



# Solar Energy-assisted Extraction of Carp Fish Viscera Oil: New Sustainable Waste Valorization Platform

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## Abstract

**Purpose** This study aimed to investigate the application of solar energy-based (SE) technology in extracting oil from common carp (*Cyprinus carpio* L.) viscera as a fish processing waste, optimize this valorization process, and analyze the extracted oil.

**Methods** SE oils' physicochemical properties were analyzed and compared with conventional extraction (CE) oil. Also, an L-optimal response surface method (RSM) was used to optimize the process. Responses from daylight hours (independent factor) were the radiation intensity, ambient and viscera temperature, and heating efficiency. Besides, process waste was analyzed by scanning electron microscopy (SEM) to elaborate on extraction mechanisms.

**Results** A new SE system was developed and valorized viscera to fish oil. This system was equipped with a perforated black cloth to protect extracted oil from the adverse effects of sun rays and impurities. The sunlight was absorbed, converted to thermal energy, and heated the waste through the conductive mode of heat transfer. Finally, oil and water were separated according to the relative density. The optimal system performance was achieved at a radiation intensity of 1100.2 W/m<sup>2</sup>, resulting in viscera temperature and heating efficiency of 81.2 °C and 63.5%, respectively. The SE oil yield was 18.4% higher than CE. Also, SE oil had lower peroxide value, free fatty acid (FA), and thiobarbituric acid than CE by 40.9, 43.8, and 27.1%, respectively. The color of SE oil was more reddish (a\*) and intense but less yellowish (b\*) than CE. The half-life of SE oil was higher than CE (100 vs. 91 days). Besides, SE oil was rich in valuable unsaturated FA, including octadecenoic (35.1%), hexadecanoic (18.8%), and octadecadienoic acid (9.9%).

**Conclusion** The fish viscera waste was valorized to a valuable oil enriched in unsaturated health-promoting omega-3 and -6 FA. The proposed process is based on clean energy technology and can reduce energy consumption, and production costs, contributing to zero waste and sustainable development goals (SDGs).

**Keywords** Food waste · Emerging technologies · Fish oil · Extraction · Solar energy · Sustainable process · Energy consumption

## Statement of Novelty

This work's novelty includes developing and applying a new straightforward solar oil extractor for fish viscera as a food waste. This valorization system is hazardous chemical-free and could simultaneously extract oil from fish viscera,

separating the oil and water from the process by-products. This manuscript is the first report on extracting oil from fish viscera (waste) using solar energy as a clean energy technology.

## Introduction

Million metric tons of fish waste, including viscera, is generated annually by the fish processing industry, which may threaten the environment if not well-managed [1, 2]. However, this processing by-product contains valuable components such as nutritional fatty acids [3]. Fish oils contain health-promoting fatty acids (FA), such as eicosatetraenoic (EPA) and docosahexaenoic (DHA). EPA and

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