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UTILIZATION OF USED COOKING OIL AS AN ALTERNATIVE COOKING FUEL RESOURCE

Consorcio S. Namoco Jr.[1], Venerando C. Comaling[2] and Cerilo C. Buna, Jr.[2]
[1]College of Engineering and Architecture, University of Science and Technology of Southern Philippines, Cagayande Oro, Philippines
[2]College of Technology, University of Science and Technology of Southern Philippines, Cagayan de Oro City, Philippines
E-Mail: csnamocojr@yahoo.com

ABSTRACT

In this study, used cooking oil was utilized as an alternative cooking fuel resource. A survey was conducted to selected major food chains and restaurant in Cagayan de Oro City, Philippines. Survey results revealed that generation of used cooking oil in these selected establishments on a weekly basis is considerably huge in volume. Modifications have been made to a commercially available pressurized kerosene stove taking into consideration the characteristics of the used cooking oil. The cooking performance of the modified stove using used cooking oil as fuel was then investigated.

Keywords: used cooking oil, alternative cooking fuel, pressurized kerosene stove.

INTRODUCTION

Used cooking oil, also known as waste cooking oil, results from cooking of foods by food cookers, food manufacturers and catering establishments such as fast food chains, restaurants and industrial kitchens. This waste is an important waste management concern since it poses some disposal problems and possible contamination of water and land resources (Arjun *et al*, 2008). As large amounts of waste cooking oils are illegally dumped into rivers and landfills, causing environmental pollution, proper collection and putting them into productive use offers significant advantages not only towards waste minimization or reduction in environmental pollution but also in extending the finite natural resources thru waste recycling. With the mushrooming of fast food chains and restaurants in the country, it is expected that considerable amounts of used-frying oils will be discarded into the drains, posing hazards to our environment.

Aside from the potential hazards and effects due to improper disposal of waste cooking oil, one pressing concern is the health hazards of re-using cooking oil more that once. The use of cooking oil more than once poses threats to the health of the community. A toxic compound 4-hydroxy-trans-2-nonenal (HNE) normally accumulates over time in some vegetable oils (e.g. corn, soybean, canola, sunflower oils) and this will react with amino acids, DNA and other biomolecules in the human body. HNE consumption can lead to diseases such as heart diseases, stroke, Parkinson's disease, Alzheimer's disease, liver and other diseases (Morrison, 2006). When cooking oils (e.g. sunflower, oil, palm oil, coconut oil, etc.) are heated for an extended time (abuse), they undergo oxidation (degradation) and give rise to oxides. Many of these such as hydroperoxides, epoxides and polymeric substances have shown adverse health/biological effects such as growth retardation, increase in liver and kidney size as well as cellular damage to different organs when fed to laboratory animals (Potgieter *et al*, 2004; Riera *et al*, 2000).

In other countries, waste cooking oils are recycled and utilized as alternative ingredients or materials. The main use of recycled WCO is in the production of animal feeds and in a much smaller proportion in the manufacture of soaps and biodegradable lubricants. Some health risks can be traced from the use of recycled cooking oils in animal feeding, such as undesirable levels of contaminants, particularly PAHs (Polycyclic aromatic hydrocarbons), PCBs (Polychlorinated biphenyls), dioxins and dioxin related substances (Riera *et al*, 2000). By consumptions of animal origin foodstuffs like milk, meats, poultry and other products, these undesirable contaminants enter the human body and cause serious long term health hazards. As these contaminants are liposoluble, they accumulate in organic lipids and finally in the body, and thereby their concentration increases gradually over the years. In other words, the body is exposed not only to a single acute action, but also to a chronic action of bioaccumulation of these hazardous compounds over the years (Riera*et.al*, 2000). Hence utilizing the recycled WCO in any way is not advisable from health standpoint. Besides the ill health effects of these WCO (abused oils), their disposable could also have a large environmental implication, because of high COD (chemical oxygen demand) (Riera*et.al*, 2000).
Aside from the above-mentioned application of recycling used cooking oil, used cooking oil utilized as an alternate feedstock in biodiesel production. Several researches along this direction have been conducted around the globe (Arjun *et al*, 2008; Canakci, 2007; Khalisanni *et al*, 2008; Zhang *et al*, 2003; Sudhir *et al*, 2007).

In this study, the viability of utilizing used cooking oil as an alternative cooking fuel resource will be evaluated. The chemical structure of plant or vegetable oils is different from that of kerosene, thus, they have distinct physical and chemical properties and have different combustion characteristics (Andrews and Mkapi, 1996; Kammen, 1995; Stumpf and Muhlbauer, 2002). For example, the flash point and viscosity of plant oils are very much higher than that of kerosene. There are two types of stoves: the wick stove and the high pressure pump stove. Previous studies on utilization of plant oil as cooking fuel found out that plant oils cannot be used in wick stoves (Stumpf and Muhlbauer, 2002). Due to their high viscosity, the flow velocity of plant oils in those wicks is

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very low; hence, the wicks cannot maintain the oil supply and the flame extinguished consequently. Since the thermal efficiency of wick stoves is very low when compared with the high-pressure stoves, the high-pressure stove will be utilized in this study. Owing to the properties of cooking oil, the commercially available pressurized cooking stove will be utilized with revisions or modifications of the nozzle, burner and pipeline. After the pressurized stove is modified or revised, performance evaluation was thenconducted utilizing kerosene and used cooking oil.

This proposed study will provide a significant contribution in easing the problem brought about by the skyrocketing cost of cooking fuels such as kerosene. This will greatly help the small-scale entrepreneurs engaged in foods and catering services as well as households. Besides, the potential environmental hazards brought about by this waste will be addressed. Finally, the dependence on imported kerosene can be reduced and sustained availability can be ensured.

METHODOLOGY

Survey on the generation, utilization and disposal of used cooking oil in the selected major food chains and restaurants in the city of Cagayan de Oro, Philippines

A survey has been conducted to assess the generation of used cooking oil in the selected major food chains and restaurant in Cagayan de Oro City, Philippines. Moreover, the utilization and disposal practices of these establishments have also been surveyed. The survey instrument to evaluate the generation and disposal of the used cooking oil as well as the list of major food chains and restaurants in Cagayan de Oro City is presented in the Appendices A& B, respectively.

Collection and filtering of used cooking oil

Used cooking oil was collected from major food chains and restaurants in the city. Collection of the used cooking oil depends on the way the establishments disposed their waste as there are establishments who will sell the waste oil to contracted buyers only. The used cooking oil was filtered to remove solid residues. Filtering was conducted by using coarse to fine layer nylon wire mesh as filter to remove any contaminants and residues. The used cooking oil must be thoroughly filtered to prevent the fuel lines and nozzle from clogging.

Revision and modification on the commercially available pressurized cooking stove taking into consideration the properties of used cooking oil

Design

Since the commercially available pressurized cooking stove is intended for kerosene fuel, revisions and modifications in the nozzle and vaporizer has been conducted. This is due to the difference in the properties of cooking oil as compared to kerosene. As the oil tank is pressurized, the fuel flows through the oil line which can be regulated with a valve provided in the line. Flame holder is also introduced in the proposed stove. An additional fitting is also added to the regulator.

The vaporizer is designed in such a way that it will be easy to maintain and clean. The materials used for the vaporizer are 3/16” copper tubes which are coiled horizontally for better efficiency of flame. In the design of the nozzle, the spray nozzle exit angle will be modified in such a way that as the gas flux emits from the nozzle into the burning area, the gas mixes with surrounding air and burns in a blue flame.

Figure-1 shows the perspective view of the proposed modified design. In this figure, the different parts of stove such as the vaporizer/copper coiled nozzle are shown. Figure-2 shows the vaporizer/coil copper tube. The coil has 4 loops with a diameter of 2 inches. The distance between nozzle and loop is 1.5 inches. In Figure-3, the three modified nozzle which can be used with the stove are shown. These nozzles are threaded depending on the fittings. Figure-4 shows the front view of the stove frame and the coiled copper tube with nozzle attached in bracket.

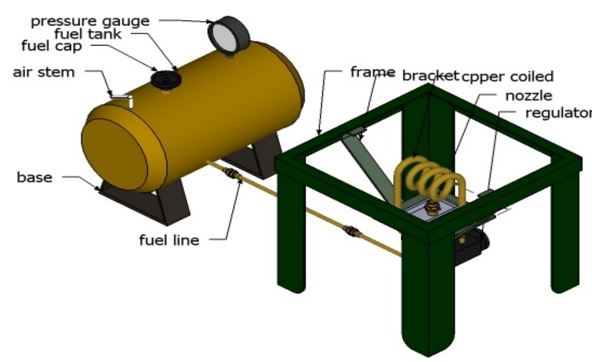

Figure-1. The perspective view of the modified stove.

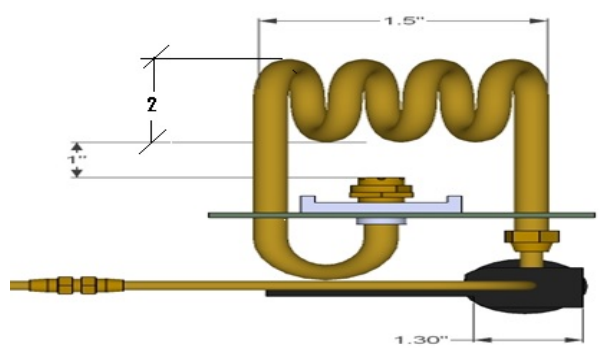

Figure-2. The designed vaporizer and nozzle.

Fabrication of the modified stove

Brass metal is used in the fabrication of the modified nozzle and fittings. The nozzle is made of ½ inch hexagonal in a diameter brass metal. The vaporizer is made up of 3/16 copper tube. Proper sizes must be observed since the fuel will leak if under sized threads are used.

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Fabrication of the nozzle

The first nozzle was made up of ¾ an inch in a diameter having 4 holes in the top to equally distribute atomized gas goes out in a nozzle. The second one has a single hole but there is an additional fabricated accessory which is in the form of a castle. Equally divided holes were rounded along the cylindrical corner. At the top, there is a cone- shaped brass metal that functions for spreading the flame. The nozzle is connected to a flared union which is attached to a vaporizer and connected to a flared nut for easy disassembling during cleaning.

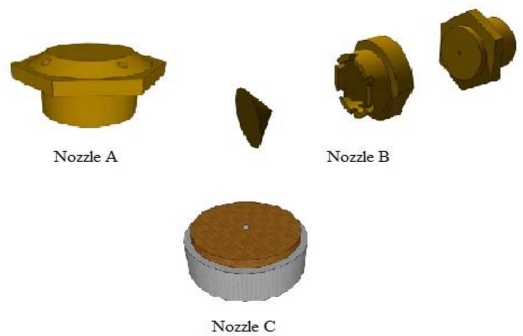

Figure-3. Three different nozzles considered in the study.

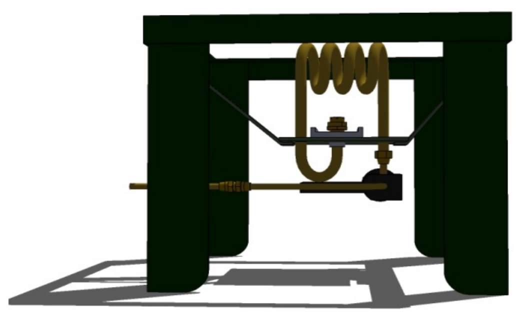

Figure-4. The image of the front view of stove frame.

Testing and fine tuning

After the fabrication, the performance of the modified parts was then tested. Before starting the test, all fittings were installed correctly and properly. They were properly tightened to prevent from leakage and losses of fuel and pressure.

Evaluation of the cooking performance of the modified pressurized stove

After the pressurized stove is modified or revised, a series of experiments has been performed to evaluate the performance of the modified pressurized stove. The experiments were conducted at constant pressure of 30 psi. Different blending ratios of kerosene and used cooking oil (100:0, 50:50, 20:80 and 0:100) were used in the experiments. The time needed to boil (100 degree Celsius)one and a half (1.5) liters of water at different blending ratio were recorded. The experiments were repeated for three trials and average value will be taken. The appearance of flame at each blending ratio was also observed.

RESULTS AND DISCUSSIONS

Generation, utilization and disposal of used cooking oil in the selected major food chains and restaurants in Cagayan de Oro City, Philippines

A survey was conducted to determine the generation, utilization and disposal of used cooking oil in selected major food chains and restaurants in Cagayan de Oro City, Philippines. From more than 40 food chains and restaurants identified as respondents for the survey (as attached in Appendix A), there were only 23 food chains and restaurants positively participated in the survey (55 percent retrieval rate). Table-1 shows the list of establishments participated in the survey. The categories of these respondents are presented in Figure-5. Details of the respondents are presented in Appendix. Table-1 shows also the volume (in liter) of waste cooking oil (WCO) generated in a week by the respondents (restaurants and food chains in Cagayan de Oro City, Philippines) in this study. Though the number of respondents is quite small as compared to the existing restaurants and food chains in the city, the total volume of WCO generation on weekly basis as determined in the survey conducted is quite large (2,521.716 liters / week). Hence, it can be deduced that the actual volume of used cooking oil generation of major restaurants and food chains in Cagayan de Oro City, Philippines is very enormous. This is not to mention the used cooking oil generated in the household level which is also a potent source of this waste.

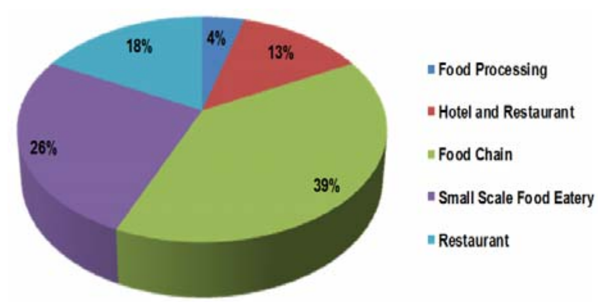

Figure-5. Distribution of the respondents participated in the survey.

Figure-6 shows the different ways employed by the establishments under study in determining that the cooking oil should not be used anymore and should be disposed. As shown in the figure, around 83% (19 establishments) are basing on the number of times the cooking oil is used in determining that the oil should not be used anymore. The number of times used varies with establishments and ranges from 1 time to 7 times. A small scale food eatery reported that they used the cooking oil continuously for one (1) day. On the other hand, around 57% (13 establishments) are basing on the color of the oil if it should not be used anymore. The color ranges from golden yellow, dark brown to black depending on the

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establishment. A small scale food eatery reported that the nature of the occurrence of bubbles is their basis in

Table-1. List of establishments in the city participated in the survey and their generation of waste cooking oil (WCO) per week.

No.	Establishment participated in the study	WCO generated (liters/week)	Ways of disposal of WCO
1	JRJ Deep Fry	21	Sell to Contracted Buyers
2	PIDOT 1971	28	Sell to Contracted Buyers
3	King Chicken and Barbeque Station	15.88	Sell to Contracted Buyers
4	PritoPaborito	18	Sell to Contracted Buyers
5	Jollibee Vamenta Carmen	65	Sell to Contracted Buyers
6	Jollibee Kauswagan	32	Sell to Contracted Buyers
7	GaisanoCommesary	1400	Sell to Contracted Buyers
8	Slers Industries	300-500	Sell to Any Interested Buyers
9	Philtown Hotel and Oriental Garden	25.176	Sell to Any Interested Buyers
10	De Luxe Hotel	63.52	Sell to Any Interested Buyers
11	Hotel Conchita	4	Sell to Any Interested Buyers
12	Jollibee Xavier	30	Sell to Any Interested Buyers
13	Turo-Turo	8	Give to Interested Person at No Cost
14	Pearl Garden	8	Store in a Container & Dispose later
15	Chowking (Oro Funchow)	40	Store in a Container & Dispose later
16	KFC Limketkai	16	Store in a Container & Dispose later
17	Tita Fannies	4	Store in a Container & Dispose later
18	PerssimonFastfood	21.176	Throw Away
19	Jollibee Gaisano	68	Throw Away
20	Jollibee Divisoria	64	Submit to Warehouse/ Main office for accounting
21	Jollibee SoutminFoodchain Corp.	20	Submit to Warehouse/ Main office for accounting
22	ChowkingGusa	44	Submit to Warehouse/ Main office for accounting
23	JRJ Divisoria	80	Submit to Warehouse/ Main office for accounting
Total Volume of Waste Cooking Oil Generated per week (liters/week)		2,521.716 liters	

determining if the oil should not be used anymore. Around 17% (4 establishments) are employing device and monitoring in determining if the cooking oil should be disposed. In this case, a secondary shelf-life monitoring, oil mileage monitoring, testomometer & thermometer and visibility tester are used.

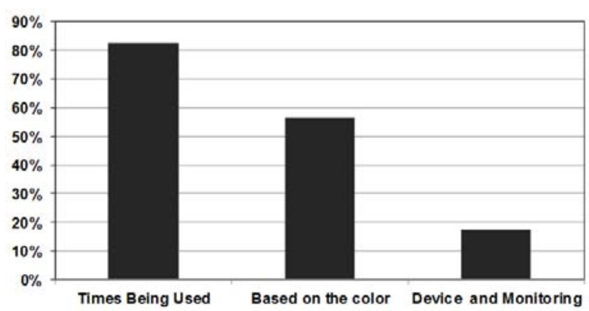

Figure-6. Different ways in determining that the cooking oil should not be used anymore and should be disposed.

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Figure-7 shows graphically the manner in which the WCO is disposed by the establishments (see Table-1). As shown in the figure, majority of the respondents sell their WCO generated to contracted/interested buyers. It is interesting to note that majority of these contracted/interested buyers utilize the WCO bought from these establishments for cooking purposes. These buyers might be unaware of the health hazards brought about by utilizing WCO in cooking/ frying of foods and snacks. As can be seen in the figure also, there are a number of establishments that directly dispose/ throw their WCO via kitchen sink/canal which may pose problems to our environment.

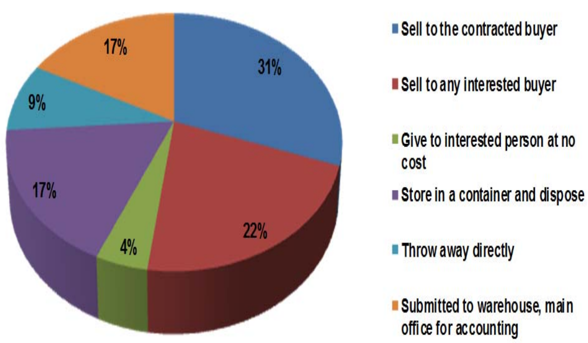

Figure-7. Different ways of WCO disposal by the establishments.

Characterization of waste cooking oil

Figure-8 shows a sample of a waste cooking oil. In Table-2, a typical characterization of waste cooking oil is shown. This characterization result is based on the study of Sanli *et al*. (2011).

Modified pressurized cooking stove

Figure-9 shows the actual photo of a modified pressure cooking stove utilizing the existing stove. Figure-10 shows the coiled copper tube center with a stainless tube flame holder on the top of the base. The stainless tube flame holder will aid in refining the air before it reaches the flame.

Figure-8. Sample of a waste cooking oil.

Table-2. Typical characterization of a waste cooking oil **Source:** (Sanli *et al*., 2011).

Parameter	Typical value
Density (g/cm^3 @ 15°C),	0.9237
Viscosity(mm^2/s @ 40°C)	42.28
Water Content (ppm),	1657.00
Acid Value (mgKOH/g)	17.85
Heating Content (kJ/kg)	39,223

Figure-9. The actual photo of the stove.

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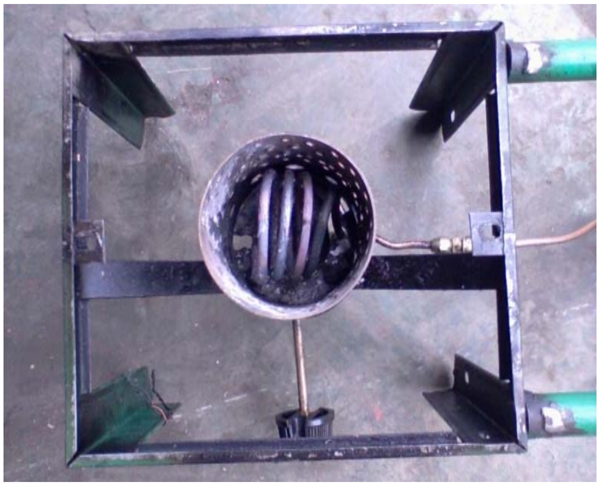

Figure-10. The coiled copper tube with the flame holder.

Performance evaluation of the modified pressurized stove

Table-3 shows the time needed to boil one and a half liters of water in different blending ratio at constant pressure of 30 psi. Results show that that the performance of waste cooking oil in terms of time to boil a given volume of water is comparable to that of the kerosene. Figures-11 shows the flame appearance at different blending ratios 100:0, 50:50, 20:80, 0:100, respectively. From these pictures, it can be observed that the flames emitted by the two blends differ in color. The colors observed are yellowish, reddish to orange or combination of orange-red or orange-blue. During the experiment, the regulator was only half open. The kerosene flame color is a combination of orange and blue while that of the waste cooking oil is a combination of three colors, namely bluish in the bottom, orange and reddish in the upper portion. Based on the color of flames emitted, there is still a need to improve the design of the vaporizer and nozzle to enhance the performance efficiency of the modified stove.

Table-3. Time to boil 1.5 liters of water at different blending ratios.

Blending ratio (kerosene: WCO)	**Pre-heating time** (minute)	**Time needed to boil 1.5 liters of water** (minute)
100:0	4:01 2:46 1:14 Aver. 2:54	7:51 6:49 6:29 Aver. 6:76
50:50	1:18 1:25 1:03 Aver. 1:15	6:40 7:35 6:47 Aver. 6:74
20:80	1:49 1:03 1:25 Aver. 1:25	7:52 7:54 7:45 Aver. 7:50
0:100	2:30 2:48 2:18 Aver. 2:32	8:20 8:22 8:15 Aver. 8:19

CONCLUSIONS

A study was conducted to evaluate the utilization of used cooking oil as an alternative cooking fuel resource. A survey conducted to selected major food chains and restaurant in Cagayan de Oro City revealed that a considerable volume of used cooking oil is generated. It is also revealed that majority of the establishments under survey are basing on the number of times the cooking oil is used in determining that the oil should not be used anymore and should be disposed. Further, majority of the respondents sell the WCO generated to contracted/interested buyers.

A modified pressurize cooking stove was then

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(a) 100:0 blending ratio

(b) 50:50 blending ratio

(c) 20: 80 blending ratio

(d) 0:100 blending ratio

Figure-11. The appearance of flame at different kerosene to WCO blending ratio.

developed taking into consideration the characteristics of the WCO. Evaluation of the modified stove revealed that the performance of waste cooking oil in terms of time to boil a given volume of water is comparable to that of the kerosene. For further studies, a better design of the vaporizer/ burner for better heat transfer and enhanced efficiency and performance of the stove is strongly suggested. A rebounding plate should be incorporated such that atomized gas will be spread prior to producing the flame.

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