Extraction and the Fatty Acid Profile of 
Rosa acicularis Seed Oil

Huanan Du, Xu Zhang, Ruchun Zhang, Lu Zhang, Dianyu Yu* and Lianzhou Jiang*

School of Food Science, Northeast Agricultural University, Harbin 150030, CHINA

Abstract: Rosa acicularis seed oil was extracted from Rosa acicularis seeds by the ultrasonic-assisted aqueous enzymatic method using cellulase and protease. Based on a single experiment, Plackett-Burman design was applied to ultrasonic-assisted aqueous enzymatic extraction of wild rose seed oil. The effects of enzyme amount, hydrolysis temperature and initial pH on total extraction rate of wild rose seed oil was studied by using Box-Behnken optimize methodology. Chemical characteristics of a sample of Rosa acicularis seeds and Rosa acicularis seed oil were characterized in this work. The tocopherol content was 200.6±0.3 mg/100 g oil. The Rosa acicularis seed oil was rich in linoleic acid (56.5%) and oleic acid (34.2%). The saturated fatty acids included palmitic acid (4%) and stearic acid (2.9%). The major fatty acids in the sn-2 position of triacylglycerol in Rosa acicularis oil were linoleic acid (60.6%), oleic acid (33.6%) and linolenic acid (3.2%). According to the 1,3-random-2-random hypothesis, the dominant triacylglycerols were LLL (18%), LLnL (1%), LLP (2%), LOL (10%), LLS (1.2%), PLP (0.2%), LLnP (0.1%), LLnO (0.6%) and LOP (1.1%). This work could be useful for developing applications for Rosa acicularis seed oil.

Key words: Rosa acicularis seed oil, aqueous enzymatic extraction, extraction rate of oil, fatty acid

1 Introduction

Rosa acicularis, also known as wild rose fruit, is the ripe fruit of Mountain Dahurian Rose Fruit of Rosaceae, which is native to the northeastern region of China, Inner Mongolia, Shanxi and other provinces in China. The fruit contains abundant nutrients, including many types of minerals, amino acids, vitamins and other nutrients that are essential for ion homeostasis in the body. People typically use the Rosa acicularis fruit to make tea or soak in wine.

Rosa acicularis seeds contain essential amino acids for the human body, such as threonine, methionine, valine, leucine, phenylalanine and lysine. Moreover, Rosa acicularis seeds oil are known to be rich in unsaturated fatty acids.

Rosa acicularis is abundant in China, but typically only the flesh is used, even though the seeds, which are discarded, comprise 17-57% of the fruit. The seeds also contain considerable amounts of vitamin C, E carotene and a lot of aromatic components, which can be extracted. Many scholars have provided instructions for the comprehensive use of Rosa acicularis resources. Studies have shown that Rosa acicularis oil is effective against anxiety disorder, others have shown that some of the aroma of Rosa acicularis oil has an antibacterial effect on Staphylococcus aureus, Escherichia coli etc. It can be widely applied to spices, cosmetics, medicine and other fields.

Plant seeds contain oils in complex with carbohydrates and proteins, such as lipopolysaccharide and lipoprotein complexes, respectively. Enzymatic hydrolysis destroys the complexes, making it possible to extract lipids based on differences in affinity and specific gravity compared to the non-oil components. Aqueous enzymatic extraction, a new plant oil extraction technology, has been extensively studied. After a seed is broken open, water and enzymes are added, and, following hydrolysis, the oil is easily extracted. Ultrasonic cell crushing technology, which uses ultrasonic dispersion in liquid, can cause cavitation damage to tissues and solid particles in liquid. As a type of advanced auxiliary technology, the ultrasonic assisted extraction oil method can be an effective way to extract grease.

With Rosa acicularis seeds as raw material, the difference of oil extraction rate between the ultrasonic - assisted aqueous enzymatic method and conventional aqueous enzymatic method was compared. The Plackett-Burman (PB) design, steepest ascent method and response surface methodology (RSM) were used to optimize the parameters.
for aqueous enzymatic extraction of oil from Rosa acicularis seeds. Additionally, this work determined the general composition of Rosa acicularis seeds and the physical and chemical properties and fatty acid profile of Rosa acicularis seed oil. The objective of this study was to characterize the fatty acid profile of acicularis seed oil triacylglycerols. Compared with the traditional solvent leaching method, ultrasonic-assisted aqueous enzymatic method without organic solvent residue, and most of the aromatic components such as citronellol, rose ether, etc. in Rosa acicularis oil was retained, can be widely used in food, cosmetics, spices and other industries, providing a theoretical basis for future use of Rosa acicularis seed oil.

2 Materials and methods

2.1 Materials

Rosa acicularis seeds were purchased from a local market. Thirty-seven fatty acid methyl esters were used as standards. Standard tocopherols and pancreatic lipase used for sn-2 position analysis were obtained from Sigma Chemical Co. (St. Louis, MO). Silica G, used for TLC plate preparation, was obtained from Qingdao Ocean Chemical Factory (Qingdao, China). The methyl reagent was chromatographically purified. Other reagents were analytical grade. Cellulase, hemicellulase and protease were obtained from NOVO company.

2.2 Methods

2.2.1 The determination of compound enzyme proportion

and Comparison of ultrasonic-assisted aqueous enzymatic hydrolysis Methods and conventional aqueous enzymatic Methods

The enzymatic hydrolysis of the raw materials was carried out using the mixed enzyme composed of cellulase and neutral protease. The combined proportions of the mixed enzymes A, B, C, D, E and F (cellulase: neutral protease) were as follows: 4:6, 5:5, 6:4, 7:3, 8:2 and 9:1, respectively. The tests were carried out under the following two conditions: (1) Ground Rosa acicularis seeds were weighed and then mixed with distilled water at material-to-water ratio 1:5 with continuous stirring. The mixture was transferred to an ultrasonic bath for 34 min, the ultrasonic power was 400 W and the pH of the mixture was adjusted to 7.0 using acetic acid-sodium acetate buffer solution and sodium phosphate dibasic-sodium dihydrogen phosphate buffer solution. 2.5% Enzyme was added to the mixture, which was kept at 45°C during hydrolysis time 3.4 h. Then, the enzyme was inactivated by increasing the temperature to 100°C for 5 min and centrifuging the mixture, after which the oil was retained in the upper layer.

High-speed centrifuge (Eppendorf 543 High-speed centrifuge) is used for separating, the extraction efficiency was used as an indicator to determine the optimal ratio of the mixed enzyme. To determine the total oil extraction rate index, the total extraction rate of oil was obtained by using the following Eq.:

\[ R = \frac{m}{M} \]

where \( R \) is the total extraction rate of oil (%); \( m \) is the quality of extracted Rosa acicularis seed oil (g); \( M \) is the quality of Rosa acicularis seed oil in raw materials (g).

2.2.2 Screening of the key enzymatic hydrolysis parameters by Plackett–Burman design

Based on preliminary experimental results, a Plackett–Burman design of the experiment number \( N \) = 12 was used with eight different independent variables (A: Enzyme dosage, B: Enzymatic time, C: material-to-water ratio, D: Ultrasound power, E: Enzymatic temperature, F: Ultrasonication time, G: Ultrasonication temperature, H: Initial pH) analyzed. Each independent variable was measured at two levels, low and high; high levels were approximately 1.25 times greater than low levels. The values of each independent variable were determined in preliminary experiments. Calculate average response of the observation of the two-level experiment and determine the effect of the factors by determining the difference between them. The t value and confidence level among each factor were compared, and a greater than 95% confidence level was determined as a significant factor for further investigation.

2.2.3 The steepest ascent experiment and response surface optimization experiments

RSM was used to define the optimal levels of key factors after the optimal region of each significant variable was determined. The path of steepest ascent was used to determine whether the optimal point was working at the optimal region of operability and to establish an effective response surface fitting equation. According to the results of the steepest ascent experiment, the center of the significant factors of zero level assumes the obtained value. High and low levels greater than or less than the zero level are obtained, which provides a practical length of the step. Plackett–Burman design is an effective method for screening for significant factors; the extraction rate of Rosa acicularis seed oil as response value (\( R_e \)) and the response surface experiments were designed.
2.2.4 Approximate Composition Analysis for *Rosa acicularis*

The moisture (Ba 2a-38), ash (Ba 5a-49), lipid content (Ba 3-38), crude protein (Ba 4a-38) and crude fiber (Ba 6-84) of the *Rosa acicularis* powder were measured using a modified version of the methods described by AOCS Official Methods. The lipid content was determined by gravimetry, lipids were extracted from 10 g of *Rosa acicularis* powder by ethyl ether in a Soxhlet apparatus and the lipid content was expressed as a percentage of the mass. The measurement of nitrogen content of samples was conducted on a Foss 2006 digester and Foss 2300 Kjeltec Analyzer Unit (Foss Technologies Co, Sweden). The total protein content was calculated as the percentage of nitrogen multiplied by a factor of 6.25. All of the data were identified on a wet basis.

2.2.5 Physicochemical Property Assays for the Crude *Rosa acicularis* Oil

Important physicochemical properties of the crude oil, such as specific gravity, peroxide value, acid value, saponification value and unsaponifiable matter content were characterized according to the IUPAC Methods 2.101, 2.501, 2.201, 2.202 and 2.401, respectively. The color of the crude oil was observed according to the AOCS Office Method Ce-13e-92. The fatty acid composition of *Rosa acicularis* Oil

The fatty acid composition of *Rosa acicularis* oil was analyzed by gas chromatography (GC-14C) equipped with CP-Sil-88 polar capillary column (100 m × 0.25 nm × 0.2 μm) (Agilent Technologies, Palo Alto, CA) and a flame ionization detector (FID) (Agilent Technologies, Palo Alto, CA). Nitrogen gas was used as a carrier gas at 30 mL·min\(^{-1}\), hydrogen gas was used as a carrier gas at 30 mL·min\(^{-1}\), and air was used as a carrier gas at 300 mL·min\(^{-1}\). The determinations of fatty acid standards and samples were calculated when the measured temperature of the injection port was 260°C, the head pressure was 281.7 KPa, the head pressure was 281.7 KPa and maintained for 12 min, the split ratio was 100:1, and the injection volume was 1 μL.

2.2.6 Fatty Acid Composition of *Rosa acicularis* Oil

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3 Results and discussion

3.1 Composition of *Rosa acicularis*

Table 1 shows the composition of *Rosa acicularis*. The crude protein, lipid, and crude fiber contents were 3.8 ± 0.4%, 6.7 ± 0.2%, and 40.4 ± 0.6%, respectively. The lipid content of the *Rosa acicularis* in our study was almost consistent with the study of Xu et al., but the content of other components were slightly different from that. Compared with the study of Xu et al., the content of crude protein, ash and crude fiber were higher, meanwhile, the content of moisture was lower relatively in our study. The reason for this phenomenon may be that the type of roses and the growth conditions are different. The growth conditions of roses (growth temperature, rainfall and harvest time) have effect on the components of the seed. Low protein content and high crude fiber content will reduce protein emulsification, it is beneficial to extract oil.

3.2 The determination of compound enzyme proportion

As stated in the Methods, the proportions of cellulase to neutral protease in compound enzymes A, B, C, D, E and F were 4:6, 5:5, 6:4, 7:3, 8:2 and 9:1, respectively. The results from the study on the impact of compound enzyme proportion on oil extraction rate are shown in Fig. 1.

Figure 1 shows that ultrason-assisted test groups were higher than those of conventional aqueous enzymatic components, the cavitation affect of ultrasound resulted in transient high pressure, oil can be completely released.

| Table 1 Composition of *Rosa acicularis*. |
|------------------------------------------|
| Composition | Crude protein\(^a\) | Lipids\(^a\) | Crude fiber\(^a\) | Ash\(^a\) | Moisture\(^a\) |
| Content% (w / w) | 3.8 ± 0.4 | 6.7 ± 0.2 | 40.4 ± 0.6 | 3.9 ± 0.1 | 9.0 ± 0.3 |

\(^a\) Values are means ± standard deviation of triplicate determinations.
because of the damage of cell wall. The wild rose seed cell wall is mainly composed of cellulose compared to other plant seed, the extraction rate of free oil is higher when the content of cellulase in the mixed enzyme is high. But when the protease content is too low, the effect of proteolysis is not obvious, the extraction rate of free oil decreased significantly ($p < 0.05$). In both experiments, the extraction rate of free oil is higher in samples treated with mixed enzyme D, which reached 67.9%, which was higher than samples treated with mixed enzyme C and E by 4.4% and 3.6%, respectively. Thus, mixed enzyme D was the best choice.

### 3.3 PB design experiments results and analysis

According to the PB experimental design, results from each group of three parallel experiments were averaged. The PB experimental design and results are shown in Table 2. The effects of various factors and significance analysis results are shown in Table 3.

As shown in Table 3, the values for hydrolysis time, materials-to-water ratio, ultrasonic power, hydrolysis temperature, ultrasonication time and initial pH are positive, which indicates these factors have positive effects on oil extraction rate; the effects of enzyme amount and ultrasonication temperature are negative in value, indicating that these two factors have a negative effect on oil extraction rate. Factors such as enzyme amount, material-to-water ratio, ultrasonic power, hydrolysis temperature, ultrasonication time and initial pH, had confidence levels greater than 90%. Among the factors with a confidence level greater than 95% are enzyme amount, hydrolysis temperature and initial pH, which are the significant factors for oil extraction rate.

### 3.4 The results of the steepest ascent experiment

According to the results in Table 3, the three significant factors changed the length of steps. The experiment design and the results for the influence on oil extraction rate are shown in Table 4.

As shown in Table 4, changes in enzyme amount, hydrolysis temperature and initial pH in the steepest ascent experiment in the order of 0.2, 2, 0.4, respectively. Group 3 had the maximum extraction rate, indicating that the optimum point of oil extraction rate is in the domain of group 3; therefore, group 3 will be used in future experiments.

### 3.5 Box-Behnken experimental design and results

Based on the factors determined from the PB experi-

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**Table 2** Plackett-Burman experimental design and results.

| No. | $A$ | $B$ | $C$ | $D$ | $E$ | $F$ | $G$ | $H$ | Extraction rate (%) |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|---------------------|
| 1   | 3.0 | 3.8 | 1:6 | 450 | 50  | 30  | 45  | 6   | 48                  |
| 2   | 3.0 | 3.0 | 1:4 | 350 | 50  | 30  | 45  | 8   | 56                  |
| 3   | 3.0 | 3.0 | 1:6 | 350 | 50  | 38  | 45  | 6   | 71                  |
| 4   | 2.0 | 3.8 | 1:4 | 350 | 50  | 30  | 35  | 6   | 81                  |
| 5   | 3.0 | 3.8 | 1:4 | 350 | 50  | 38  | 35  | 8   | 63                  |
| 6   | 3.0 | 3.8 | 1:6 | 450 | 40  | 30  | 35  | 8   | 48                  |
| 7   | 2.0 | 3.0 | 1:6 | 350 | 40  | 30  | 35  | 6   | 62                  |
| 8   | 3.0 | 3.0 | 1:4 | 450 | 40  | 38  | 35  | 6   | 69                  |
| 9   | 2.0 | 3.8 | 1:4 | 450 | 40  | 38  | 45  | 6   | 81                  |
| 10  | 2.0 | 3.0 | 1:4 | 450 | 50  | 30  | 45  | 8   | 80                  |
| 11  | 2.0 | 3.0 | 1:6 | 450 | 50  | 38  | 35  | 8   | 69                  |
| 12  | 2.0 | 3.8 | 1:6 | 350 | 40  | 38  | 45  | 8   | 48                  |
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The steepest ascent experiment, the Box-Behnken central composite design was used to determine the effects of three independent variables, i.e., enzyme amount ($A$), hydrolysis temperature ($B$) and initial pH ($C$), on oil extraction rate ($R_1$). The independent variables were coded at three levels ($-1$, $0$ and $+1$). Independent variables level codes are shown in Table 5. Experimental design and results are shown in Table 6.

Results obtained using the optimization option of Design-Expert 7.0 software are shown in Table 7 ($p < 0.001$). The results for lack of fit analysis were not significant ($p > 0.05$). The model had $R^2 = 95.68\%$, $R^2_{Adj} = 90.13\%$, indicating a high degree of correlation between the various factors and response values from the regression model.

Multiple regression fitting of experimental data was used to obtain the regression equation of the extraction rate ($R_1$) to the independent variable, enzyme amount ($A$), hydrolysis temperature ($B$) and initial pH ($C$), is:

$$R_1 = 81.1 + 0.85A + 0.33B - 1.14AB + 1.20AC + 1.18BC - 0.10A^2 - 0.47B^2 - 1.56C^2.$$ 

Response surface analysis was used to determine the optimal response by analyzing the regression model using

**Table 3** Values of various factors and significance analysis of Plackett-Burman experimental design.

| Factors            | Low levels (-1) | High levels (+1) | Effect  | Coefficient | T     | Pro>F |
|--------------------|------------------|------------------|---------|-------------|-------|-------|
| $A$ Enzyme amount (%) | 3.0              | 4.0              | -8.6    | -4.3        | -3.4  | 0.04  |
| $B$ Hydrolysis time (h) | 3.0            | 3.8              | 5.7     | 2.9         | 2.3   | 0.1   |
| $C$ Materials to water rate | 1.6          | 1.4              | 6.4     | 3.2         | 2.5   | 0.09  |
| $D$ Ultrasonic power (W) | 350            | 450              | 6.4     | 3.2         | 2.5   | 0.09  |
| $E$ Hydrolysis temperature (°C) | 40          | 50                | 11.1    | 5.5         | 4.4   | 0.02  |
| $F$ Ultrasonic time (min) | 30            | 38                | 8       | 4           | 3.1   | 0.05  |
| $G$ Ultrasonic temperature (°C) | 35            | 45                | -4      | -2          | -1.6  | 0.2   |
| $H$ Initial pH | 6                | 8                | 9.8     | 4.2         | 3.9   | 0.03  |

**Table 4** The steepest ascent experiment.

| No. | Enzyme amount (%) | Hydrolysis temperature (°C) | Initial pH | Extraction rate (%) |
|-----|-------------------|-----------------------------|------------|---------------------|
| 1   | 4.0               | 40                          | 6.0        | 55.6                |
| 2   | 3.8               | 42                          | 6.4        | 68.5                |
| 3   | 3.6               | 44                          | 6.8        | 75.8                |
| 4   | 3.4               | 46                          | 7.2        | 64.3                |
| 5   | 3.2               | 48                          | 7.4        | 59.4                |

**Table 5** Box-Behnken experimental design factor level codes table.

| Level | Enzyme amount (%) | Factors Hydrolysis temperature (°C) | Initial pH |
|-------|-------------------|------------------------------------|------------|
| -1    | 3.4               | 42                                 | 6.4        |
| 0     | 3.6               | 44                                 | 6.8        |
| +1    | 3.8               | 46                                 | 7.2        |
Design Expert 7.0. The results are shown in Table 8.

### Table 6 Box-Behnken experiment design program and the results.

| Run No. | Enzyme amount (%) | Hydrolysis temperature (°C) | Initial pH | Oil extraction rate (%) |
|---------|-------------------|-----------------------------|------------|------------------------|
| 1       | -1                | -1                          | 0          | 63.2                   |
| 2       | 1                 | -1                          | 0          | 64.2                   |
| 3       | -1                | 1                           | 0          | 68.6                   |
| 4       | 1                 | 1                           | 0          | 74.1                   |
| 5       | -1                | 0                           | -1         | 86.3                   |
| 6       | 1                 | 0                           | -1         | 84.1                   |
| 7       | -1                | 0                           | 1          | 66.4                   |
| 8       | 1                 | 0                           | 1          | 69                     |
| 9       | 0                 | -1                          | -1         | 76.4                   |
| 10      | 0                 | 1                           | -1         | 75.7                   |
| 11      | 0                 | -1                          | 1          | 60.1                   |
| 12      | 0                 | 1                           | 1          | 68.2                   |
| 13      | 0                 | 0                           | 0          | 83.5                   |
| 14      | 0                 | 0                           | 0          | 82.2                   |
| 15      | 0                 | 0                           | 0          | 80                     |
| 16      | 0                 | 0                           | 0          | 80                     |
| 17      | 0                 | 0                           | 0          | 79.9                   |

### Table 7 Box-Behnken experiment the result of variance analysis.

| Source    | Degree of freedom | Sum of squares | Mean square | F value | Prob>F   |
|-----------|-------------------|----------------|-------------|---------|-----------|
| Model     | 9                 | 1025.6         | 114         | 17.2    | 0.0006    | Significant |
| A         | 1                 | 5.8            | 5.8         | 0.9     | 0.4       |
| B         | 1                 | 88.6           | 88.6        | 13.4    | 0.008     |
| C         | 1                 | 373.9          | 373.9       | 56.6    | 0.0001    |
| AB        | 1                 | 5.2            | 5.2         | 0.8     | 0.4       |
| AC        | 1                 | 5.7            | 5.7         | 0.9     | 0.4       |
| BC        | 1                 | 5.5            | 5.5         | 0.8     | 0.4       |
| A²        | 1                 | 40.5           | 40.5        | 6.1     | 0.04      |
| B²        | 1                 | 461.9          | 461.9       | 69.9    | < 0.0001  |
| C²        | 1                 | 10.2           | 10.2        | 1.6     | 0.3       |
| Residual  | 7                 | 46.3           | 6.6         |         |           |
| Lack of fit | 3             | 35.3          | 11.8        | 4.3     | 0.1       | Not significant |
| Pure error | 4               | 11            | 2.7         |         |           |
| Cor total | 16                | 1071.9         |             |         |           |

3.6 Physicochemical Properties of *Rosa acicularis* Oil

The physicochemical properties of crude *Rosa acicularis* oil are presented in Table 9. The specific gravity (20°C), peroxide value, acid value, saponification value, unsaponifiable matter content and color of *Rosa acicularis* seed oil were 0.9 ± 0.002 g/cm³, 6.1 ± 0.02 mmol/kg, 1.6 ± 0.03 mg/g, 188.6 ± 0.4 mg KOH/g, 10.4 ± 0.2 g/100 g and R2.6 Y70, respectively. The tocopherol content was 200.6
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3.7 Fatty Acids Composition and Positional Distribution in Rosa acicularis oil

Fatty acid composition and their distribution can affect the physicochemical properties of oil. The major unsaturated fatty acids in Rosa acicularis oil were linoleic acid (56.5%), oleic acid (34.2%) and linolenic acid (1.7%). The amounts of palmitic acid and stearic acid were 4% and 2.9%, respectively.

The amounts of pentadecanoic acid and heptadecanoic acid were lower than 1% (Table 10). The total unsaturated fatty acids amounted to 93%, and the ratio of total unsaturated fatty acids to saturated fatty acids was approximately 13.3%. Compared with the study of Musa 29, the proportion of unsaturated fatty acids was consistent with the results of their study. However, the types of fatty acids in rose seed oil are different, and in this study the content of linolenic acid is lower than it, while the content of oleic acid is higher than it, which may be due to the different types and growth conditions of roses. The fatty acids composition and content of vegetable oils are affected by species, growth temperature, rainfall and harvest time 29. The fatty acid of sn-2 position, which is in triglyceride of Rosa acicularis oil, was analyzed. The major fatty acids in the sn-2 position of triacylglycerol in Rosa acicularis oil were oleic acid (33.6%), linoleic acid (60.6%) and linolenic acid (3.2%). The amounts of palmitic acid and stearic acid were 0.9% and 1.6%, respectively.

Table 8 response surface optimization results.

| Factors                      | The actual value transformation | Extraction rate (%) |
|------------------------------|---------------------------------|---------------------|
| Enzyme amount (%)            | 3.8                             |                     |
| Hydrolysis Temperature (°C)  | 44.3                            | 83.2                |
| Initial pH                   | 6.4                             |                     |

Table 9 Physicochemical properties of Rosa acicularis oil.

| Characteristic | Specific gravity (g/cm³) | Peroxide value (mmol/kg) | Acid value (mg/g) | Saponification value (mg KOH/g) | Unsaponifiable matter (g/100 g) | Color       | Tocopherol (mg/100 g oil) |
|----------------|--------------------------|--------------------------|------------------|---------------------------------|---------------------------------|------------|--------------------------|
| Crude Rosa acicularis oil | 0.9 ± 0.002                | 6.1 ± 0.02               | 1.6 ± 0.03       | 188.6 ± 0.4                     | 10.4 ± 0.2                      | Y70, R2.6  | 200.6 ± 0.3               |

Table 10 Total and sn-2 fatty acid composition of Rosa acicularis oil.

| Fatty acid           | Retention time (sn-1,2,3 Position (%)<sup>a</sup>) | sn-2 Position (sn-1,3 Position (%)<sup>b</sup>) |
|----------------------|-----------------------------------------------------|-----------------------------------------------|
| erucic acid (Er)     | 8.5                                                 | 0.1                                           |
| Pentadecanoic acid (Pe) | 9.3                                             | 0.03                                          |
| Palmitic acid (P)    | 12.2                                               | 4                                             |
| Heptadecanoic acid (He) | 13.1                                            | 0.09                                          |
| Stearic acid (St)    | 14.3                                               | 2.9                                           |
| Linolenic acid (Ln)  | 15.2                                               | 1.7                                           |
| Oleic acid (O)       | 16.2                                               | 34.2                                          |
| r-linolenic acid (γ-Li) | 17.2                                             | 0.5                                           |
| Linoleic acid (L)    | 17.7                                               | 56.5                                          |
| Saturated fatty acids (S) | 7                                                | 2.5                                           |
| Unsaturated fatty acids (U) | 93                                               | 97.5                                          |
| U/S                  | 13.3                                               | 39.4                                          |

± 0.3 mg/100 g oil.
position of the fatty acid (b) are shown in Fig. 2, Fig. 3, Fig. 4, Table 10 and Table 11.

4 Conclusions

An efficient ultrasound-assisted enzymatic extraction of Rosa acicularis seed oil determined that the best cellulase to neutral protease ratio is 7:3. The Plackett-Burman central composite design was used to determine the effects of three independent variables, i.e., enzyme amount, hydrolysis temperature and initial pH, approaching the maximum response area by the steepest ascent experiment. Applying the response surface optimization method to analyze the regression model, the response surface revealed the following optimal values: enzyme amount 3.8%, hydrolysis temperature 44.3°C, initial pH 6.4 and an oil extraction rate of 83.2%. This work has presented the general properties of Rosa acicularis oil and its fatty acid profile, which has a high degree of unsaturation and iodine and is rich in vitamin E. Rosa acicularis oil could be a good source of natural oil rich in linolenic acid and tocopherols. At the same time, ultrasonic-assisted water-enzymatic extraction of oil without organic solvent residue, most of essential oils of citronellol and rose ether was retained which are slightly soluble in water. In conclusion, Rosa acicularis oil is a nutrient-rich plant oil with potential for development. This paper will be helpful to provide some theoretical basis for the application of Rosa acicularis seed oil in food, cosmetics and other fields.

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Laboratory of Soybean Biology in Chinese Ministry of Education Northeast Agricultural University, Harbin, China, 150030.

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