A review of compositions & toxic elements present in fish oil (Extraction SFE)

Jamana K. Khandagale, Vidya Pradhan

Dr. Rafiq Zakaria College for Women Navkhanda, Jublee Park,
Aurangabad, Maharashtra, India.

***Abstract*: Fish oil is one of the most valuable marine products that has been used unrefined for animal feed, poultry and aquaculture and can be used by humans due to the existence of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). In this study, oil extraction was investigated by the supercritical fluid (SFE) method. The technique has been widely used to extract oil from fish meat and treat waste. This study aims to optimize the operating conditions for the extraction of supercritical fluids (SFEs) of toxic elements from fish oil. The SFE operating parameters of pressure, temperature, CO2 flow rate and extraction time were optimized using a central composite (CCD) design of the response surface methodology (RSM). The high coefficients of determination (R2) (0.897–0.988) for the predicted response surface models confirmed a satisfactory fit of the polynomial regression models with the operating conditions. These optimized SFE conditions enabled the production of fish oil with reduced lead, cadmium, arsenic and mercury contents by 98.3%, 96.1%, 94.9% and 93.7% respectively. The fish oil extracted under the optimized operating conditions of SFE was of good quality in terms of fatty acid components.**

***Keywords*: Supercritical fluid extraction, Fish oil, Toxic elements, Fish oil composition.**

Introduction:

The food industry continually researches the best separation technologies to obtain healthy products of excellent quality from natural compounds of high purity. Conventional extraction methods often have some limitations with regards to toxicity, flammability and waste of solvents. Supercritical fluid extraction (SFE), a relatively new extraction technique that is selectively used to extract specific components, has aroused great interest in many industries (Raventos et al. 2002). Supercritical fluid technology is considered an ideal extraction process due to its non-flammable, non-toxic, non-polluting and recoverable characteristics. SFE is also known for its extraction speed, residue-free extract, selectivity for specific compounds, economy and ability to produce high quality, high purity products (Ashraf-Khorassani et al. 1997). SFE is a separation process in which substances dissolve in a fluid that exhibits modified solvation capacities under specific conditions above their critical temperature and pressure, called the supercritical region. The properties of a supercritical fluid are used selectively to extract a specific compound by changing temperature and pressure without any phase change (Erkey 2000). SFE applications in the food industries include tea decaffeination, herbal flavor extraction, fat and oil extraction, cholesterol extraction, fat and oil fractionation, de-alcoholization of alcoholic beverages, l 'extraction of flavorings in juices (Ollanketo et al. 2001), extraction of dyes, refining of fats and oils, extraction of antioxidants and deacidification of oil (Dunford & King 2000). A supercritical fluid has physico-chemical properties between those of a gas and a liquid and has the ability to dissolve compounds that dissolve little or no at all in the gaseous or liquid state. Carbon dioxide (CO2) has become the ideal supercritical fluid in the food industry due to its critical temperature, pressure and density (Brunner 2010). CO2 has many advantages over conventional organic solvents and is therefore used in food processing to achieve excellent extraction and an optimal final product (Raventos et al. 2002). Fish waste is generally used for the production of fish oil and fish meal. The levels of environmental contamination, especially of toxic elements, in fish discards can be worrying when compared with the limits established by the regulations, especially if the product has a high fat content (Antelo et al. 2012). Therefore, purification steps may be required before consumption. The World Organization of EPA and DHA (GOED 2012) has recommended the accepted maximum limit of 0.1 μg g - 1 of the toxic elements (mercury, arsenic, cadmium and lead) in fish oil for human consumption. According to GOED, the permissible daily exposure to toxic elements is 1 μg per day - 1 per 50 kg of body weight. Several technologies are used to make fish oil from waste and some are not effective in removing toxic elements. Therefore, considerable levels of toxic elements have been reported in commercial fish oils used for human consumption (Lunde 1968; Kołakowska et al. 2002; Foran et al. 2003; Schmeisser et al. 2005). SFE, a process used to extract and refine edible oils and fats, has been studied for the reduction of certain types of contaminants in fish oil during extraction. It has been reported as an effective method for reducing PCBs, PCDD / Fs, dioxins and dibenzofurans in fish oil (Maes et al. 2005; Kawashima et al. 2009). However, this technique has rarely been studied for the removal of toxic elements from fish oil. In our previous study, fish oil extracted from mackerel using SFE contained lower levels of lead, cadmium, mercury and arsenic than conventional extraction methods (unpublished data). In this study, the operating conditions of the SFE were optimized in order to minimize the levels of toxic elements in fish oil extracted from fish waste.

Methods:

Using combinations of keywords such as “Supercritical fluids extraction” “Fish oil” “Toxic elements” and “Fish oil composition” etc. a search was performed on different search engines for articles on the topic related to SFE. The search was limited to English language articles published previously resulting abstracts were reviewed and articles were excluded if the focus was not on the present topic in hand. Articles representing a developing body of literature were limited to the most recent date.

Types of Techniques:

Soxhlet extraction

Soxhlet extraction is a simple and effective method. It is used for a variety of samples such as soil, frogs, and animal and plant tissues. A variety of solutions such as dichloromethane (DCM), pure or mixed with acetone or hexane, and acetone-hexane mixtures can be used. It is not recommended to use only non-polar solvents. The minimum required time for a typical Soxhlet release is usually ~8 hours. The sulfur present in the sample and in the soil is also removed, and should be removed by a later cleaning step. There was no significant difference between the release of the Soxhlet method and SFE in terms of oil production. Sahena et al. (2010).

Supercritical CO_2 Extraction:

Supercritical carbon dioxide extraction is a commonly used method to separate various components from the plant due to it producing a pure, clean, and safe product. Carbon dioxide reaches a supercritical state at 1071 psi and 31.1°C. When a molecule is in a supercritical state, it has properties of both liquid and gas.

Supercritical Fluid Extraction (SFE)

Sweet liquid extraction is similar to any other extraction process; the only difference here is the use of solvents as solvents for extraction purposes. Sensitive liquids (SCF) are those solvents containing solvents such as liquids and gases where temperature and pressure are above the critical point (See et al., 2017). The low viscosity combined with the high dispersion facilitates the rapid dispersal of the solvent in the matrix and thus facilitates the extraction process. Among the various SCFs present in extraction, carbon dioxide (SC-CO2) is the most widely used solvent (Duarte et al., 2014).

Result:

A total of 244 articles were retrieved through various search engines such as Science Direct, Google Scholar, Springer and Elsevier. We found 112 article titles that match the aspects of our study. Abstracts of 50 were reviewed 38 of which were selected and reviewed here.

Discussion:

SFE-prepared fish oil contains traces of toxic nutrients. The levels of these toxins in fish oil extracted in the form of Soxhlet were higher than those of raw materials. Our previous study also showed that extraction of fish oil using other conventional methods, such as enzymatic extraction and dehydration, can lead to the accumulation of substances in the oil components during extraction (unpublished data). High levels of toxic substances have been reported in fish oil supplements. (Schmeisser et al. 2005) reported arsenic levels of 4.3 to 10.5 µg g-1 in fish oil. (Kolakowska et al. 2002) and (Lunde et al. 1968) identified 6.6 and 3.9 µg g-1 arsenic in cod liver oil, respectively. Mercury concentrations of 6 to 12 lg l - 1 have been reported in various fish oil products (Foran et al. 2003). The levels of toxic substances in fish oil extracted using the prepared method used in this study were significantly lower ($p < 0.05$) lower than those obtained in our previous study using various SFE operating conditions (unpublished data). This can be caused by the performance effects of SFE, especially pressure and temperature. The pressure, temperature and flow rate of CO2 used in the current study were higher than those used in the previous study.

The SFE has effectively implemented the proposed operating conditions to reduce toxic substances and effectively remove more than 94% of toxic substances from fish oil extracted. Pressure and temperature were identified as the most efficient parameters that can be considered as the main parameters of fish oil reduction in toxic substances. However, using very high CO2 pressure and long extraction times is not money. Fish oil extracted under appropriate SFE operating conditions was high in terms of fatty acids. The levels of toxic substances in the fish oil produced were significantly below the safe limits, making them safer to use.

Conclusion:

This study shows that by using deep liquid extracts we can not only get fish oil, but we can also increase the toxic substances in fish oil. The results showed that extraction processes not only affect oil production but also oil indicators in terms of oil quality, vitamins, fatty acid content, flexible compounds and nerve structures. The SFE-prepared fish oil contains traces of toxic elements such as lead, cadmium, arsenic and mercury which have been reduced by 98.3%, 96.1%, 94.9% and 93.7% respectively. These SFE-prepared conditions have been able to produce fish oil through this content.

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