Study of vacuum microwave extraction krill oil

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ABSTRACT

Krill oil contains a lot of phospholipid, polyunsaturated long chain fatty acids (such as: DHA, EPA) and astaxanthin; therefore, it is easily absorbed by human and has better physiological activity than fish oil. Microwave extraction of oil by ethanol can significantly reduce extraction time and solvent, and improve extraction efficiency. Moreover, the application vacuum in the microwave extraction system can avoid oil oxidation reaction of the oxygen sensitive components (such as: EPA & DHA) during extraction. Therefore, 95% ethanol in this study was the extraction solvent for fresh kril. The experimental designs were the solid-liquid ratio (1: 4, 1: 6, 1: 8, 1: 10, 1: 12 (g / mL)), the extraction time (0, 5, 10, 15, 20 (min)) and vacuum pressure (76 (no vacuum), 46, 36 and 26 (cmHg)) on the DHA content from krill by 300 W microwave extractiion. The results showed that DHA extraction ratio increased with increasing liquid ratio. Howerver, DHA extraction ratio significantly declined with microwave extraction time, presumably due to oxidation. The solid-liquid ratio of 1: 8, and 5 min under 300 W micorwave extraction was the optimal extraction condition. Higher vacuum pressure significantly increased the DHA extraction ratio from krill oil.

Key words: Microwave extraction, vacuum, krill

INTRODUCTION

Antarctic krill are small, shrimp-like perennial planktonic crustaceans that belong to the bottom level of consumer in the Antarctic marine ecosystem. In recent years it found that krill oil contains large amounts of long-chain polyunsaturated fatty acids that bound with phospholipids,. Therefore, krill oil are considered to be the great potential sources of function oil for human consumption. However, the conventional oil extraction method requires a lot of organic solvents and longer extraction times that was inconsistent with current environmental requirements. Therefore, it is necessary to study an innovative extraction technology with environmentally friendly and high efficiency. It has been shown that microwave heating can rapidly increase temperature and pressure in the cells resulting in cells be ruptured and the oil can be dissolved in solvent to increase oil extraction yield and decrease extraction time. Vacuum system can lower the boiling temperature of the solvent and reduce oxygen content in the extraction system, to avoid the oxidation of oxygen-sensitive components (OSC) such as: astaxanthin, DHA, EPA etc.

METHODOLOY

A 1.6 kW, 2450 MHz vacuum microwave extraction system with adjustable power, pump and cooling water condenser was used in this study **(Fig. 1.)**. The oil was extracted from the homogenized krill using 95% ethanol by microwave extraction and the DHA in the krill oil extract was analyzed. Fatty acid profile of krill oil by GC was shown in **Fig. 2.** The effects of solid-solvent ratio (1:4, 1:6, 1:8, 1:10, and 1:12), absolute pressure (76 (no vacuum), 46, 36 and 26 (cm Hg)) on DHA content in krill after microwave extraction were investigated. Data were expressed as mean ± S.D (n = 3). Statistical analysis was carried out using the Duncan's test. Means with different letters are significantly different ($p < 0.05$).

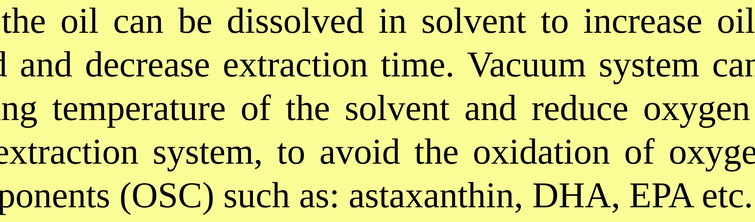

Fig. 1. Photograph of the microwave vacuum extraction system.

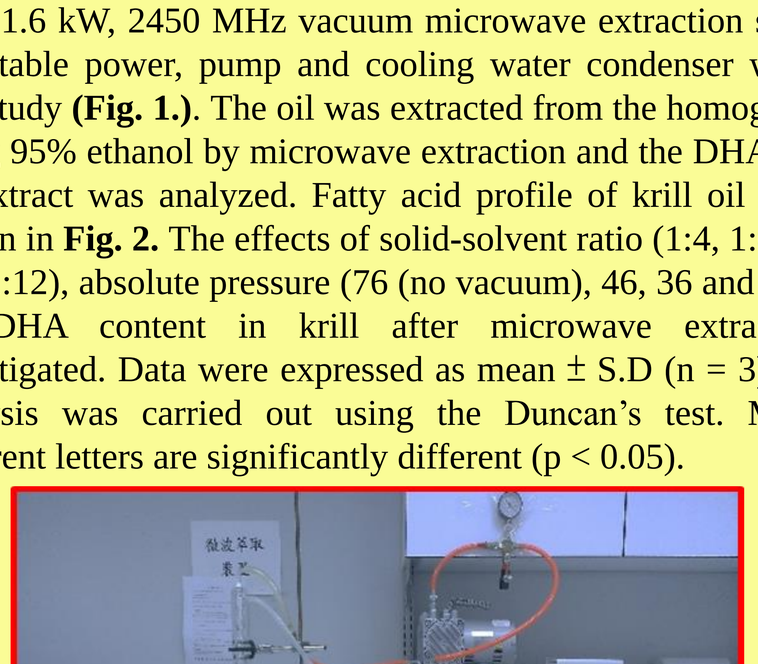

Fig. 2. Fatty acid profile of krill oil by GC.

RESULTS AND DISCUSSION

DHA extraction efficiency increases (8.14-11.68 (mg/g D.B.)) with increasing solid-liquid ratio (1:4 - 1:12 (g/mL)). However, in order to reduce the waste of solvent, using a solid: liquid ratio of 1:8 as follow-up study (**Fig. 3.**). The absolute pressure set as 76, 46, 36 and 26 cm Hg which the boiling temperature of the solvent were approximately 71, 59, 52 and 46℃ **(Fig. 4.)**. DHA extraction efficiency significantly decline in extraction time (0-20 (min)). It's presumably due to be accelerated oxidation by high temperature during MAE process**.(Fig. 5.)** Furthermore, under the same conditions (solid-liquid ratio of 1:8, microwave power of 300W was extracted 20 min), vacuum system significantly increased the extraction efficiency of DHA (6.65-11.41 (mg/g D.B.)) **(Fig. 6.)**. It's confirmed that the vacuum system can protect DHA against the damage of high temperature and oxidation during MAE process and enhance its extraction efficiency..

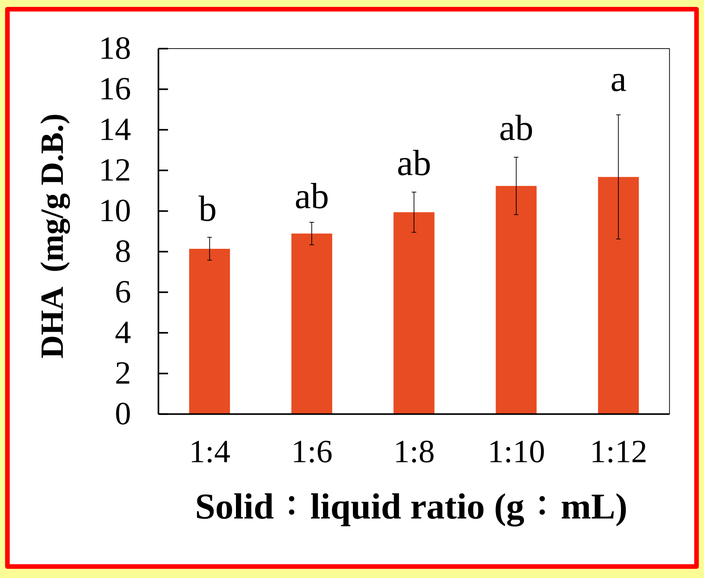

Fig. 3. Effect of solid : liquid ratio on extraction efficiency of DHA from fresh by 300W microwave extraction with ethanol at 1 atm after 5 min.

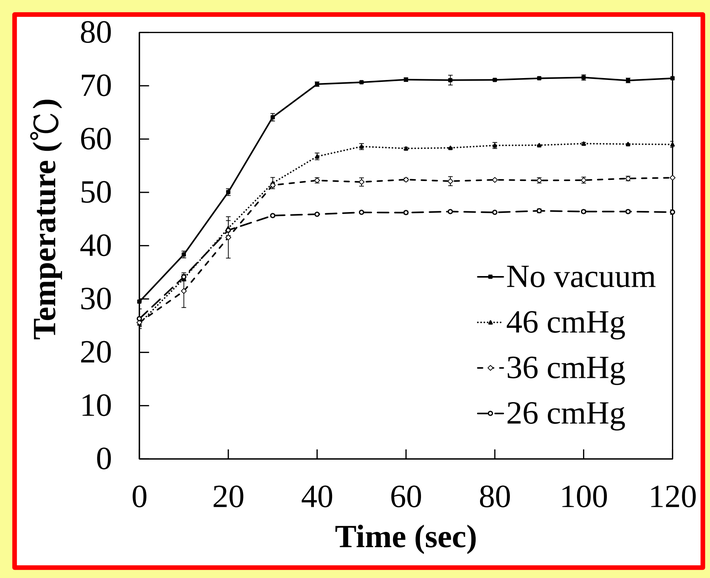

Fig. 4. Temperature-time history of fresh krill-ethanol mixture (6.25g : 50mL) during 300W microwave extraction by different vacuum condition.

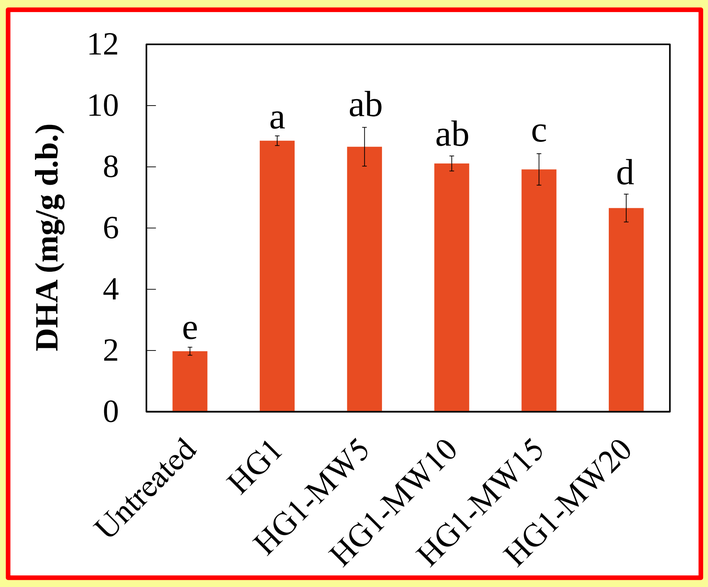

Fig. 5. Effect of different treatment on extraction efficiency of DHA form fresh krill-ethanol mixture (6.25g : 50mL). (HG1: homogenization 1 min, MW5-20: microwave 5-20 min.)

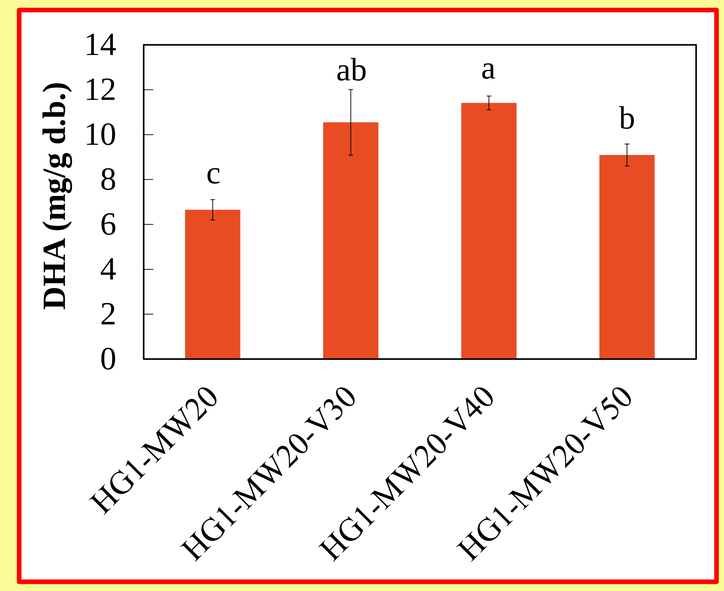

Fig. 6. Effect of vacuum condition on extraction efficiency of DHA from fresh krill-ethanol mixture (6.25g : 50mL) by microwave extraction. (HG1: homogenization 1 min, MW20: microwave 20 min，V30-50: vacuum gauge pressure 30-50 cmHg.)

CONCLUSIONS

Microwave vacuum extraction can protect DHA against the damage of high temperature and oxidation during the extraction process and enhance DHA extraction efficiency from krill.