Austin Food Sciences

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Review Article

Utilization of Seafood Industry Waste for Biodiesel

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Received: May 25, 2020; **Accepted:** June 15, 2020; **Published:** June 22, 2020

Introduction

Fish and fish products have a crucial role in nutrition and global food security, as they represent a valuable source of nutrients and micronutrients of fundamental importance for diversified and healthy diets. Fish contains several amino acids essential for human health, such as lysine and methionine. Many fish (especially fatty fish) are a source of long-chain omega-3 fatty acids. Fish also provides essential minerals such as calcium, phosphorus, zinc, iron, selenium and iodine as well as vitamins A, D and B.Fish by-products can serve a wide range of purposes. The fish heads, fillet cut-offs and skin can be used directly as food or processed into fish sausages, cakes, nuggets, biscuits, gelatin, sauces and other products for human consumption. The seafood's by-products are also used in the production of feed, fishmeal and fish oil, biodiesel and biogas, chitosan, pharmaceuticals (including oils), natural pigments, cosmetics and constituents in other industrial processes. Some by-products of fish like viscera and frames are a source of potential value-added products such as bioactive peptides for use in food supplements and in biomedical and nutraceutical industries. Shark by-products like cartilage, but also ovaries, brain, skin and stomach are used in many pharmaceutical preparations and reduced to powder, creams and capsules. Fish collagens are used in cosmetics and in extraction of gelatin, FAO, 2018).

The internal organs of fish are an excellent source of specialized enzymes. A range of proteolytic fish enzymes are extracted, e.g. pepsin, trypsin, chymotrypsin, collagenases and lipases. Protease, for example, is a digestive enzyme used in the manufacture of cleaning products, in food processing and in biological research. Fish bones, in addition to being a source of collagen and gelatin, are also an excellent source of calcium and other minerals such as phosphorus, which can be used in food, feed or food supplements. Calcium phosphates present in fish bone, such as hydroxyapatite, can help hasten bone repair after major trauma or surgery. Fish skin, in particular from larger fish, provides gelatin as well as leather for use in clothing, shoes, handbags, wallets, belts and other items.

Raw material for production of biodiesel

Biodiesel extractedfrom byproducts of seafood's wastes like non targets fish spp, skin, bones, heads, muscles, bloods, and visceral parts of body organ like spleen, liver, pancreas, gonads, intestine, stomach, fish tails from seafood's industrial wastages from salmon, cod, herring, anchovy, tilapia, oil sardine, mackerel, tuna, dolphin fish and any variety of medium and fatty fish species. These by-products are predominantly composed of the heads, viscera, skin, scales, and bone. In the past, these non-edibles seafood (by-products and discards) are considered as unusable material and used as animal feed, fertilizers or just discarded in the environment, resulting in environmental problems and waste of valuable compounds. Recently, utilisation of seafood by-products are important source of valuable compounds such as protein, chitin, collagen, fatty acids, peptides, carotenoids, and minerals that can be extracted and reused as nutraceutical ingredients or additives in food, pharmaceutical, and cosmetic industries. Moreover, they are a promising source for biofuel production .

Process of production of biodiesel

The biodiesel fuel are produced from the transesterification of recycled waste oil of fish with methanol (CH_3OH) catalyzed by sodium hydroxide (NaOH). The fish processing industry generates large quantities of fish waste which tend to be either discarded or given at low value for fertilizer or animal feed. However, continuous efforts are being made in many countries to utilize fish processing waste into high value products which sometimes will be fetching better value compared to meat itself. Another way to utilize from these by products is to transesterify the fish oils extracted from fish waste for the purpose of production of biodiesel. Fish oil biodiesel contains saturated free fatty acids, unsaturated free fatty acids and long carbon-chain fatty acids. The Oleic acid ($C_{18:1}$), palmitic acid ($C_{16:0}$) and docosahexa-enoic acid ($C_{22:6}$) are the three major components of the anchovy fish oil biodiesel [1]. Biodiesel is comprised of monoalkyl esters of vegetable oils, animal fats or fish oils which can be synthesized from edible, non-edible and waste oils. Biodiesel can be produced chemically or enzymatically. Currently, the biodiesel production on an industrial scale is being carried out chemically, using alkali (NaOH) as catalyst due to high conversion ratio of Triglycerols (TAG) to methyl esters (biodiesel) and low reaction times (4-10 h).

Biodiesel (fatty acid alkyl esters) is a renewable and environmentally friendly energy source. The most commonly used technique to produce biodiesel from fats is transesterification, in which triglycerides are reacted with alcohol, usually methanol, in the presence of a catalyst, usually potassium or sodium hydroxide (KOH or NaOH), to produce mono alkyl esters. The recent trends in biodieselare produce from fatty sources vegetal or animal [4].

Process of production of biodiesel from salmon

Biodiesel are produced by transesterification reaction can be catalyzed with alkali, acid, or enzyme, in which a primary alcohol reacts with the triglycerides of fatty acids form glycerol and esters. Triglyceride for biodiesel production comes from various sources

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Citation: Verma SK, Elavarasan K, Remya S, Mohan CO, Ashok Kumar K and Ravishankar CN. Utilization of Seafood Industry Waste for Biodiesel. Austin Food Sci. 2020; 5(1): 1038.

Table 1: The utilization of fish by-products from seafood's [8].

By products	Valuable components	Utilized as
Heads	Proteins, Peptides, Lipids, Collagen, Gelatine, Minerals Including Calcium, Flavour	Food, Fish Meal, Fish Oil, Food Grade Hydrolysates, Animal Grade Hydrolysates, Pet Food, Nutraceuticals, Cosmetics
Frames (Bones, Flesh, Fins)	Proteins, Peptides, Lipids, Collagen,Gelatine, Minerals Including Calcium, Flavour	Food, Fish Meal, Fish Oil, Food Grade Hydrolysates, Animal Grade Hydrolysates, Pet Food, (Bones, Flesh, Fins) Nutraceuticals, Cosmetics
Trimmins	Proteins, Peptides, Lipids	Food, Fish Meal, Fish Oil, Food Grade Hydrolysates, Animal Grade Hydrolysates, Pet Food
Viscera	Proteins, Peptides, Lipids, Enzymes Such As Lipase	Food Grade Hydrolysates, Animal Grade Hydrolysates, Fish Meal, Fish Oil, Fuel, Fertilisers
Skin (With Belly Flap)	Collagen, Gelatine, Lipids, Proteins, Peptides, Minerals, Flavor	Fish Meal, Fish Oil, Cosmetics, Food, Fish Meal, Nutraceuticals, Cosmetics, Leather, Fuel, Fertilisers
Blood	Proteins, Peptides, Lipids, Thrombin & Fibrin	Fuel, Fertiliser, Therapeutants
Mortalities	Proteins, Peptides, Lipids, Collagen, Gelatine, Calcium And Other Minerals, Flavour	Animal Feed (Fur Animals), Zoo Animal Feed, Fuel, Fertilisers

edible and nonedible oil, waste and used oil, and fats [2].

To produce biodiesel from salmon oil extracted from salmon processing wastes, the biodiesel yield and the behaviour of salmon oil during transesterification reactions. Biodiesel (fatty-acid alkyl esters) is a renewable and environmentally friendly energy source. It can be produced from animal fats and plant oils. Several techniques are available for biodiesel production. The most commonly used technique is transesterification in which triglycerides are reacted with alcohol, usually methanol, in the presence of a catalyst, commonly potassium or sodium hydroxide (KOH or NaOH), to produce mono alkyl esters. Several factors affect the biodiesel yield and process economics. The most important factors are alcohol type, alcohol/oil molar ratio, reaction temperature and time, catalyst type and amount and water content of the reactants [7].

Salmon oil are separated by centrifugation of acidified salmon hydrolysate for 20min at 7000 rpm, with a relative centrifugal field of 7970g. The second methods of the oil separated directly after grinding of fresh salmon processing by-products. One-step process: - In this process used sulphuric acid as catalysed for pretreatment. The alkaline-catalysedtransesterification process used for biodiesel production from salmon oils, which is extracted from fresh salmon by-products by acidified salmon hydrolysate process [6]. Two-step process: - Salmon oil, a by-product of salmon processing, was used as a feedstock for biodiesel production via transesterification process, in this process applied KOH as catalysedtransesterification.

The methyl esters produced from salmon oils, which is separated from fish processing by-products and hydrolysate and their derived methyle esters. Salmon oil methyl esters contained relatively high concentrations of eicosapentaenoic acid ($C_{20:5}$) and docosahexaenoic ($C_{22:6}$) acid methyl esters [3].

Biodiesel production from Indian oil sardine

Indian oil sardine (Sardinella longiceps) of the family Clupeidae is found very abundantly in the West coast of India. It forms one of the major fishery contributing 15 – 20% to the total marine landings of India. Indian oil sardine is categorised as fatty fish species and is one of the mainstay for meeting the nutritional requirement of coastal population in western coast of India. However during the times of glut, it is being commonly used for the production of fishmeal and fish oil production. Indian oil sardine, being rich in fat content is one of the best candidate species for biodiesel production. The reports suggest a transesterification using KOH at 1500C at atmospheric pressure was found optimal [10]. The optimal yield of 96.57% biodiesel were obtained using 1.25% KOH, 20% methanol with reaction time of 25 min [10]. Although Indian oil sardine yields better quality biodiesel, it is not advisable to use this fish for the production of biodiesel as it forms a major source of protein, essential fatty acid and other vital nutrient supplier. Improved efforts are needed to collect the waste from all the segments including industry, retail shops, markets and households for the production of biodiesel from Indian oil sardine.

Process of production of biodiesel from shrimp

Shrimp shell mainly comprises chitin, crude protein, fat, ash, fiber, calcium salt, and phosphate. The shrimp shell has dry basis 69%. Chitin. Chitin has random network structure in the shrimp shell, grows in parallel with surface layer of shrimp shell; protein, which regards chitin as skeleton, grows along shrimp shell layer in flake; inorganic salt, which presents honeycomb porous crystal structure, fills in the interspaces between the chitin layer and the protein layer [5].

Raw material

The seafood's industries produce lot of crustacean shell waste from shrimp, crabs. Thesewaste materials are utilized for extraction of chitin, chitosan, glucosamine and also used to production of biodiesel. The shrimp shell are used to preparation of biodiesel by catalyst process (heterogeneous base).

Process

The shrimp shell are used to preparation of biodiesel by catalyst process (heterogeneous base). The preparation process of shrimp shell catalyst are simple and environmentally friendly. Shrimp shell catalyst exhibited relatively high catalytic activity, good thermal and chemical stability, and interesting base catalytic property. The transesterification process are involved shrimp shell catalyst lead to minimum pollution and wastes, and the catalyst itself are environmentally benign. The catalytic activity dependence on such as carbonization temperature, loading amount of KF, and activation temperature during the biodiesel production process. Generally optimum catalyst preparation conditions are carbonization at 450°C, loading KF of 25 wt %, and activation at 250°C. Which exhibited the best catalytic activity for the transesterification. The catalytic performance are evaluated by the transesterification of rapeseed oil with methanol [9].

Advantages of biodiesel

Biodiesel offers wide range of applications starting from its biodegradable nature which does not harm the environment. It is nontoxic and most importantly it is renewable in nature. Environmental friendly nature of this biodiesel will help in restoring the earth's natural environment by avoiding petroleum based diesel. However, the very high cost of production is the major disadvantage for its effective use (Table 1).

Acknowledgement

Authors would like to thank Director, ICAR-CIFT, Cochin for permitting to publish this article.

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