Research progress on utilization of used catering oil resources

Ziyang He[1] , Min Wang[1] , Peng Wu[1*], Weiwen Su[2*]

[1]Department of Food Science, Shandong Agricultural University, Taian City, China

[2]Department of Molecular Biosciences and Bioengineering, University of Hawai'I Manoa, Hawaii, United States.

Abstract

Used catering oil has raised serious environmental and food safety concerns, but it is also a good resource raw material. With effective recycle/reuse one can effectively solve the problems of food safety, used oil pollution while simultaneously generate useful products. From the perspective of resource recycling and environmental protection of catering used oil, this paper summarizes the current status and main forms of utilization of catering used oil resources in representative countries, analyzes their existing problems and solutions, and looks forward to the research directions and development trends of their increasing utilization.

Keywords: Used catering oil, Bioresource utilization, Recycle, Waste utilization.

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Introduction

Used catering oil, commonly called 'UCO' or 'WCO' (Used catering oil) refers to the oil generated daily by food industries, restaurants, and households which has been discarded and has no direct consumption value [1]. It contains a large amount of heavy metals and bacterial viruses, and if handled in an inappropriate manner, it will cause a series of hazards such as numerous ecological, environmental and municipal problems. UCO accounted for a larger proportion in the kitchen waste, and China's kitchen waste accounted for up to 30% to 50% of the proportion in the household waste. Most wasted food includes 33% fats and oils estimated by the US Department of Agriculture [2]. The oil content of kitchen waste is high, some parts of China compared with some European countries are particularly prominent (Figure 1), if properly recovered, will obviously saving resource, bring economic profit and relieve environmental pressure.

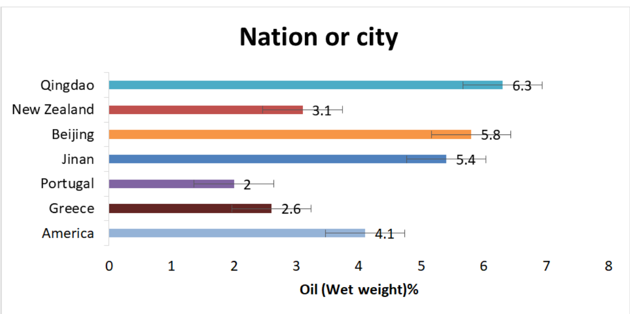

Figure 1. *Oil content of kitchen waste in parts of China and Europe.*

A National Renewable Energy Laboratory study of 30 metropolitan areas showed that about 2.7 billion pounds of UCO are generated per year [3]. 168.85 vegetable oil million metric tons were produced globally in the end of 2013-2014 seasons according to the United States Department of Agriculture. Consumption of deep frying vegetable oils is also high. It is estimated that in Europe totaling 2.5 million metric tons of UCO are generated per year [4]. About 20 million tons UCO produced in China's catering industry every year in 2019 [5].

Necessity for the Collection and Recovery of UCO

UCO is not feasible for food; it not only has changes in physical appearance but also causes a series of chemical reactions such as oxidation, hydrolysis and polymerization. [6]. during cooking process, many oxidative products such as hydroperoxide and aldehydes are produced. UCO could severely compromise one's antioxidant defense network, leading to pathologies such as hypertension, diabetes and vascular inflammation because it accelerates oxidative degradation of lipids, forming hazardous reactive oxygen species and depleting the natural antioxidant [7]. UCO will occur a series of chemical reactions such as acid failure, oxidation, and decomposition and produce toxic substances in the contaminated environment. One of its harmful substances – arsenic, if it ingested into the human body, there will be poor digestion, dizziness, headache, insomnia and other symptoms. Another harmful substance-lead poisoning will case anemia, severe abdominal pain, toxic liver and other symptoms of the disease. UCO contains aflatoxins and benzodiazepines, which may lead to stomach cancer, bowel cancer, kidney cancer and other diseases [8]. UCO produce a series of environmental effects include: clog the sewage pipelines, causing malfunctions in the wastewater treatment facilities [9] Suffocation of animals and plants due to their food source micro-organisms, phytoplankton, and algae which coated with UCO; The death of aquatic plants and animals as a result of reduction in dissolved oxygen content; Rancid odor production; Proliferation of rats and vermin which feed on UCO then creates a pest control problem or health hazard [10].

UCO can potentially contaminate a million liters of fresh water. The kitchen waste contains a large amount of oil, which easily forms foam and slag layer on the surface of the material, hinders the overflow of biogas, reduces the amount of methane gas that can be collected and utilized in fermentation liquid, results in the loss of anaerobic microorganisms in anaerobic system.

Oil slick, dispersed oil, emulsified oil, dissolved oil, solid phase internal oil are the main forms of UCO, of which, oil slick is an important index to measure the oil-raising characteristics of kitchen waste. [11]. However, in the original kitchen waste, oil slick content is very low. Before the oil lifting form kitchen waste, wet heat with pretreatment are needed to enhance the diffusion of moisture and grease performance, damage the structure of cells, release the intracellular grease and leach the solid internal grease, so it is important to improve the recovery rate (Table 1).

Table 1. *Summary of UCO generation in a year estimates by country/region.*

Country/ region	Estimate	Date	UCO collection source	Reference source
UK	250 million liters	2011	All	(Spöttle et al., 2013)
EU	972,000 tones	2013	Gastronomy sector	(Spöttle et al., 2013)
USA	885,000 tones	2012	Gastronomy sector	(Swisher, 2009)
China	6.5 million tones	2013	households and food	(Spöttle et al., 2013)
Malaysia	50,000 tons	2006	processing industry	(Kheang et al., 2006)
Spain	5.66 kg per capita	2017	Gastronomy sector	(Lombardi et al., 2018)
Italy	5.52 kg per capita	2017	Gastronomy sector	(Lombardi et al., 2018)
Greece	5.32 kg per capita	2017	Gastronomy sector	(Lombardi et al., 2018)
Indonesia	646,800t	2012	Gastronomy sector	(Spöttle et al., 2013)
Argentina	20,100	2012	Gastronomy sector	(Spöttle et al., 2013)
Colombia	225000 t	2018	All	(Rincón et al., 2019a)

Recycling of UCO can make it turn into a favorable resource, which not only will eliminate its potential harm to food safety and environment, but also will supplement the oil consumption, so as to achieve a unity of economic, social and environmental benefits. Today, non-renewable resources are about to be exhausted, all countries in the world without exception will face the pressure brought from environmental pollution and fossil energy depletion. It is the general trend to change waste into treasure, give full play to the role of renewable energy to reduce the consumption of fossil energy. How to make use of UCO has become a widely concerned issue of governments.

Collection and Recovery of UCO

Methods for collecting and extracting UCO in various countries

The collection and extraction methods of UCO vary from country to country. The United States has a special collection of high-oil kitchen waste in the fully enclosed garbage cans, not allowed to be crushed in the food residue shredder crushing for general kitchen waste. It should be recovered by special personnel. New Zealand also has a special response in recycling of UCO, clearly defined it, do not allow UCO directly dumped and discarded privately, but should be stored in a separate container waiting for collection by specially designated companies. Germans must purchase equipment for oil and water separation designed according to the strictest European oil separation standards, and the separated oil is recycled by a government-approved company. Countries such as Canada and the United Kingdom have special used oil bins or used oil collection wells, which are collected by companies designated by the government to recycle UCO [12].

UCO Processing Devices

In order to make full use of the UCO, some processing devices came into being, their composition and efficacy are as follows (Table 2).

Table 2. *The composition and efficacy of some processing devices.*

Name	Composition	Efficacy	Reference source
A UCO separation barrel	Consisting of a box, a lid, a waste liquid barrel, a flow pipe and a collection tank.	Can be used for the food UCO slag classification and collection.	(Lee et al., 2011)
An environmental engineering UCO recovery treatment device with deodorization equipment	Consisting of deodorizing equipment and other separation equipment parts.	Can clean up solid kitchen waste and remove odors while separating and recycling UCO, the operation process is convenient and clean.	(Cheng et al., 1994)
A highly automated belt UCO extraction equipment	Consisting of oil, water, slag three separate areas of clear function	UCO can be collected automatically and equipment is easy to be installed and operated.	(Lowe, 1981)
A kind of microwave installation	Consisting of a cylindrical shield with a cover, inclined base and nipple for liq.	Invented for the extraction of melted fat from fat-containing animal.	(Lam et al., 2019)
A separation device	Consisting of a tank with at least two chambers located one after the other	Can be used for water and UCO separation and cleaning of tableware without food residue.	(Cooper et al., 1976)

	separated by a separation wall.		

These devices can easily separate UCO and play an extraordinary role in environmental protection and food safety.

Main Uses of UCO

Currently, UCO is used most commonly as feedstock for biofuels. Other applications, though not as common, have also been proposed and practiced. These applications are reviewed in this section.

The main use forms of UCO can be listed as follows:

UCO as a feedstock for renewable fuels

The idea of using UCO as an alternative source of fatty materials for the production of biofuels was originated in the 1980's [13] then it is increasingly being carried out to produce fuel [14].Biodiesel, also known as "sun fuel", is a renewable biomass fuel that is not only friendly to environment, but can also be applied directly to existing diesel engines, making it an ideal alternative to fossil fuels. UCO transformation to biodiesel can have significant advantages in energy, environment, safety and positive effect on employment [15].

From the experience of some countries, UCO can be used as raw materials to produce other useful products, such as a variety of energy-saving materials and chemical products; it can also be refined into biodiesel fuel and aviation fuel.

Japan has re-resourced the UCO for the production of methyl ester biodiesel for garbage trucks and buses. In October 2018, Japan's Euglena Corporation completed Japan's first demonstration plant for the production of renewable aviation coal and diesel fuel in Yokohama, using heterogeneous conversion process of biofuels to create innovative and renewable diesel fuel from UCO [16-18].

Almost all of the UAE's UCO is used to produce biodiesel, which is in full compliance with international standards, and burns less carbon dioxide than conventional diesel after combustion. The biodiesel adapts to a wide range and available for any type of engine; Special chemicals extracted from recycled UCO for the production of biodiesel, functional chemicals, organic fertilizers and other products in Germany. The deoxygenating UCO could be refined into a "hydrogenated renewable flight fuel by Royal Dutch Airlines". The United States makes UCO into a liquid polymer, which is applied to the roof as an energy-saving coating to regulate the heat absorption, it keep cool in the summer room and keep warm in the winter room, reduce the use of air conditioners and fireplaces, achieving the effect of reducing emissions [19].

Biodiesel preparation by hydrogenation and catalytic cracking technology

At present, the process of hydrogenation and catalytic cracking technology is still in the industrial trial stage. It is used to produce biodiesel, and the ratio of carbonization temperature in the solid catalyst and the treatment process can be improved to improve the flotation performance and determine the optimal ratio of biodiesel to ordinary diesel [20-22]. The preparation of novel catalysts and mixed fatty acids, and the relationship between the amounts of catalyst used, reaction time and temperature, are of great reference value for the production of biodiesel from UCO [23].

The biodiesel produced by catalytic cracking technology has good compatibility. It has the same chemical composition as petrochemical diesel, and its physical and chemical properties are closer or even better than petrochemical diesel. Compared with the hydrogenation process, the catalytic cracking of UCO to produce low-carbon olefins, gasoline, and diesel has a wider prospect. The UCO hydrogenation process is greatly affected by the water content and solid impurities in the raw material, the raw material pretreatment cost is relatively high, and a large amount of high-purity hydrogen is also required. The catalytic cracking process can make full use of existing refining units and save equipment investment and producing high-quality products to alleviate the pressure of gasoline and diesel demand is an effective resource utilization approach for UCO [24,25].

Transesterification to prepare biodiesel

The transesterification method is to use the catalyst to make the UCO and alcohols undergo a transesterification reaction. Acid, alkali or lipase can be used as catalysts to generate Monoalkyl esters of long-chain fatty acid, that is, biodiesel. Generally speaking, there are two processes for the production of biodiesel from UCO, it namely the "two-step method". One is to first reduce the acid value of the raw materials, and then use the transesterification method to prepare biodiesel. Then, the transesterification method is used to prepare biodiesel. Using UCO as a raw material, decolorization treatment is performed first, and then methanol and concentrated sulfuric acid are used as catalysts for transesterification reaction [26]. The biodiesel produced can be used as a slime flotation experiment. UCO plus ethanol, in a closed reactor using concentrated sulfuric acid and p-toluene sulfonic acid as catalysts, simultaneously transesterification and esterification to produce biodiesel, and acid-catalyzed one-step biodiesel technology for UCO. Other high acid value oils have good applicability and fully meet the biodiesel index requirements [27].

The transesterification method for producing biodiesel is highly adaptable and the reaction conditions are easy to implement, which is one of the methods with relatively significant economic advantages in the current UCO utilization schemes [28]. However, the process of transesterification is greatly affected by mass transfer and catalyst stability.

Enzyme-catalyzed method of biodiesel preparation

Among the various methods for preparing biodiesel, the enzyme-catalyzed method has the most development prospects due to mild reaction conditions, low waste liquid discharge, and low requirements for the quality of UCO. It has gradually received attention from researchers at home and abroad. However, the cost of enzyme catalysis is high, and the cost of enzymes, auxiliary additives and reaction raw materials is extremely high [27]. In order to solve the obstacle of high cost of enzyme catalysis, adopting immobilized enzymes, which can be used repeatedly, reduce the costs. Compared with traditional chemical methods, enzyme-catalyzed hydrolysis of UCO has gradually attracted people's attention due to the advantages of mild reaction conditions, few by-products, low energy consumption, and environment friendly [29]. However, because there are too few enzyme sources and harsh temperature requirements, most of them are still in the laboratory stage and there is basically no industrial application, but the development prospect is broad.

Production of 1 ton of biodiesel can produce approximately 100 kg of glycerin by side. Scientists found the refining method of UCO based biodiesel by-product glycerin by sodium oxalate complex separation, which shows that after deep processing, the by-product glycerin can be fully used for the production of cosmetics, chemical raw materials, chemical analysis and medical supply [30]. It can be seen that the production of biodiesel from UCO can not only turn harm into profit, but also replace fossil fuels to reduce waste, which is a good solution.

Production of Non-fuel Products from UCO

Detoxification/refining UCO

For non-fuel applications, especially for production of food/feed products, refining UCO with detoxification may be necessary. Some lipid peroxidation products, usually represented by malondialdehyde (MDA), should be removed since they are harmful to the feeding animals and in the end human beings [31]. Therefore, many methods have been developed to quantify MDA in different sample sources such as fried food, meat, organism tissues, and EOs [32]. The industrial procedure for UCO purification includes degumming, bleaching, and deodorizing processes, by which, most of the impurities in UCO can be removed to meet the standards for animal feed additives.

But the variability of composition and resulting properties is increased because of different vegetable oils, varying degrees of use such as temperature and time [33]. So in order to purify UCO, scientists use many adsorbent methods such as silica gel, magnesium oxide, aluminum hydroxide gel, activated clay and the powder of Salacia skin to improve the quality parameters of UCO [34].

Analysis of UCO using HPLC

Firstly, a simple and reliable HPLC method was developed to measure the content of MDA and other 2-thiobarbituric acid-reactive substances in purified UCO. Furthermore, the removal of harmful substances from UCO was investigated using three methods, i.e., water extraction, physical adsorption, and chemical adsorption. Results show that among the three methods, chemical adsorption is the most effective, which can remove 80% of main harmful substances from UCO. While other methods also be studied such as purified UCO was obtained by settle, mixed with aqueous saturated sodium chloride solution, boiling, separating, drying, dissolving in chloroform, filtering off and evaporating [13].

The general HPLC method normally utilizes derivatizing reagents, such as TBA and various hydrazine compounds, to enhance the sensitivity to detect MDA, a Vis/UV detector or a fluorometric detector is generally used. The advantage is simple and inexpensive and the disadvantage is not accurate, lack of sensitivity.

A rapid and convenient HPLC method without any pre-derivatization has been developed and successfully used for the determination of MDA in edible oils with disadvantage that the analysis process practically more complicated and also bringing new risk of the detection accuracy.

Biotransformation

Biotransformation technology has been investigated for many years because of its properties and potential applications in industrial and used oil treatment [10]. This kind of technology can be exploited to develop sustainable, “green” and eco-friendly processes that are demanded and imposed by society and drive the research of oleochemical industry [11].

UCO contains sufficient carbon sources for microbial fermentation, so it can be considered to be used for anaerobic fermentation, which has been confirmed by some research. A simple explanation of principle: UCO contains a lot of fatty acids. Lipase plays an important role in the process of grease hydrolysis. Many microorganisms have the ability to secrete lipases, such as bacteria, yeasts and fungi. For the decomposition of long-chain fatty acids, the main roles are two groups include sulfate reduction bacteria and symbiotic flora which produce methane and ethane bacteria.

As a resource insect, black soldier fly digest and decompose the organic components of kitchen waste through its own feeding behavior and digestive effect, transfer UCO into biological oil and protein, in the process of their own growth and development, which can be used to process the preparation of high value-added insect protein feed, substitutes for fishmeal and biodiesel in compound feed [35]. It is not only reduces the volume of kitchen waste and the amount of odorous gas escape but also avoids breeding of flies and eliminates bacteria [36]. The effects of different proportions of eggs added on the biotransformation process and fresh insect yield in the biotransformation technology of black otters were studied; the reduction level of the biological transformation technology of black otters on kitchen waste was explored [37]. The organic matter is biodegraded by aerobic microorganisms and stable high-fertility humus is obtained. On this basis, the organic matter in kitchen waste could be converted into nutrient by the physiological metabolism of radon [12]. Recently, scientists have developed an abandoned biological substance for recycling or producing of value-added products.

Yeast, fungi, bacteria and algae, and other microorganisms have been used for this purpose [38].

Animal feed

Traditionally, UCO was collected for animal feedstock as an additive, but it was ended after the introduction of animal by-product Regulation EC/1774/2002, which restricts the use of UCO in animal feed because it imparts an objectionable odor and decreases palatability of the feed, Additionally, inhibition of fiber digestion in rumen can occur when excess fat or oil exceeds 6% of the feed dry matter [39].

Functional chemicals

In addition to biodiesel, a variety of products with higher added value can be produced from UCO by a variety of processing methods.

Daily washing supplies

The main components of UCO are similar to those used to make washing soap, so it is possible to use the three glycerin has saponification reaction with alkali in UCO and obtain the product glycerin and washing soap. UCO saponification products, surfactants and phosphorus-free compound formulations have been used as raw materials to processed the phosphorus-free laundry powder successfully.

The main component of UCO is triglycerides, which were formerly natural animal or vegetable oils. As a kind of prepare important raw materials for chemical products, UCO can be used to produce many functional chemicals through direct esterification and saponification after decolorization, deodorization. There are an increasing number of studies focusing on the functional chemical products. A kind of very high purity refined glycerin with colorless and tasteless has been obtained using the method of sodium oxalate complex separation. The low-cost and highly decontamination force of soap, with simple operation and pollution-free characteristics, from the UCO has technical support by pre-treatment and citrus peel added [40]. A kind of laundry soap, which easy to be promoted in the market and accepted by consumer was invented through pretreatment, acidification, saponification and other steps from UCO [41]. Solid alcohol with a long burning time was invented through pre-treatment such as salt analysis, filtration, drying and other steps to obtain saponification, plus alcohol dissolved injection mold and cooled down [34]. These functional chemicals have a stable nature, good physical and chemical properties, which quality can be comparable to traditional functional chemicals; it is of great practical significance to the diversified use of UCO.

There is a Manufacturing method of industrial cleaning solutions UCO was patented [42] which make the solid soap from UCO by mixing fatty acids and potassium hydroxide to prepare base solution, then adding soap powder and a natural extractant.

Surfactants

Surfactants have functions such as foaming, thickening, decontamination, emulsion and rust protection, and are often used as thickeners, foaming agents or emulsifiers. The collected UCO sizzling in an alkaline environment by ester exchange reaction to obtain fatty acid methyl esters, or hydrolyzed in an acidic environment to produce fatty acids, both can be reacted with ethanolamine, the product acetamide, is an excellent surfactant. Compared to the use of ordinary natural oils, this preparation method significantly reduces the cost [13].

A study conclude that UCO could be a kind of biosurfactant which is capable of removing copper, lead, zinc, chromium, and cadmium respectively, from artificially contaminated water, highlighting its potential for bioremediation.

UCO has a potential impact on soft the asphalt binders and can be used to produce soft asphalt binders to reduce the pavement damage and increase the cost of road maintenance [43]. The blending of recycled asphalt with UCO has been shown to improve the performance qualities of the resulting blends. The potential for the reuse of UCO as an asphalt modifier capable of producing customized UCO modified asphaltic blends for special applications was highlighted (Potential of used frying oil in paving material: solution to environmental pollution problem).

UCO-based organic solvent is approved by scientists that it is a potential green and low-cost organic solvent for $Cu^{2}+$ ion extraction from aqueous solutions [44].

Lubricants

Lubricants are needed in many mechanical devices which effectively reduce wear. UCO can replace hard oil or sic acid glycerin in preparing lubricants, basic lubricants can be obtained through reasonable purification and ratio by application of certain molecular distillation technology.

Bioplastics are polymer has gained importance since it can be easily degrade in nature. UCO was found as a carbon source for synthesis of bioplastic in an economic process so it can be exploited as low-cost materials for bioplastics production [45].

Compound modifiers

Modified asphalt used of UCO and waste rubber powder can improve the performance of the original matrix asphalt, overcome the existence of single modified asphalt deficiencies, significantly improve the high temperature stability and low temperature anti-cracking. High-performance PVC plasticizer was prepared with UCO as the main raw material by commonly used chemical reactions such as ester exchange, epoxidation and ring opening [46].

The Application of UCO in Agriculture

A green low-toxic insect repellent can be obtained by the method: UCO pre-treat crude products, react with ethanol through continuous catalytic ester exchange reaction, let the fatty acid glycerides transfer into fatty acid ethyl, then mix with emulsifier and synergist stirred evenly to obtain a pesticide emulsion. Transfer UCO into biodiesel as raw materials, another part can continue to ferment into fuel ethanol and biogas, the remaining waste slag is all converted into fertilizers; improve the comprehensive utilization rate of geo-oil resources [47].

Challenges and Countermeasures in the Utilization of UCO

The current situation

At present, the resource utilization of UCO is still in the research stage, and there is no mature development system. All kinds of technology are more or less constrained (Table 3).

Table 3. *Comparison of UCO Treatment Technology.*

Technical name	Advantages	Reference	Disadvantages	Reference
HPLC method	Easy operation and low cost.	(Snyder et al., 2012)	Lack of accuracy and sensitivity, the analysis process is complicated.	(Ghari et al., 2013)
Biotransformation Technology	Low transportation and disposal cost, developing fully fermented raw materials without the additional nutrients.	(Lim et al., 2016)	Technology is not yet fully mature.	(Wang and WANG, 2008)
Biodiesel preparation by hydrogenation and catalytic cracking technology	Market value is high; the oxidation stability can meet the relevant standards.	(Yano et al., 2015)	Complex operation, high processing cost, high catalytic condition, low efficiency and the product is difficult to separate.	(Xu et al., 2017)
Transesterification to prepare biodiesel	High output rate, good overall product performance, strong adaptability, little impact on diesel engine power performance	(Demirbas, 2009)	High process cost, cumbersome follow-up process, difficult separation between catalyst and conversion oil, poor environmental protection performance, poor stability of petrochemical diesel. The UCO hydrogenation process is greatly affected bt oxidation.	(Maneerung et al., 2016)
Enzyme catalysis for biodiesel preparation	Mild reaction conditions, low waste liquid discharge, low quality requirements for UCO.	(Lam et al., 2010)	The raw materials are expensive and the production cost is high.	(Moazeni et al., 2019)
Functional chemicals	Higher added value, simple production process, low cost, low environmental pollution good product quality.	(Orjuela and Clark, 2020)	There are few product varieties, the depth of development is not broad enough.	(Ullah et al., 2015)

Nowadays the global energy industry is in a period of deep adjustment, energy consumption structure is undergoing change. Characteristics of clean, low-carbon have become an important trend of contemporary development, production structure has also undergone adjustment and optimization, and green environmental protection will become the core competitiveness of energy enterprises in the new era. The utilization of UCO is a strong support for current “clean” and “green” resource utilization [48]. But there are still a series of problems in the utilization and recovery of UCO due to various of social and economic reasons. For the time being, the most important point in the management of UCO recovery in countries around the world is to give it a reasonable way and clear the use purpose, so that the whole process of development and utilization is open and transparent. In order to solve this problem, government departments should give policy and financial support to the relevant industrial departments dealing with UCO, which is used to support the recovery and utilization of it. Due to the imperfection of most countries’ food safety supervision system. In recent years, there have been many loopholes in the supervision, which leaded a small number of illegal elements to produce and sell "geo-oil" for profit through the underground black workshops, put serious harm to public health, and caused adverse effects to the community, also delay the normal recycling of UCO.

Challenges

The collection cost of UCO is too high and the recycling is insufficient. UCO collection system and recycling mechanism is not perfect, including lack of special filter recycling equipment and special recovery work personnel. Most restaurants are small, inconvenient to clean and collect the used oil timely [25].

The government and the relevant departments are not strong enough to guide, the relevant legal system is not perfect. The publicity of UCO treatment and reuse is not enough, and the public is not aware of UCO reuse. Due to people's weak awareness of the recycling of UCO, a small number of illegal elements recovered a large amount of UCO to process trench oil speculation, resulting in serious waste of resources, pollution of the environment and affecting people's physical and mental health [49].

The resource utilization technology development of UCO is insufficient and the support of the recycling industry of UCO is not strong enough. The research and development time of using UCO for biodiesel is short, the research and development input is not enough, the industrial chain of biodiesel production is short, cannot bring high value-added products for producers, the in-depth research and development of products is not favorable [50].

Countermeasures

In order to reduce the negative impact of improper disposal of UCO, the following must be performed:

A recycling and treatment industry chain and regulatory system should be established, the government regulation for resource utilization of UCO should be strengthened with the follow steps. Establish reasonable recycling methods and systems, speed up the establishment of a nationwide UCO collection system and application of machine quality, improve the collection and utilization rate, including the research and development of recycling equipment, the design of UCO storage container, transportation, preservation and extraction methods to make the whole process open and transparent. At the same time, a strict regulatory system to monitor the direction of UCO should be established; severe punishment should be put for illegal elements who trying to recover UCO for producing trench oil [51-60].

Strengthen publicity efforts to guide the public to know more reuse industries of UCO, build environmental awareness, while guiding the public to develop good consumption and hygiene habits, encourage the public to use the UCO reuse products, stop the casual discharge of food oil behavior. We should carry out a pilot project on the energization of UCO; expand the collection scope of UCO resources and the application of biodiesel. Start from the pilot, then gradually promote.

Strengthen subsidy support on the production and sales of biodiesel, implement preferential policies into details, cover all aspects of the industrial chain, take care of every research and development personnel and practitioners, cover all aspects of the collection, production, sale and use of UCO, while reducing sales tax, reduce the price of biodiesel through subsidies. Special support measures may be implemented in the necessary areas and plants.

Strengthen scientific and technological investment, train highly educated and excellent research and development personnel, and increase research and development efforts. Strive to extend the industrial chain to a deeper and farther level, with more abundant products to support the UCO recycling industry. At present, the technology of biodiesel production has been basically mature, but the application and applicability of it was poor. Take the road of industrialization and large-scale development, while broadening the application channels of products. In addition to biodiesel, functional chemicals and other major products, it has also increased the research and developments of chemical products, improved the added value and competitiveness of products, and encourage the vitality of the new biomass diesel industry [61-70].

Conclusion

In summary, a particularly important point in the recovery and management of catering used oil in China is to give catering used oil a reasonable utilization path, clarify the use of catering used oil, make the whole process of development and utilization open and transparent; and promote the method of the laboratory Industrialized production methods and methods that find wide adaptability and large-scale production are under greater pressure.

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*Correspondence to

Dr. **Peng Wu**

Department of Food Science

Shandong Agricultural University

Taian City

China

E-mail: 13954847828@163.com