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WASTE COOKING OIL: CHALLENGES AND SCOPE

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Abstract

Waste cooking oil(WCO) discarded by large scalefood manufacturing industries and restaurants is often re-used by micro- food units, especially street vendors.WCO contains polycyclic aromatic hydrocarbons, polychlorinated biphenyls, dioxins and dioxin related substances. Evidence suggests that consumption of foods cooked in such oils increases risk for throat infections, damage to sclera of the eyes, respiratory problems, cardiovascular disease, cancer etc. Greater consumer awareness and stringent laws are preventing the reuse of WCO. Resultant to this, disposal of WCO, being generated at large scale all over the world, is increasingly becoming a challenging task.Improper disposal of WCO impacts the environment and ecology negatively. When disposed improperly like pouring down in the drain, it causes clogging of the internal sewage system, pollutes rivers and groundwater. This in turn harms the aquatic ecosystems and public water supply. Irrigation of crops with such polluted water or use of WCO in animal feeds results in the return of harmful compounds back into the food chain. Recycling of WCO is therefore increasingly gaining attention worldwide. Studies have indicated that WCO can be used to manufacture products such as resins for paints and varnishes, detergents, soaps, fabric softeners, animal-feed, glycerin, lubricants for engines and biofuels.The process should however be done carefully and efficiently to support sustainable development. This review paper shall critically discusses the pros and cons of converting WCO into non-edible products.

Keywords: Recycling, waste cooking oil, ecosystem, deep- frying, health

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INTRODUCTION

The past few decades have witnessed a steady rise in the population as well as increase in the production and consumption of food. This has led to increased production of kitchen waste. While the waste generated from the processing of fruits and vegetables has caught major attention; that arising from the use of cooking oils for frying, sautéing etc. has not. Inappropriate disposal of waste cooking oil/fats (WCO) has created serious problems especially for the environment(Man 504).The generation of WCO is increasing in various countries. India is the second largest producer of WCO, the largest producer being the USA. India is contributing 9.2 million tons while China adds around 3.8 million tons to the annual global pool of WCO. In future, India may emerge as top WCO producing country in the world because of its rapid population growth (Gui 1647-1648). This can be attributed to the lack of awareness and need for efficient waste disposal system as well as stringent laws (Azahar112).

Transformation of Cooking Oil to Waste Cooking Oil

Substantial amount of cooking oil is used for frying both at home as well in the commercial food sector.Many physical and chemical changes occur when oil is heated repeatedly at high temperature for prolonged period of time due to its interaction with the food and the environment(Boskou 109-115). Physio-chemical changes result in foam formation, darkening of color, viscosity, density, specific heat as well as increase in the content of free fatty acids, polar material, and polymeric compounds in oils. There is also decrease in the level of unsaturated fatty acids in misused oil (Hong 826-827). Refer fig.1.Resultant to these changes the oil becomes unfit for human and animal consumption. Consumption of foods

fried in such misused oil can cause health problems such as gastrointestinal disorders and even mutagenesis in human body (Man 506).

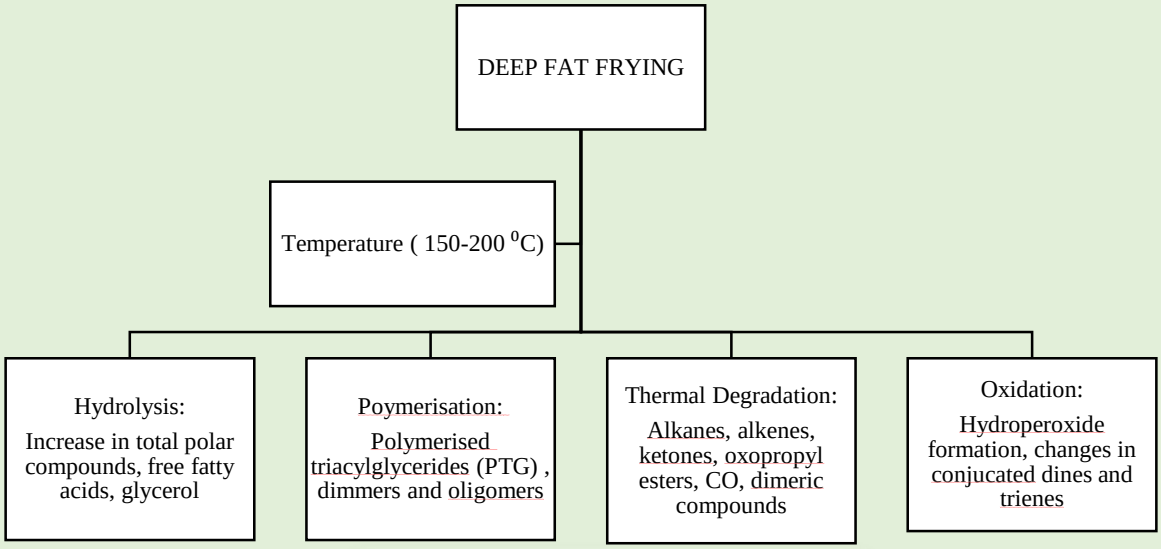

Fig 1: Salient chemical changes during frying – Waste Cooking Oil

WASTE COOKING OIL – An Environment and Health Hazard

Both, developed and developing countries are making significant contributions to the ever expanding pool of WCO. Inappropriate disposal of WCO leads to contamination of the ecosystem especially the water and land resources. Contamination of soil and water with polycyclic aromatic hydrocarbons, polychlorinated biphenyls and dioxins present in misused WCO leads to return of these compounds back into the food chain; via the agriculture, aquaculture and animal husbandry. These and several other substances present in WCO act as pollutantsand are a serious threat to the health of humans and animals. Inappropriate disposal of WCO can also cause corrosion and blockage of the sewage pipes. In USA, 40 percent of the sewage structure blockages are due to the WCO poured into kitchen sink. (Krishna and Shivraj 303).

Stringent surveillance systems are now being implemented. WCO is collected by stakeholders and processed to be reused such as for the production of biodiesel and

electricity(Panadare and Rathod 57).India is also taking some major steps to combat this problem, Food Safety and Standards Authority of India under its policy on "Biofuel" has developed RUCO (Repurpose Used Cooking Oil) which is an ecosystem that enables the collection and conversion of WCO to biodiesel and electricity generation (Panadare and Rathod 57). There are many more applications of WCO such as production of hydrogen gas, pyrolytic oil, bio-lubricants, graces, resins etc. Thus the main focus of this review paper is to briefly outline the salient applications of WCO.

APPLICATIONS OF WASTE COOKING OIL

I. Waste cooking oil as source of energy

Depleting natural reserves, increasing cost of conventional energy resources and global warming are the main driving forces for exploringunconventional sources (such as waste) for producing energy(Chhetri and Watts 4)(Selvi 743).WCO can be used for production of biodiesel, biomethanol, hydrogen gas, hydrocarbons which can be used for generation of energy;to produce electricity or to run vehicles or machines. Rudolph had demonstrated as early as in 1912 that vegetable oils could be used as a fuel to run engines. However,due to low volatility, reactivity of unsaturated molecules, high viscosity, high acid valueand contamination by food particles, WCO can cause problems such as blocking of injectors andincreased tendency for deposition of carbon (Amit 5). Therefore, WCO should either be diluted with diesel fuel or solvents or subjected to micro emulsification, transesterification, pyrolysis(Julia 353).

1.1 Pyrolysis of WCO

Pyrolysis of WCO involves thermal cracking at 550-880 degree centigrade or use of catalysts (Hafriz 490).This helps to produce light hydrocarbons, dihydrogen, synthetic gas (such as a mixture of dihydrogen, carbon monoxide and carbon dioxide) as well as biomethanol. These products can be used as raw material in the petrochemical industry, in fuel cells and also to produce biodiesel – a green fuel(Song and Guo 561-565).Table 1 shows various studies on production of bio-hydrocarbons/ bio-fuel from WCO by Pyrolysis.The heating value

ofpyrolytic oil is~93% of heating value of diesel and flash point (80°C)is more than biodiesel(Czernik and Bridgwater 591). Pyrolytic oil also haslower nitrogen oxides and almost no sulphur which solves the problems of smog and corrosion.

Table1: Pyrolysis of Waste cooking oil- Hydrocarbon/ Bio fuels

Author (Year)	Type of oil	Source of energy	Temperature (^{0}C)	Viscosity (40^{0}C)	Acid value (mg KOH/g)	Density Kg/l	Cetane Number
Trabelsi et al., 2018	Unspecified WCO	Bio-Fuel	550-800	8.95 cSt	126.8	--	--
Hafriz et al., 2018	Unspecified WCO	Bio-hydrocarbon	390	--	186	--	--
Sani et al., 2017	Fish fryer	Bio-hydrocarbon	400	2.15	--	0.94	76.23
Sani et al., 2017	Fish fryer	Bio-hydrocarbon	350	2.20	--	0.97	78.52
Chiaramonti et al. (2015)	Unspecified	Bio-hydrocarbon	500	2.24	117	0.87	--

Billaud et al., 2007	WCO	Bio-hydrocarbon	700-800	11.1	--	0.88	--

1.2 Hydrogen gas from WCO

Hydrogen gas (H_2), is a clean fuel and "energy carrier" of the future with no carbon-dioxide emissions. It can be used in fuel cells for generation of electricity andas feedstock for the production of several chemicals, hydrogenation of fats and oils in food industry, production of electronic devices, processing of steel and desulfurization as well as re-formulation of gasoline in refineries (Kapdan and Kargi 570).Converting WCO into H_2 would address issues related to pollution, food security, and energy security (Ashekuzzaman and Jiang 98). Various processes have been proven theoretically and some experimentally by different research groups (Refer table 2).

Table 2: Production of hydrogen gas from waste cooking oil using Chemical looping reforming (CLR) method

Author (year)	Temperature (^{0}C)	Hydrogen (%)
Wei et al., 2018	750-900	91.7
Nahla et al., 2015	600-800	69.1
Pimenidou et al., 2010a	600-700	98.0
Pimenidou et al., 2010b	600	70.1

1.3 Transesterification

Transesterification is the most common and economical method (Stella 311)to produce biodiesel (mono alkyl esters of long chain fatty acids) from WCO (Chauhan and Suri 75). It, involves reacting vegetable oils with alcohol such as ethanol, methanol, or butanol in the

presence of a catalyst. The catalyst used are acidic and alkaline (Wang, 15-16).A number of studies have shown that the properties of biodiesel fuel are similar to conventional fossil diesel (Aatola 2-3).Use of biodiesel can reduce the emission of carbon monoxide, hydrocarbon, and particulate matter in the exhaust gas compared to conventional biodiesel(Satyarthi 70-74) (Canakci and Van 1429). Refer Table 3for details.

Table 3: Physiochemical properties of European standard biodiesel and biodiesel produced from waste cooking oil

Characteristics	Diesel (European Standard) (Allah and Alexandru 2016)	Waste cooking oil (Enweremadu et al., 2010)	Waste cooking oil (Pathak et al. 2015)	Waste cooking oil (Allah and Alexandru 2016)	Waste cooking oil (Sani et al., 2017)
Viscosity (40^0C)	3.5-5	1.8	4.5	4.57	3.35
Density (Kg/l)	0.86-0.90	0.80	0.88	0.88	0.91
Cetane Number	46.21	50.54	47.07	--	--
Flash Point (^{0}C)	>101	160	44.5	159	--

II. Waste cooking oil as a component of animal feed

Vegetable oils are used in animal feeds to bind ingredients together, enhance physical appeal and nutritive value (Panadare and Rathod 70-71). Due to economic reasons, WCO obtained from commercial establishments (deep fryers) are used. Food provided to the animals like poultry farms and pigs, indirectly come to human beings via food chain. Ingredients used in

animal feeds should be free from detergents, other liquids or solid material,scrapings from hot plates and other cooking utensils such as saucepans and fry pans. Thus, WCO should be free from lipid peroxides and thiobarbituric acid reactive substances. Filtering of WCO does not result in removal of harmful components like dioxins(Supple 175).The government of United Kingdom allows the use of WCO which is collected by a licensed waste carrier, treated well and certified to be used in animal feeds (Panadare and Rathod 71).

III. Waste cooking oil in soap formation

WCO can be used for the manufacture of soap and detergents which can be used for washing dishes, cleaning house, animals and vehicles as well as for bathing. Adane (4-5) in their study indicated that samples (waste palm oil) were taken from three different places such as hotel, restaurant, and from street food vendor for manufacturing of soap and found that the saponification value of WCO obtained from restaurant have high saponification value 205.00 as compared with hotel and street food vendor 201.33 and 196.60 respectively.Table 5 gives brief information about some studies conducted on the production of soap from WCO.

Table 5: Waste cooking oil as source for production of soap

Author (Year)	Type of oil	Saponification value (mg NaOH/g)
Adane, (2020)	Waste palm oil	196.60
Sani et al. (2017)	Unspecified (WCO)	190
Soocheta and Pavaday. (2017)	Unspecified (WCO)	186.53
Zahooretal., (2014)	Waste palm oil	194
Demirbas, (2009)	Unspecified (WCO)	188.2

CONCLUSION

Waste cooking oil can be recycled to produce a variety of products such as biodiesel, soap, hydrogen gas etc. Since recycling of WCO is not feasible at household level there is need to develop a community based system through which WCO can be collected from each and every food service unit and households and sent to processing units where it can be recycled for various purposes. Proper collection, transportation, purification and utilization of WCO can make it a potential renewable source of energy rather than a form of waste or a pollutant.

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