A MICROCONTROLLER-BASED OIL QUALITY DETECTOR FOR FASTFOOD ESTABLISHMENTS

Katrine Marie B. Abad[1], Dandy C. Alas[2], Jane M. Javelosa[3] Roderick Y. Yap[4]
Department of Electronics and Communications Engineering
De La Salle University, Manila
2401 Taft Ave., Malate, Manila 1004, Philippines
[1] Student, *katrine_abad@dlsu.edu.ph*
[2] Student, *dandy_alas@dlsu.edu.ph*
[3] Student, *jane_javelosa@dlsu.edu.ph*
[4] Faculty Adviser, *roderick_.yap@dlsu.edu.ph*

ABSTRACT

Frying has been an inevitable process in the cooking industry. Despite the awareness of its increasing health risks, people have been accustomed to this process which made it a staple in cooking. Cooking oils deteriorate when subjected to prolong use overtime. This widely applies in cooking establishments like fast-food establishments; hence there is a need to regularly monitor the cooking oil's quality and properly time its disposal. In this study, a microcontroller based prototype was implemented to test the quality of palm and soy bean oil The quality is centered on measuring the oil's polar compound using viscometer and a test kit.. A system automatically checks the oil quality and regulates the disposal of oil.

Key Words *– Cooking Oil, Frying, Polar Compounds, Smoke Point, Viscosity*

I. INTRODUCTION

In our world today, fast food has become the convenient means of having breakfast or lunch or even dinner. Many such food are served fried. Reusing of cooking oil in household and even in fast food restaurants is a common practice. Some studies show repeated recycling of cooking oil can post health risk[1][3]. During frying, oil undergoes several changes due to the heat it is subjected to and the chemical reaction of the food being processed with the oil. Repeated recycling of cooking oil can lead to formation of surfactant compound which affects the quality of food being cooked [2]. To assess oil quality, people in eatery business may mistakenly rely on personal judgment. This can make judgment either uneconomical or health hazardous. Some oil could be disposed of prematurely which would be a waste economically. Similarly, some oil could be disposed of too late which would increase the health risks to people. Some researches have investigated the quality of cooking oil based on certain parameters. One of these is the polar compound. It was noted that as oil is repeatedly recycled, the polar compound increases[6]. Another parameter is the oil's smoking point. This the maximum temperature at which oil can be heated before it breaks down and starts to smoke[4]. As oil gets repeatedly used, the smoking point decreases [4]. Polar compounds and oil's viscosity have been proven to have a relationship based from researches and data[5]. In this research, a prototype is designed to regularly sample and test the quality of a cooking oil that is assumed to be used continuously in fast food restaurants. The system is automated from sampling to providing output indication of good, far or bad for the quality of oil.

II. DESIGN CONSIDERATIONS

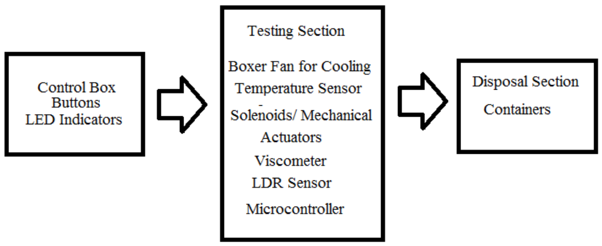

Figure 1. System Setup

Figure 1 shows the process and interconnection of all the devices integrated into the system. The hardware consists of the control box, the testing section and the disposal section. The control box consists of a switch and 3 LEDs colored green, yellow and red indicating the status of the oil. Green indicates good oil; yellow indicates fair oil; and red indicates bad oil. The testing section is composed of pumps, solenoid valves, boxer fans, viscometer, a dark sensor, and a mechanical actuator for opening and closing the orifice of the viscometer.

The disposal section only consists of a pump and a storage bin. When testing result shows the oil as unfit for reuse, this section will direct the oil to the disposal container. A red LED will light up and an alarm will sound off as a reminder to the user of the oil's poor quality.

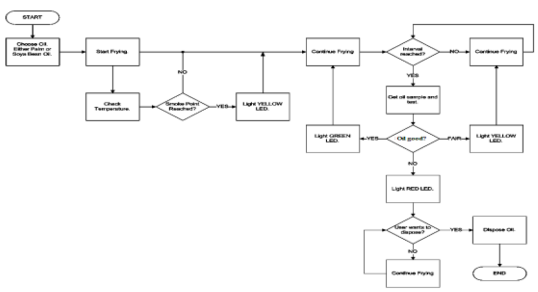

Figure 2. System Flowchart

Figure 2 shows the whole process of the system and all the conditions that apply. The system starts by allowing the user to choose between palm oil and soy bean oil. The chosen oil will be released mechanically into the fryer. In fast food establishments, an oil may be used from several hours to several days. It is for this reason that periodical sampling during the cooking process may be necessary. When the actual cooking has started, a pump would draw oil samples from the fryer to subject it to testing. As the oil is drawn, it passes through a winding path of aluminum pipe. A set of boxer fans turn on while the oil is inside the pipe to allow the oil to cool to room temperature. A solenoid valve is provided to block the path of the oil before it could reach the next stage which is the viscometer. After some minutes of cooling, a compressor motor actuates to cover the viscometer's orifice. This signals the microcontroller to actuate the solenoid valve to release the oil into the viscometer.

Once the viscometer is full, the actuator motor uncovers the orifice of the viscometer. This allows the oil to start flowing out of the viscometer. The system triggers a timer to measure the oil's flow rate using the viscometer. A dark sensor acts as the microcontroller's eye as it waits for the oil flow to stop. The higher the oil's viscosity, the longer will be the waiting time. The flow rate measured corresponds to a viscosity value which in turn relates to a measure of the oil's polar compound. The value of the polar compound obtained forms the basis for determining the oil's reusability. If the oil is still fit for reuse, a second pump would activate to save the oil for future use.

The most important concern with the creation of the prototype is the cooling of the oil and the maximization of the space allotted without jeopardizing the functionality of the whole system. The actual length of the pipe was set to 6 feet i.e. enough to fill up the viscometer with enough quantity of oil up to the rim. To save space, the aluminum pipe was bent several rows providing a winding path for the oil. For the cooling of the oil, four boxer fans were used; enough to cool the entire aluminum pipe. The motor used to open and close the orifice of the viscometer, comes from an old portable air compressor used in vehicles. PIC16F877A microcontroller was used as the main controller for the whole system. Guided by Fig. 2, a code was written to govern the sequence of operation for testing the oil.

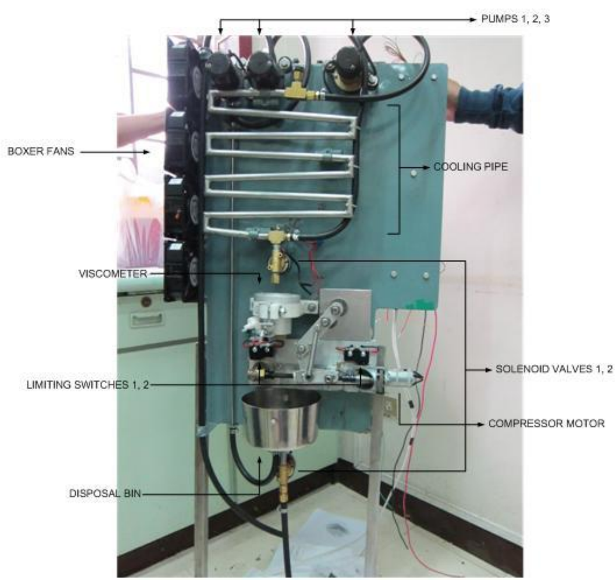

Figure 3. Final Prototype

Figure 3 shows the prototype built. The winding aluminum pipe is terminated by a solenoid valve which releases the oil to a viscometer directly placed below it. Figure 4 shows another view of the prototype detailing the other parts of the system. The compressor motor serves as an arm for opening and covering the exit port the viscometer.. The flow rate is obtained with aid of the signal from the photo sensor.

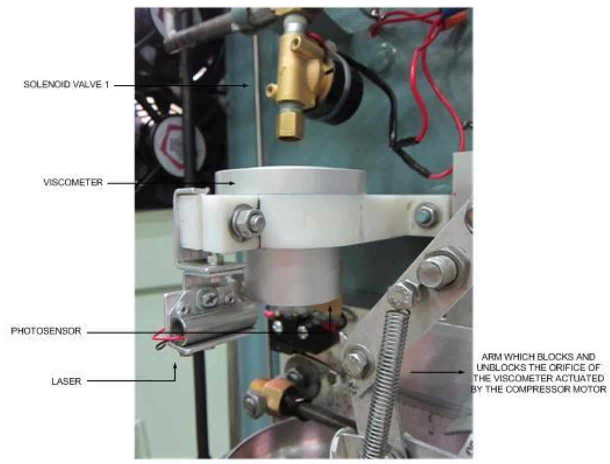

Figure 4. Viscometer

III. EXPERIMENTS AND ANALYSIS OF RESULTS

The experiment was conducted by cooking fish balls (1/2 kilogram per day for 8 hours) using palm oil and soya bean oil. The authors performed experiments under the same test medium, fish balls (1/2 kilo), and cooking hours, eight hours per day, for three days. The tests were conducted by cooking only at constant medium heat. In obtaining the data, viscosity was measured on a per hour basis. To test for consistency of the measurements for viscosity, the procedure was repeated five times. To test validity of the results obtained, a test kit was used for measuring the polar compound.

A. Viscosity Testing

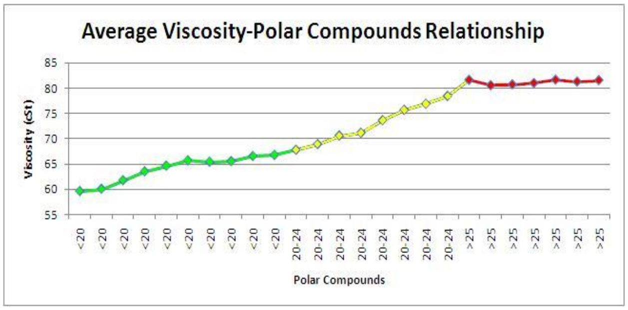

Figure 5. Average Viscosity-Polar Compounds Relationship of Palm Oil

Figure 5 shows the relationship between viscosity and percentage polar compounds for palm oil. The relation shows viscosity increasing linearly with polar compound as oil deteriorates due to prolong usage. Similar observation is noted for using soy bean oil which is shown in Figure 6.

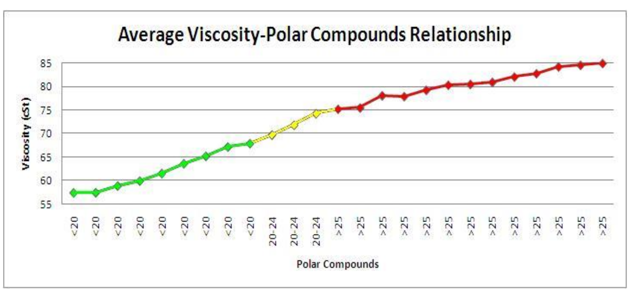

Figure 6. Average Viscosity-Polar Compounds Relationship of Soya Bean Oil

B. Calibration of System through the Test Kits

The test kits used in this experimentation was adopted for the calibration of the system so that the system would be able to give accurate and efficient results and to validate the measurements of the viscometer. Table 1 guides the kit users by showing the relation of the reaction color with the viscosity and the polar compound.

Table 1. Polar Compounds of Palm Oil

COLOR SCHEME	1	2	3	4	5	6	7	8
HOURS	0-9			10-17			18-24	
VISCOSITY (cSt)	<67			68-79			>80	
POLAR COMPOUNDS	<20%			20-24%			>25%	
INDICATOR	GREEN			YELLOW			RED	

Figure 7: Test Kit Color Result for Palm (Color Scheme 1, 2, 3)

As shown in Figure 7, palm oil samples that have viscosity measurements between 0 to 67 cSt show a color result of 1, 2, 3. Specifically, in the conducted experimentation, these viscosity measurements can also be concluded to fall within the range of 0-9 cooking hours. These color results mean that palm oil within the range of anywhere below 67 cSt is still fit for reuse.

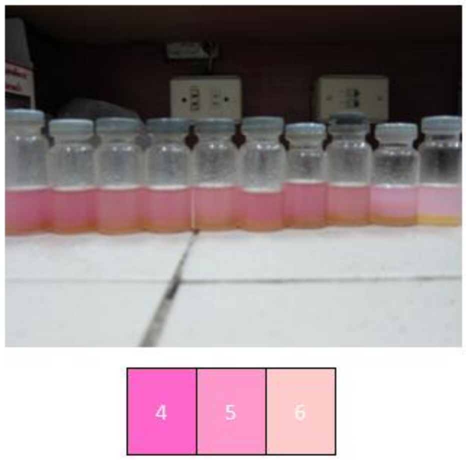

Figure 8. Test Kit Color Result for Palm (Color Scheme 4, 5, 6)

Figure 8 shows the palm oil samples that have viscosity measurements between 68-79 cSt and color results of 4, 5, 6. Correspondingly, these viscosity measurements fall under the range of between 10-17 cooking hours under the experimentation conditions. These color results mean that palm oil within the range of anywhere between 68-79 cSt can still be used, however it is suggestive to replace the oil.

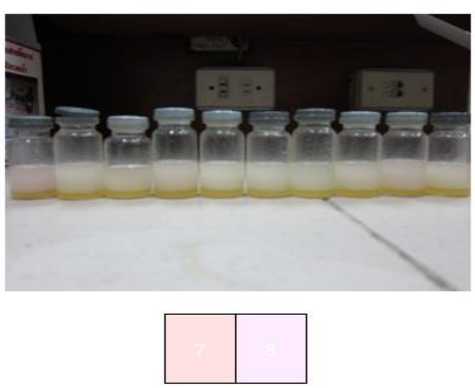

Figure 9. Test Kit Color Result for Palm (Color Scheme 7,8)

Figure 9 shows the palm oil samples that have viscosity measurements anywhere above 80 cSt and a color result of 7 and 8. In the same way, these viscosity measurements can be said to result after 18-24 hours of cooking. In the experimentation, these color results mean that palm oil within the range of anywhere above 80 cSt is already unfit for reuse.

Similar observations were noted when using the test kit on soybean oil . Based on experiments however, soybean oil seems to show a longer life before it is rendered unfit for consumption.

C. System Evaluation in the Assessment of Oil

Table 2 shows the system's evaluation in assessing the quality of oil. The evaluation was done by comparing the automated viscosity measurements obtained by the system and the manually-obtained viscosity measurements. It also shows the computed percentage differences.

Table 2. Determination of Good Palm Oil

Trial	Determination of Good Palm Oil (>67 cSt)		% Difference
	Automated	Manual	
1	60	59.89	0.184%
2	64	64.62	0.964%
3	67	66.45	0.824%
4	65	64.02	1.519%
5	62	60.99	1.642%

Table 2 shows the system's evaluation in assessing good palm oil. The measured values show close resemblance to the system generated values. Similar close relations are noted for the values obtained for testing fair oil and bad oil. These are indicated in Tables 3 and 4 respectively.

Table 3. Determination of Fair Palm Oil

Trial	Determination of Fair Palm Oil (68-79 cSt)		% Difference
	Automated	Manual	
1	64	68.25	6.427%
2	66	71.30	7.721%
3	72	69.12	4.082%
4	77	77.76	0.982%
5	77	77.73	0.944%

The total average percentage difference of all the percentage differences obtained for palm oil is placed at 2.068%. On the other hand, when using soybean oil, the total average percentage difference is placed at 4.076%.

Table 4. Determination of Bad Palm Oil

Trial	Determination of Bad Palm Oil (>80 cSt)		% Difference
	Automated	Manual	
1	83	83	0%
2	84	84.33	0.392%
3	94	93	1.07%
4	95	92	3.209%
5	95	94	1.058%

IV. CONCLUSION

Developed in this research is an Automated Microcontroller-Based Cooking Oil Quality Detector with the use of the PIC16F877A. The final prototype was used for determining the quality of two oils: palm and soy bean oil. The prototype made use of pumps which are responsible for the pumping of oil samples for testing, returning oil samples that are fit for reuse and disposing oil that are unfit for reuse. Four boxer fans that cover a length of six feet, are used to cool oil. A compressor motor was also added to covers and uncovers the orifice of the viscometer. Solenoid valves were used to time and control the flow of oil. Most importantly, included in the prototype is the Ford Cup #3 viscometer which determines the viscosity of the oil. In this experiment, only one type of food was cooked and data gathering was obtained with the condition that the food was under constant medium heat Determination of oil quality was based on the oil's polar compound using viscometer and test kits.

REFERENCES

[1] Federico Soriguer, Gemma Rojo-Martínez et al., Hypertension is related to the degradation of dietary frying oils, American Journal of Clinical Nutrition, Vol. 78, No. 6 , 2003, 1092-1097

[2] Richard Stier, Process Control Ensuring the Safety and Quality of Fried Food, Food Safety magazine, 2007, [Available Online: http://www.foodsafetymagazine.com/article.asp?id=1969&sub=sub1].

[3] Kamsiah Jaarin and Yusof Kamisah, Repeatedly Heated Vegetable Oils and Lipid Peroxidation, Department of Pharmacology, Faculty of Medicine,Universiti Kebangsaan,, Malaysia, [Available online: http://www.intechopen.com/books/lipid-peroxidation/repeatedly-heated-vegetable-oils-and-lipid-peroxidation]

[4] The Hazards of Reusing Cooking Oil, [available online: http://www.livestrong.com/article/532582-the-hazards-of-reusing-cooking-oil/]

[5] Benito Jose, Jose Garcia-Perez et. al. Rapid evaluation of frying oil degradation using ultrasonic technology. Food Research International, Volume 40, Issue 3, April 2007, Pages 406-414

[6] Reusing Cooking Oil Ups Blood Pressure, [Available Online: http://preventdisease.com/news/articles/reusing_cooking_oil_ups_bp.shtml]