Anti-Obesity Effect of Red Radish Coral Sprout Extract by Inhibited Triglyceride Accumulation in a Microbial Evaluation System and in High-Fat Diet-Induced Obese Mice

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In eukaryotes and several types of bacteria, neutral lipids, including triglycerides (TGs), are stored in lipid droplets (LDs) that serve as the energy reservoir of the cell [1, 2]. LDs are associated with oil production in microorganisms and plants [1]. However, in humans, they are often associated with metabolic diseases such as obesity, diabetes, atherosclerosis, and cancers [1, 2].

Preadipocytes such as 3T3-L1 have been traditionally used as in vitro cell models before in vivo testing for obesity research. Although the in vitro evaluation using cultivated cells is economical and convenient, this method can be disadvantageous owing to problems such as cell damage occurring during cell maintenance and storage [3, 4].

Oleaginous yeasts highly producing lipids are getting recognition in the field of microbial biodiesel [5] and also proposed as an in vitro model for obesity research [6]. Among them, the red yeast Rhodosporidium toruloides is capable of accumulating lipids, such as TGs, at more than 70% of its dry cell biomass [7]. Previously, we reported R. toruloides as a novel in vitro tool to evaluate the TG reduction effects of potential anti-obesity food materials [4].

Radish (Raphanus sativus) possesses various biological properties, such as antimicrobial, antiviral, antioxidant, antitumor, antiplatelet, and immunological activities, intestine motility stimulation, and cardiovascular disease prevention [8]. In particular, red radish is used as a functional natural colorant because it is rich in anthocyanin pigments, which are known natural antioxidants [8–10].

In this study, we examined the inhibitory effect of the red radish coral sprout extract (RRSE) among anti-obesity candidates in TG accumulation, using the in vitro microbial evaluation system R. toruloides, and confirmed its anti-obesity activity in a diet-induced obesity mouse model. The RRSE powder was kindly provided by Aenong Association (Korea). The extract powder was added to a yeast extract peptone dextrose (YPD) broth (Becton, Dickinson and Company, Sparks, USA) at a final concentration of 0.1% red radish coral sprout extract (RRSE)-treated R. toruloides. We also evaluated the anti-obesity effect of the RRSE in a mouse model. The body weight gain of mice fed a high-fat diet (HFD) with 0.1% RRSE (HFD-RRSE) was significantly decreased by 62% compared with that mice fed the HFD alone after the 8-week experimental period. Body fat of the HFD-RRSE-fed group was dramatically reduced by 38.3% compared with that of the HFD-fed group.

Keywords: Rhodosporidium toruloides, red radish coral sprout, triglyceride, anti-obesity

Rhodosporidium toruloides, an oleaginous yeast, can be used as a fast and reliable evaluation tool to screen new natural lipid-lowering agents. Herein, we showed that triglyceride (TG) accumulation was inhibited by 42.6% in 0.1% red radish coral sprout extract (RRSE)-treated R. toruloides. We also evaluated the anti-obesity effect of the RRSE in a mouse model. The body weight gain of mice fed a high-fat diet (HFD) with 0.1% RRSE (HFD-RRSE) was significantly decreased by 62% compared with that mice fed the HFD alone after the 8-week experimental period. Body fat of the HFD-RRSE-fed group was dramatically reduced by 38.3% compared with that of the HFD-fed group.

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Received: February 9, 2018
Revised: March 2, 2018
Accepted: March 12, 2018
First published online March 15, 2018
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pISSN 1017-7825, eISSN 1738-8872
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under a 12-h light/12-h dark cycle (temperature 22 ± 2°C, humidity 50 ± 5%), the mice were divided into three groups (10 mice per group). For 8 weeks, each group was fed different diets: (i) normal diet (ND), (ii) high-fat diet (HFD), and (iii) HFD with RRSE. RRSE was dissolved in sterilized drinking water at 1,000 mg/kg body weight and orally administered on a daily basis. The same volume of drinking water during the 8-week experimental period. Food consumption and weight gain were measured daily and weekly, respectively. The body fat weight of each period. Food consumption and weight gain were measured

All results were expressed as the average and standard deviation using SPSS ver. 12 for Windows (SPSS Inc., USA).

Data were analyzed by one-way ANOVA followed by Duncan’s multiple range test for multiple comparisons. A difference of p < 0.05 was regarded as being statistically significant.

In the test for inhibitory effect of RRSE on TG accumulation in R. toruloides, the red yeast growth was not inhibited by treatment with RRSE (data not shown), and the wet cell mass was rather significantly increased compared with the control (Table 2). The TG content in the red yeast incubated in RRSE-including YPD medium was significantly decreased compared with the control, although the total lipid content was not different, demonstrating that RRSE can effectively lower TG accumulation in the red yeast in a concentration-dependent manner. The TG content in the yeast was significantly reduced to 0.1% RRSE concentration compared with the control, although the total lipid content was not different, demonstrating that RRSE can effectively lower TG accumulation in the red yeast in a concentration-dependent manner. The TG content in the yeast was significantly reduced to 0.1% RRSE concentration compared with the control group. Although 0.5% RRSE lowers more TG content than 0.1% RRSE does, 0.5% RRSE showed a slight decrease in the TG content by 14.4% compared with 0.1% RRSE concentration.

Control, R. toruloides incubated in YPD medium without red radish sprout extract; 0.1%, 0.5%, and 1.0% RRSE, R. toruloides incubated in YPD medium with 0.1%, 0.5%, and 1.0% red radish sprout extract, respectively. Data are means ± standard deviations from three independent experiments. **Means with the different letters within the same column are significantly different at p < 0.05 by Duncan’s multiple range test.

Control, 0.1%, 0.5%, and 1.0% red radish sprout extract, respectively. Data are means ± standard deviations from three independent experiments. **Means with the different letters within the same column are significantly different at p < 0.05 by Duncan’s multiple range test.

### Table 1. Nutritional compositions of the diets.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>ND*</th>
<th>HFD*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>20.0 gm%</td>
<td>20.3 kcal%</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>64.0 gm%</td>
<td>63.9 kcal%</td>
</tr>
<tr>
<td>Fat</td>
<td>7.0 gm%</td>
<td>15.8 kcal%</td>
</tr>
<tr>
<td>Total</td>
<td>91.0 gm%</td>
<td>100.0 kcal%</td>
</tr>
<tr>
<td>kcal/gm</td>
<td>3.9</td>
<td>2.2</td>
</tr>
</tbody>
</table>

### Table 2. Effect of red radish sprout extract on inhibition of triglyceride (TG) accumulation in Rhodosporidium toruloides.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Wet cell mass (g)</th>
<th>Total lipid content (mg/g wet cell mass)</th>
<th>TG content (mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.49 ± 0.03</td>
<td>19.76 ± 3.53</td>
<td>894.23 ± 85.71</td>
</tr>
<tr>
<td>0.1% RRSE</td>
<td>0.62 ± 0.02</td>
<td>18.10 ± 2.09</td>
<td>513.30 ± 44.29</td>
</tr>
<tr>
<td>0.5% RRSE</td>
<td>0.59 ± 0.08</td>
<td>14.83 ± 1.37</td>
<td>384.48 ± 34.06</td>
</tr>
<tr>
<td>1.0% RRSE</td>
<td>0.60 ± 0.03</td>
<td>16.12 ± 3.34</td>
<td>346.06 ± 62.85</td>
</tr>
</tbody>
</table>