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

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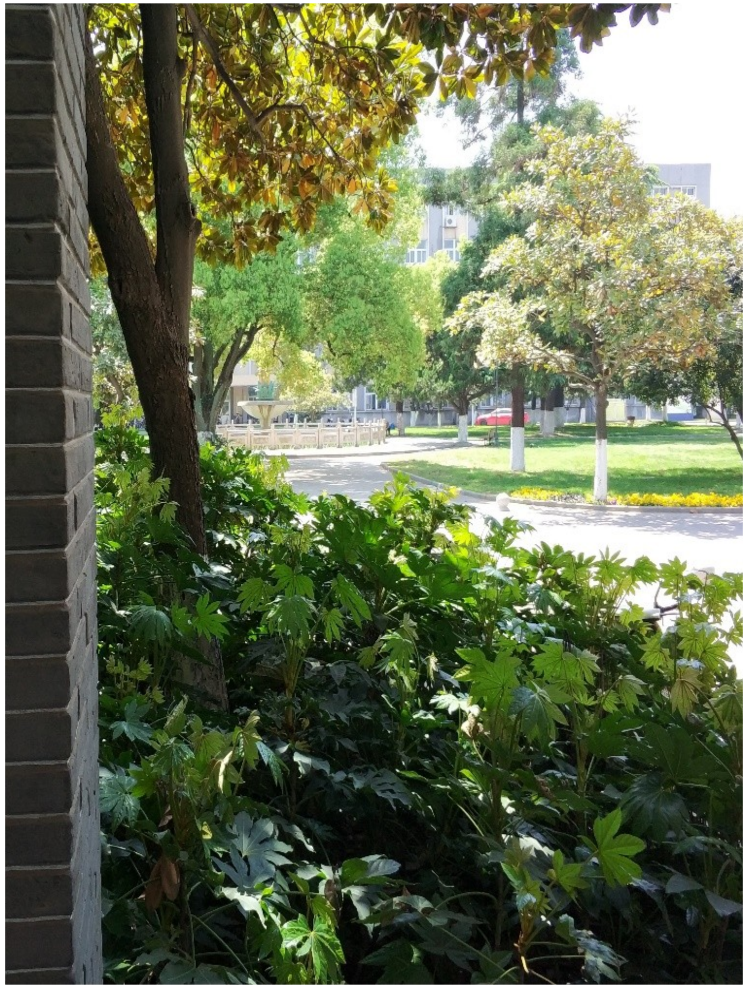


Introduction

Methods

Results

Conclusions

Acknowledg-ements

01 Introduction

Reuse of by-products
or wastes

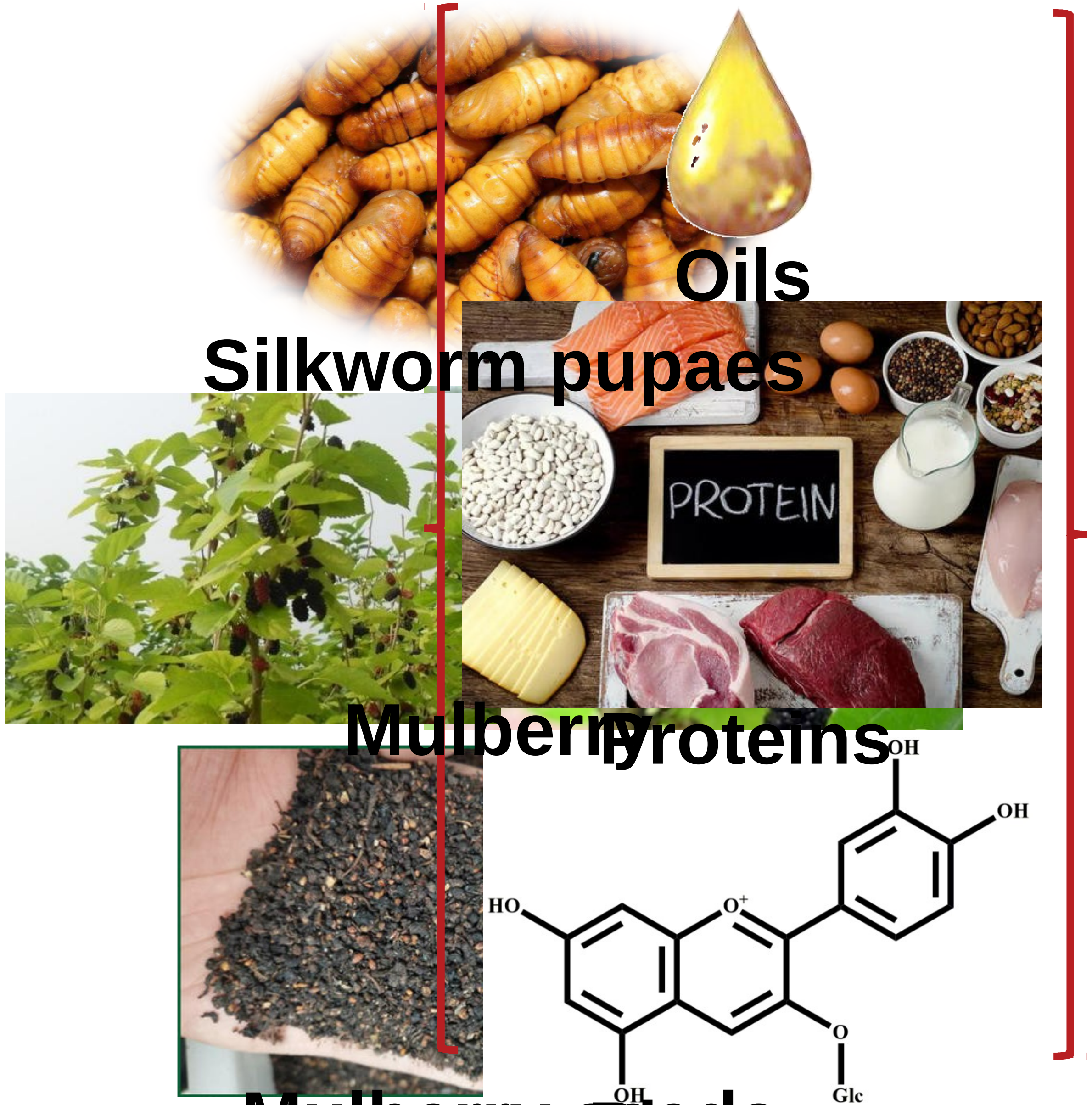
Reduce environmental pollution

Improve resource utilization

Produce high value-added products

01 Introduction

sericulture



Large production
High nutrition
Multiple utilization

01

Introduction

Edible fats

APA-Human milk fat-style products

Oil

Novel structure lipids enriched unsaturated fatty acids

Functional lipids

transesterification

Phenolic acid structured lipids

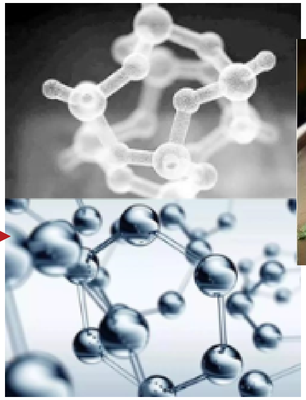
Health care products

[1]Zhao X Y, et al. European Journal of Lipid Science and Technology, 2015, 117(6): 879-889.
[2]Manzano-Agugliaro F, et al. Renewable and Sustainable Energy Reviews, 2012, 16(6): 3744-3753.
[3] Yang L I F. Journal of Food Lipids, 2006, 13(3): 277-285.

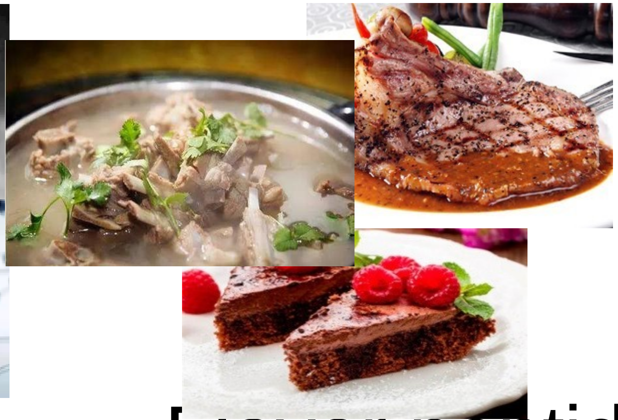
01 Introduction

Feeding ingredients

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



Proteins



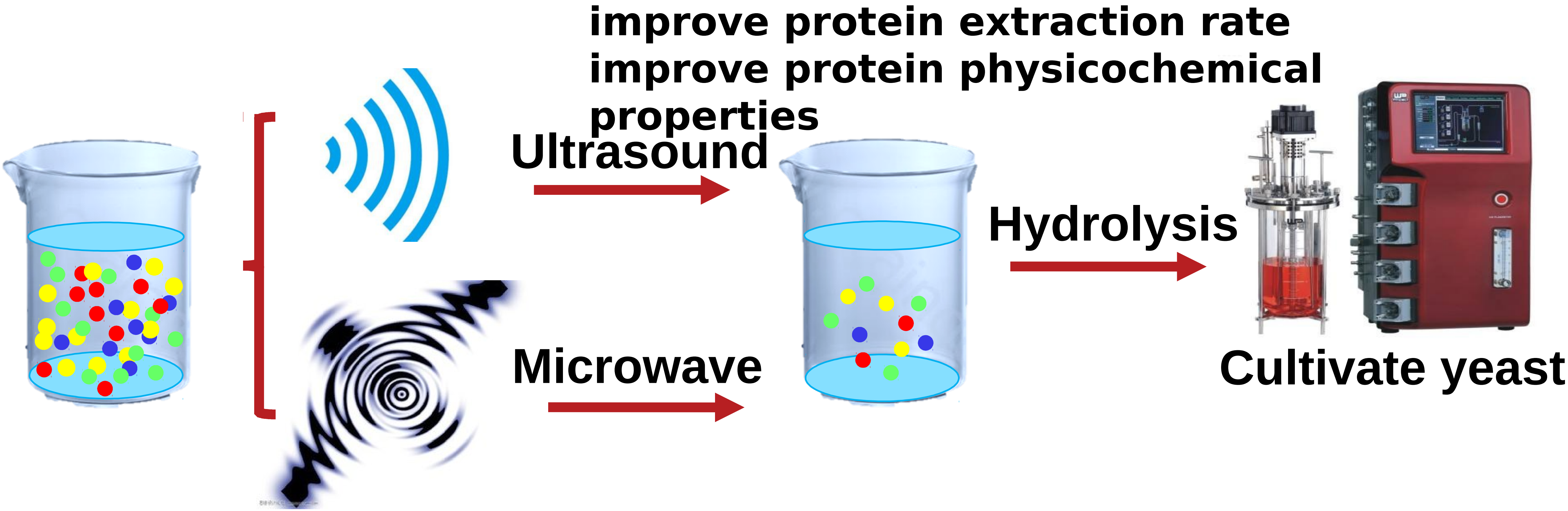
Flavor peptides

Skin care products

How to improve the protein property and increase the protein yield ?

02

Methods



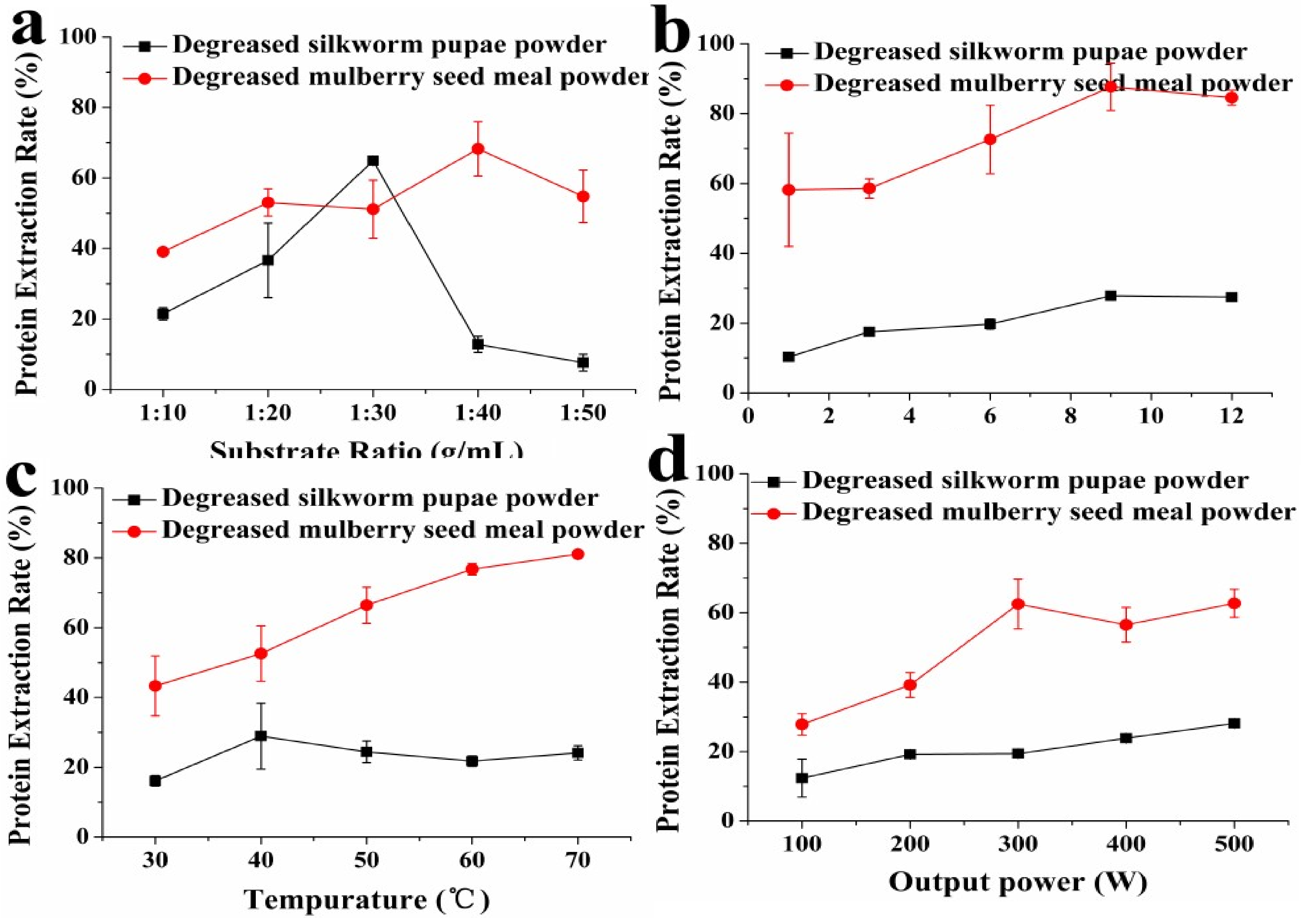
After pretreatment a large amount of protein dissolved in solution

Low-cost nitrogen source substitutes for microbial culture

03

Results

Ultrasound Treated



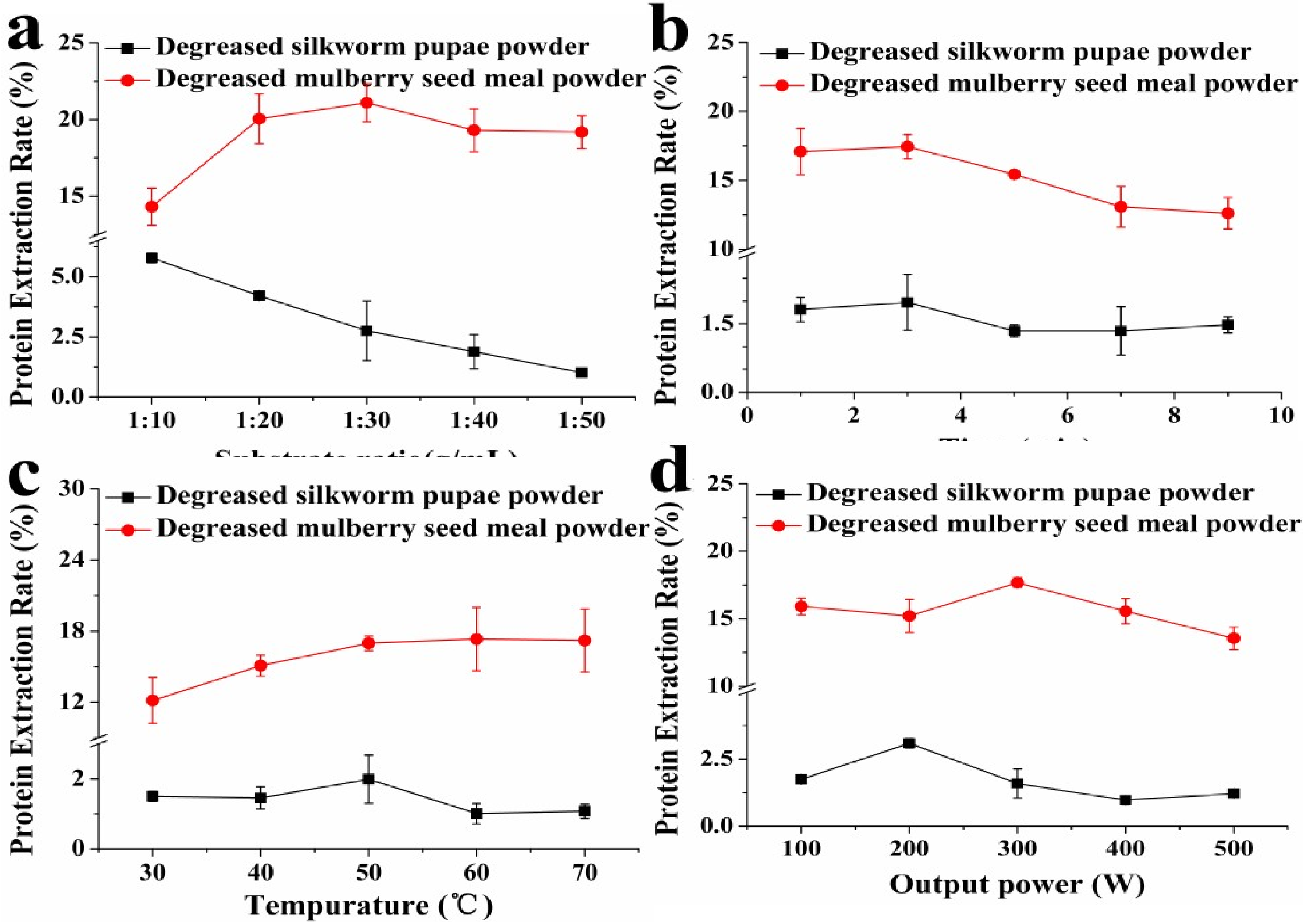
Mulberry seed meal:
a-1:40, b-9 min,
c-70 °C, d-300 W
Up 70%

Silkworm pupae:
a-1:30, b-9 min,
c-70°C, d-400 W
Up 30%

Fig. 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.

Results

Microwave Treated



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℃, d-200 W

Low growth

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).

Results

Response surface optimization

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

Source	df	Mean Square	F Valve	p-value	
Silkworm pupae	14	27.19	15.84	<0.001	significant
Lack of fit	10	2.31	4.39	0.0581	Not significant
Mulberry seed peal	14	98.87	11.29	<0.0001	significant
Lack of fit	10	5.11	0.32	0.9418	Not significant

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

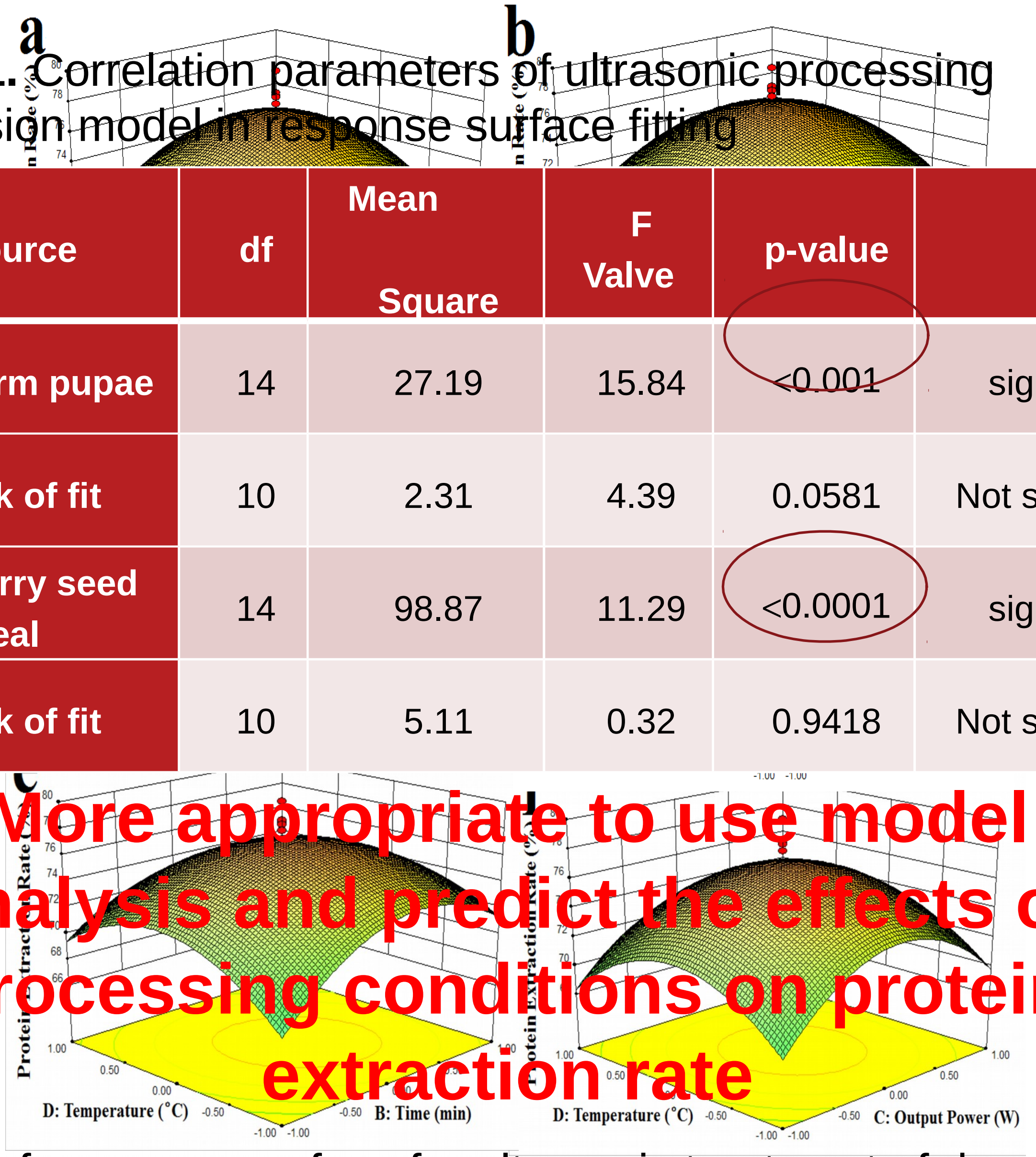


Fig. 3. Optimization of response surface for ultrasonic treatment of degreased mulberry seed peal

03

Results

Protein physicochemical properties

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

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

Ultrasound & microwave destroying hydrophobic interactions of protein

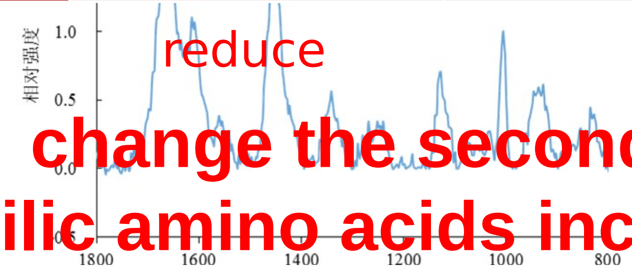
Resulting in exposure of more hydrophobic groups

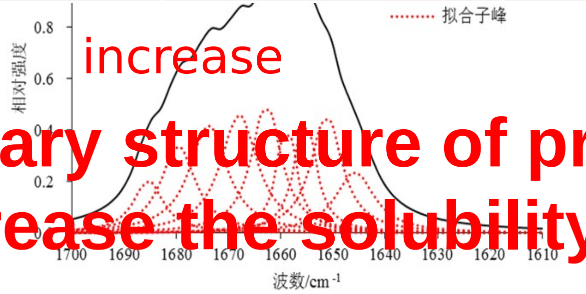
Results

Raman spectroscopy

Table 3. Secondary structure of protein.

Simple	α-spiral （%）	Random coil （%）	β-folding （%）	β-concer （%）
UM	41.36±0.30[a]	13.50±0.25[c]	39.53±0.28[b]	6.51±0.43[d]
UM1	31.61±0.45[b]	18.01±0.28[c]	40.86±0.63[a]	9.52±0.31[d]
MM	39.92±0.62[a]	12.68±0.33[b]	40.24±0.55[a]	7.06±0.27[c]
US	52.22±0.24[a]	11.21±0.47[d]	25±0.33[b]	12.12±0.24[c]
US1	49.56±0.32[a]	17.31±0.25[c]	25.16±0.42[b]	8.11±0.23[d]
MS	50.17±0.17[a]	13.21±0.32[c]	30.15±0.21[b]	7.21±0.25[d]





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.

Alternative nitrogen source

Generation kinetics of biomass

$$C_x(t)=\frac{8.611e^{0.048t}}{32.232+e^{0.048t}0.265}$$

Fermentation kinetics of oil production

$$P=\frac{2.5836e^{0.048t}}{32.232+0.265e^{0.048t}}+2.031\ln\left(\frac{32.232+0.265e^{0.048t}}{32.497}\right)$$

Substrate depletion kinetics

$$S=117.18-2.837\left(\frac{8.612e^{\mu_m t}}{32.232+0.265e^{0.048t}}\right)-5.256\,\frac{32.232+0.265e^{0.048t}}{32.497}$$

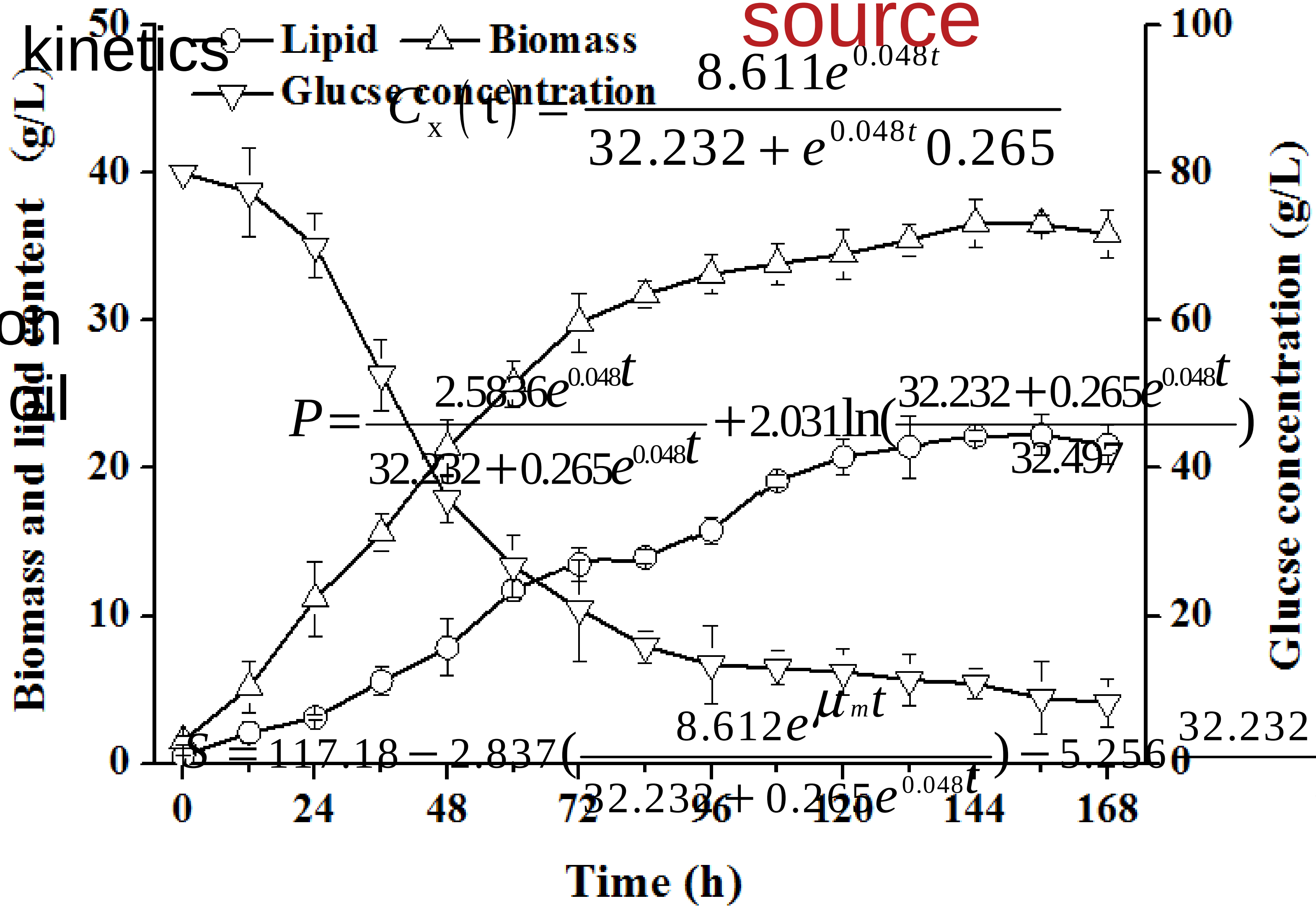


Fig. 5. The growth of S. *limacinum* SR21 and its lipid yield during the fermentation with alternative nitrogen source.

The feasibility of using protein hydrolysate as a nitrogen source to culture microalgae

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Conclusions

- **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.**

Acknowledgments

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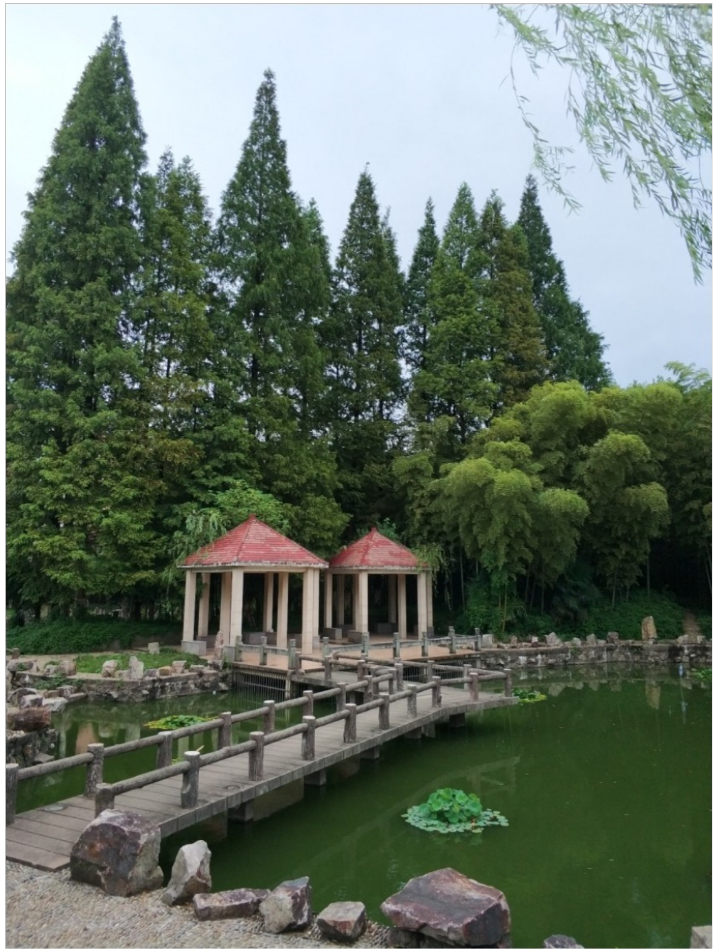

Thanks for listening