Effect of ultrasonic and microwave processing on physicochemical property of silkworm pupae protein and mulberry seed meal protein to improve protein availability

Wen-Jing Li, Hang-Xing Ding, Shuai You, Fu-An Wu, Jun Wang

Jiangsu University of Science and Technology, China

E-mail: wangjun@just.edu.cn
Introduction

Reuse of by-products or wastes

Reduce environmental pollution

Improve resource utilization

Produce high value-added products
01 Introduction

sericulture

Mulberry proteins

Mulberry seeds

Mulberry pigments

Silkworm pupae

Oils

Large production
High nutrition
Multiple utilization
Introduction

Edible fats

Functional lipids

Oil

Health care products

APA-Human milk fat-style products

Novel structure lipids enriched unsaturated fatty acids

Phenolic acid structured lipids

transesterification

Introduction

Low protein solubility lead to low protein yield and affects the utilization of protein.

How to improve the protein property and increase the protein yield?
After pretreatment a large amount of protein dissolved in solution can be improved in extraction rate and protein physicochemical properties. Ultrasonic and microwave methods are used. Low-cost nitrogen source substitutes for microbial culture can be established.
Fig. 1. Effects of different factors on extraction rate of silkworm pupae protein and mulberry seed meal protein by ultrasonic treated. (a) Substrate concentrations; (b) Time; (c) Temperature; (d) Output power.

Mulberry seed meal:
- a: 1:40, b: 9 min, c: 70 °C, d: 300 W
- Up 70%

Silkworm pupae:
- a: 1:30, b: 9 min, c: 70°C, d: 400 W
- Up 30%
Fig. 2. Effects of different factors on extraction rate of silkworm pupae protein and mulberry seed meal protein by microwave treated. (a. Substrate concentrations; b. Time; c. Temperature; d. Output power).

Mulberry seed meal: a-1:30, b-3 min, c-60 °C, d-300 W

Silkworm pupae: a-1:20, b-3 min, c-50°C, d-200 W

Low growth
### Table 1. Correlation parameters of ultrasonic processing regression model in response surface fitting

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Mean Square</th>
<th>F Valve</th>
<th>p-value</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Silkworm pupae</td>
<td>14</td>
<td>27.19</td>
<td>15.84</td>
<td>&lt;0.001</td>
<td>significant</td>
</tr>
<tr>
<td>Lack of fit</td>
<td>10</td>
<td>2.31</td>
<td>4.39</td>
<td>0.0581</td>
<td>Not significant</td>
</tr>
<tr>
<td>Mulberry seed peal</td>
<td>14</td>
<td>98.87</td>
<td>11.29</td>
<td>&lt;0.0001</td>
<td>significant</td>
</tr>
<tr>
<td>Lack of fit</td>
<td>10</td>
<td>5.11</td>
<td>0.32</td>
<td>0.9418</td>
<td>Not significant</td>
</tr>
</tbody>
</table>

More appropriate to use model analysis and predict the effects of processing conditions on protein extraction rate.

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**Fig. 3.** Optimization of response surface for ultrasonic treatment of degreased mulberry seed peal.
## Results

### Protein physicochemical properties

**Table 2. Effect of ultrasonic and microwave on physicochemical properties of mulberry seed meal protein and silkworm pupae protein**

<table>
<thead>
<tr>
<th>Functional Properties</th>
<th>Mulberry seed meal protein</th>
<th>Protein treated by ultrasonic</th>
<th>Protein treated by microwave</th>
<th>Silkworm pupae protein</th>
<th>Protein treated by ultrasonic</th>
<th>Protein treated by microwave</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content of crude protein (%)</td>
<td>40.7±0.8</td>
<td>-</td>
<td>-</td>
<td>70.7±0.9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Solubility (%)</td>
<td>25.2±1.31</td>
<td>30.89±2.62</td>
<td>28.33±1.11</td>
<td>4.46±0.23</td>
<td>9.23±1.12</td>
<td>7.93±0.34</td>
</tr>
<tr>
<td>Foaming capacity (%)</td>
<td>20.00±4.3</td>
<td>27.63±2.31</td>
<td>22.2±4.0</td>
<td>21.50±1.12</td>
<td>47.38±1.21</td>
<td>42.15±1.12</td>
</tr>
<tr>
<td>Foam stability (%)</td>
<td>45.81±8.4</td>
<td>50.31±3.45</td>
<td>48.17±3.3</td>
<td>32.00±1.45</td>
<td>55.19±2.38</td>
<td>52.18±2.32</td>
</tr>
<tr>
<td>Emulsibility (m²/g)</td>
<td>83.35±10.8</td>
<td>100.82±2.38</td>
<td>90.0±2.5</td>
<td>79.49±4.87</td>
<td>88.19±4.12</td>
<td>82.34±5.12</td>
</tr>
<tr>
<td>Emulsion stability (min)</td>
<td>18.46±1.05</td>
<td>20.03±4.12</td>
<td>18.59±1.2</td>
<td>33.21±1.77</td>
<td>57.11±2.25</td>
<td>41.20±2.23</td>
</tr>
<tr>
<td>Holding oil capacity (%)</td>
<td>220.67±13.1</td>
<td>280.67±8.77</td>
<td>234.27±1.0</td>
<td>130.67±13.1</td>
<td>250.67±8.77</td>
<td>234.27±1.01</td>
</tr>
<tr>
<td>Water retention (%)</td>
<td>123.12±0.89</td>
<td>151.35±1.23</td>
<td>130.45±2.2</td>
<td>138.12±0.89</td>
<td>180.35±2.12</td>
<td>140.45±3.20</td>
</tr>
</tbody>
</table>

*Ultrasound & microwave destroying hydrophobic interactions of protein*

*Resulting in exposure of more hydrophobic groups*
Ultrasound change the secondary structure of proteins, expose hydrophilic amino acids, increase the solubility of proteins.

Fig. 4. Raman spectra of protein from seed meal of mulberry (amide1 band and secondary structural sub-peaks). (a) Untreated; (b) Treated by ultrasound; (c) Treated by microwave.
Results

Alternative nitrogen source

Generation kinetics of biomass

Fermentation kinetics of oil production

Substrate depletion kinetics

Fig. 5. The growth of *S. limacinum* SR21 and its lipid yield during the fermentation with alternative nitrogen source.
Protein modification was achieved by ultrasound and microwave treatment.

The solubility of silkworm pupae protein was more than doubled, and the solubility of mulberry seed protein was increased by 22.58%.

The protein extraction rate of the two protein up to 77% and 28%.

The degree of proteolysis after modification increased making the protein easier.
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Thanks for listening