | 14.68 | 0.0018 |
| BD | 0.22 | 1 | 0.22 | 0.37 | 0.5512 |
| CD | 2.27 | 1 | 2.27 | 3.85 | 0.0699 |
| $A^2$ | 7.77 | 1 | 7.77 | 13.19 | 0.0027 |
| $B^2$ | 82.78 | 1 | 82.78 | 140.48 | < 0.0001 |
| $C^2$ | 12.55 | 1 | 12.55 | 21.3 | 0.0004 |
| $D^2$ | 28.45 | 1 | 28.45 | 48.29 | < 0.0001 |
| Residual | 8.25 | 14 | 0.59 | | |
| Lack of Fit | 8.25 | 10 | 0.82 | | |
| Pure Error | 0 | 4 | 0 | | |
| C.V. % | 4.15 | | | | |
| PRESS | 47.52 | | | | |
| $R^2$=0.9405 | | | | | |
| $R^2_{adj}$=0.8811 | | | | | |

**Table S3. Comparison of BRP extraction studies by different methods.**

| Source | Extraction Method | Extraction temperature (◦C) | Microwave-ultrasound time (min) | Ratio of water to material (mL/g) | Ultrasound power (W) | Microwave power(W) | Yield (%) | References |
|---|---|---|---|---|---|---|---|---|
| Urumqi, Xinjiang, China | HWE | 93.3 | 258 | 75 | - | - | 21.480± 0.410 | [1] |
| Yushu, Qinghai, China | UAE | 60.01 | 55.05 | 43.05 | 366.45 | - | 1.450± 0.110 | [2] |
| Atuh, Xinjiang, China | MUAE | 76.5 | 9.7 | 25 | 292 | 440 | 21.800± 0.680 | This study |

**Table S4. $^{1}$H and $^{13}$C NMR chemical shifts (ppm) for residues of BRP-1-1.**

| Sugar residue | | Chemical shift (ppm) | | | | | |
|---|---|---|---|---|---|---|---|
| | | H1/C1 | H2/C2 | H3/C3 | H4/C4 | H5/C5 | H6/C6 |
| A | T-α-Manp | 5.42/100.86 | 3.84/71.91 | 4.06/76.76 | 3.72/67.55 | 3.57/74.30 | 3.73/63.52 |
| B | 1,2-α-Manp | 5.42/106.42 | 3.59/73.88 | 4.05/74.93 | 3.72/67.08 | 3.92/73.78 | 3.83/61.75 |
| C | 1,2-α-Glcp | 5.42/94.94 | 3.69/70.38 | 3.57/74.30 | 3.43/72.36 | 3.84/72.39 | 3.76/61.8 |
| D | 1,4-β-Glcp | 4.66/98.63 | 3.24/74.88 | 3.50/78.54 | 3.84/74.08 | 3.47/76.83 | 3.68/62.30 |
| E | 1,6-α-Glcp | 5.24/94.80 | 3.55/73.83 | 3.71/75.47 | 3.42/72.36 | 3.43/74.15 | 3.72/72.26 |

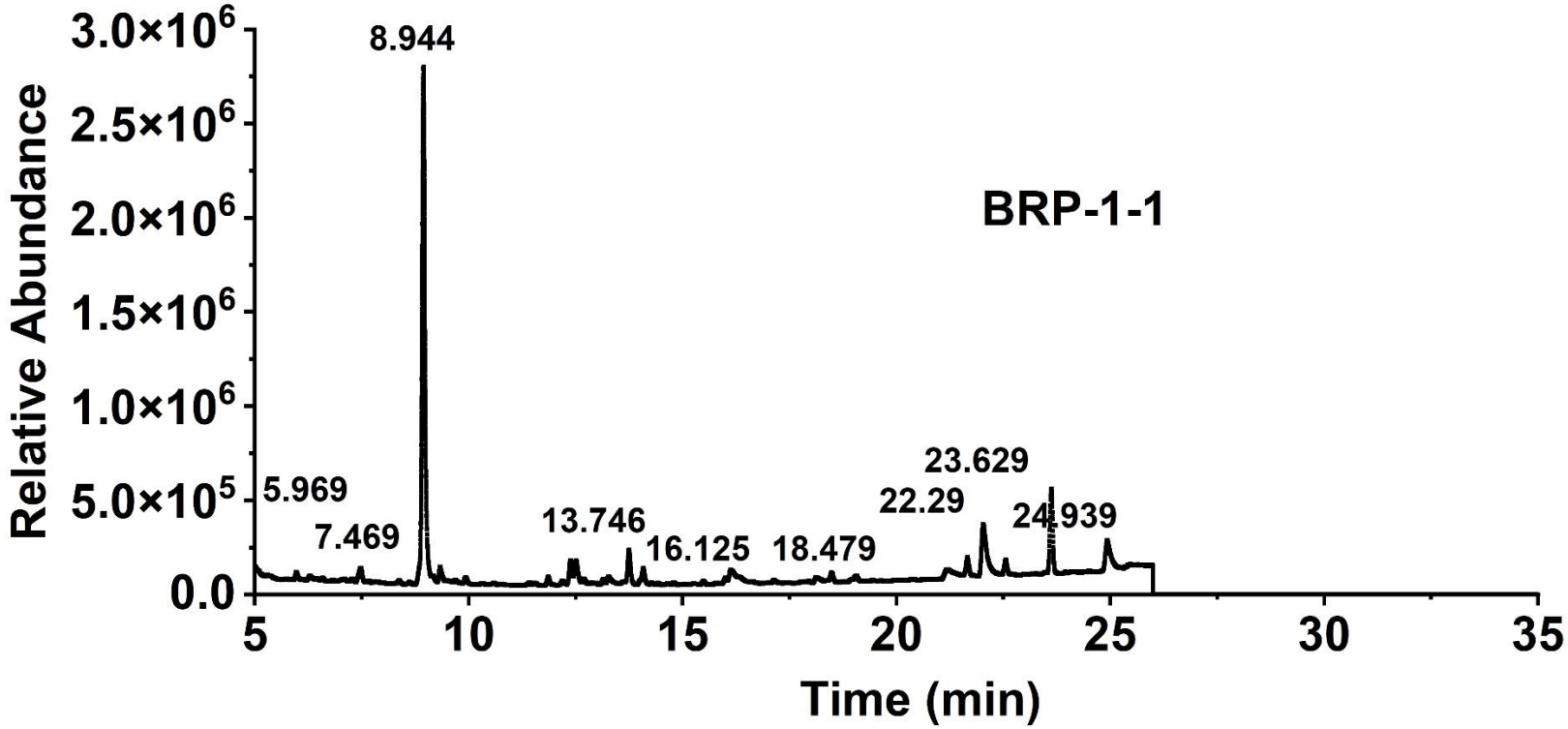


**Figure S1. Total ion rheology of BRP-1-1**

## References


1. Wang, W.; Wang, X.; Ye, H.; Hu, B.; Zhou, L.; Jabbar, S.; Zeng, X.; Shen, W. Optimization of extraction, characterization and antioxidant activity of polysaccharides from *Brassica rapa L. International Journal of Biological Macromolecules* **2016**, *82*, 979-988, doi:https://doi.org/10.1016/j.ijbiomac.2015.10.051.
2. Zhao, W.; Zhang, W.; Liu, L.; Cheng, Y.; Guo, Y.; Yao, W.; Qian, H. Fractionation, characterization and anti-fatigue activity of polysaccharides from *Brassica rapa L. Process Biochemistry* **2021**, *106*, 163-175, doi:https://doi.org/10.1016/j.procbio.2021.04.016.