Wheat germ oil is a number of nutritional and health benefits, such as reducing plasma and liver cholesterol levels, improving physical endurance/fitness, and delaying aging (5). These effects are attributed to the high concentration of bioactive compounds present in the germ. Wheat germ is one of the richest natural sources of tocopherol, which possesses Vitamin E activity (1). Wheat germ oil is also added to lecithin and cod liver oil. Wheat germ oil has been reported to improve human physical fitness, and this effect is attributed to its high polycosanol (PC), specifically to its high octacosanol (OC) content (5). There is a growing interest in wheat germ octacosanol as a potential nutraceutical and functional food ingredient.

Wheat germ oil is used in products such as foods, biological insect control agents, pharmaceuticals, and cosmetic formulations (5).

Wheat germ oil (WGO) is rich in PUFA and bioactive compounds. These compounds are prone to oxidation and degradation under the conditions used for conventional edible oil extraction and refining methods. Hence there is a need for development of new processing techniques that will maintain WGO quality and biological activity of the oil components during processing. Supercritical fluid technology is an alternative method to conventional hexane extraction and refining. Several research studies reporting supercritical carbon dioxide (SC-CO2) extraction of WGO have been published (2,3,7,9). Taniguchi et al. (9) reported that WGO solubility in SC-CO2 was 0.35% (w/w) at 40°C and 20 MPa. SC-CO2-extracted oil had a lighter color and contained less phosphorus than hexane extracted oil. According to Panfili et al. (7), FFA content and PV of the oils collected during the first 45 min of extraction were higher than those of the oil fractions collected at the later stages of the process. Extraction of wheat germ with liquid and SC-CO2 (5–40 MPa) at relatively low temperatures (10–60°C) indicated that pressure had a significant effect on the oil yields whereas the effect of temperature was insignificant (3). Dunford and Martinez (2) studied the effect of pressure and temperature on the SC-CO2 WGO extraction yields in the range of 10–55 MPa and 40–80°C. Yields of SC-CO2 extracts varied significantly with temperature and pressure in the 2 to 20% (w/w) range. Soxhlet extraction using hexane as a solvent yielded 11% (w/w) WGO. These results indicate that
SC-CO\textsubscript{2} at high pressure extracts some of the wheat germ components that are not soluble in hexane. At higher temperature and pressures, moisture can be co-extracted with oil, resulting in higher extraction yields (2,9). The highest SC-CO\textsubscript{2} extraction yield was obtained at the highest pressure used (55 MPa).

2. RESULTS AND DISCUSSIONS

The amount of oil were evaluated gravimetrically. Compared with traditional extraction with organic solvents, the maximum extraction yield is 83%. The amount of wheat germ oil extracted with supercritical carbon dioxide ranging from 87 g to 200 bar and 60 °C up to 224 g of oil obtained at 300 bar and 40°C. The effect of pressure on wheat germ oil extraction with supercritical carbon dioxide has been investigated at pressures of 20, 25 and 30 MPa and temperatures of 40, 50 and 60°C.

Oil solubility in supercritical carbon dioxide is mainly influenced by the density of supercritical carbon dioxide and volatile oil components.

Table 1. Supercritical carbon dioxide density

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Pressure p, bar</th>
</tr>
</thead>
<tbody>
<tr>
<td>t °C</td>
<td>200</td>
</tr>
<tr>
<td>40</td>
<td>839.9</td>
</tr>
<tr>
<td>50</td>
<td>784.4</td>
</tr>
<tr>
<td>60</td>
<td>723.8</td>
</tr>
</tbody>
</table>

Oil yield extraction with supercritical CO\textsubscript{2} is defined as being equal to the ratio, expressed as a percentage, of the amount of oil extracted with supercritical CO\textsubscript{2} and the amount of oil extracted by standard method (Soxhlet plant, petroleum ether).

At 40°C and pressure from 200 to 250 bar the extraction efficiency increased with 17%, while at pressure of 300 bar the efficiency increased by 25%. After 210 minutes mostly of oil are extracted from existing oil, in the final period of extraction only a small amount of oils recovered.

As shown in Figures 1-3, in the first period of the extraction curves are approximated by a straight line, which is the extraction constant speed curves extraction will then evolve into a limit value given by the total amount of extractable compounds. Linearity of the extraction curves in the first stage is given by setting a constant resistance to the transfer of substance in this period, resistance located at the interface solid - fluid. Although it is obvious that in this period is not reached equilibrium solubility, the slope of straight lines in the graph is used to approximate the oil solubility in supercritical solvent. In the second phase, after substrate depletion near the surface of separation, the quantities of soluble compounds to be transported within the solid thus adding additional strength. Also met resistance from undamaged cells and extraction of oil from low levels lead to reduced oil available

Fig.1. Effect of pressure on supercritical carbon dioxide extraction yield of wheat germ oil, at 40 °C.

At 50°C increase in pressure from 200 to 250 bar increases the extraction efficiency of 30%, while at the pressure of 300 bar, the yield increasing by 36%.

Fig.2. Effect of pressure on supercritical carbon dioxide extraction yield of wheat germ oil, at 50 °C.

At 60°C the trend is the same as for 50°C, the yield increases between 30 and 36%.

Fig.3. Effect of pressure on supercritical carbon dioxide extraction yield of wheat germ oil, at 60 °C.
At constant pressure the best extraction yields are obtained at 300 bar and 40°C (lowest temperature). Under isobaric best extraction yields are obtained at 300 bar and 40 °C (lowest temperature), due to the predominant effect of the supercritical solvent density in these conditions has the highest value and therefore the solvation power high. At low pressures the negative effect of temperature on extraction efficiency is even more pronounced, due to more pronounced reduction of carbon dioxide density.

3. CONCLUSIONS

✓ Extraction yield is variable
  – for wheat germ oil the yield vary from 32% to 83%; the maximum yield is obtained at 300 bar and 40°C;
✓ The analysis of extraction curves shown that wheat germ oil extraction with supercritical carbon dioxide reach a maximum levels yield after 210 minutes at the beginning of extraction.

4. REFERENCES