

## Non- Destructive Fish Fat Detection Using Infrared Sensor

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**Abstract.** This paper presents an overview and results of a preliminary research using an inexpensive infrared-based technology to detect fish fat. The results of the fish fat detection and measurement from this non- invasive test is then compared to the results of fish fat measurement using Soxhlet method, a standard fish fat measurement procedures as recommended by the Association of Official Analytical Chemist (AOAC). Preliminary results from the research suggest that it is possible to detect fish fat using infrared technology as the fish sample with the higher fat percentage absorbed more of the infrared radiation. The investigation indicates the existence of correlation between absorption of the infrared radiation and percentage of fat content in the fish samples. The research presented herewith indicates that the use of infrared radiation technology enable the prediction of fish fillet fat percentage with a reasonable accuracy.

**Keywords:** Infrared, Sensor, Fish Fat, Near-infrared spectroscopy

### 1. Introduction

In recent years, the popularity of fish consumption has increased tremendously due to the benefits that fish consumption provides. For example, a study by Siscovick [1] reported that a consumption of two fatty fish meals per week will reduce the risk of primary cardiac arrest. As more and more fish is consumed, the market for certain types of fish such as Salmon (*Salmo solar*) and the Catfish (*Pangasius hypophthalmus*) which used to be supplied from the wild is now supplied commercially from fish farms [2, 3]. Due to the increased concern for food components and quality of food [4] and in this case fat percentage in fish, there is a need for methods to measure fat especially fat from fish fillets from farmed fish for quality control.

The quality of fish in most cases refers to the aesthetic appearance and freshness or degree of spoilage which the fish has undergone. However, "quality" implies different things to different people. In fish production, the quality of certain fish such as Salmon and the Catfish can be categorized by its fat content. The size of the fish as well as its fat content is an indicator of whether a fish is ready to be harvested. The fat content of the harvested fish can be used as an indicator of "quality" as the fat content will affect the flavour of the cooked fish and thus taste as perceived by most people. Various techniques have been developed to measure fat contents in fish. However, in many cases when chemical analyses methods are used, it involves the destruction of the sample itself, is usually labour intensive and costly [5]. For example, Ho used [2] a chemical extraction method to compare the fat content of catfish compared to the fat content of Atlantic Salmon and Asian Seabass. Similarly, Khodabux [6] also used a destructive method which is the Soxhlet method to measure free fat in Tuna fish. Hence, there is a need for a low cost non-invasive method to detect and measure fish fat content.

In the past, various techniques have been investigated in an attempt to develop a reliable, inexpensive and non-destructive method to detect fish fat. For example, Shannon [7] used ultrasound pulse transit time measurement techniques to measure the intramuscular fat in Salmon fillets. From his research, Shannon

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concluded that using this technique does not enable prediction of the fat content with great accuracy because of in-homogeneity in the structure of the fish muscle. It was only possible to categorize the samples into three categories which are “high fat”, “medium fat” and “low fat” categories.

There are now many researchers that used spectroscopy especially near-infrared spectroscopy (NIR) for various type of quantitative analysis of food such as using NIR Reflectance to analyze menthol concentration in tobacco and prediction of soil content [3]. An example of the use of NIR radiation with fishes is an investigation by Lin [5], who proved that the spoilage process of rainbow trout fillets can be successfully monitored using the short wave near-infrared (SW-NIR 600 to 1100) spectroscopy. The objective of the investigation presented herewith is to study if short wave near-infrared spectroscopy can be used to detect and measure fat content in fish fillets.

## 2. Methods And Material

The fish fat measurements were carried out using two methods. Fat from all fish samples were measured twice. First, by the NIR radiation method and then by using the standard Soxhlet method. The Soxhlet method is a traditional method for the analysis of fat that was developed by a German chemist Franz von Soxhlet in 1879. It is a popular and proven standard procedure to identify and measure fat for data gathering and is a recommended method by the Association of Official Analytical Chemists (AOAC) [3]. The results from the Soxhlet measurement are used to validate the result from the NIR radiation measurement method. Figure 1 shows the fish samples and the experimental set up for the NIR radiation fat measurement method.

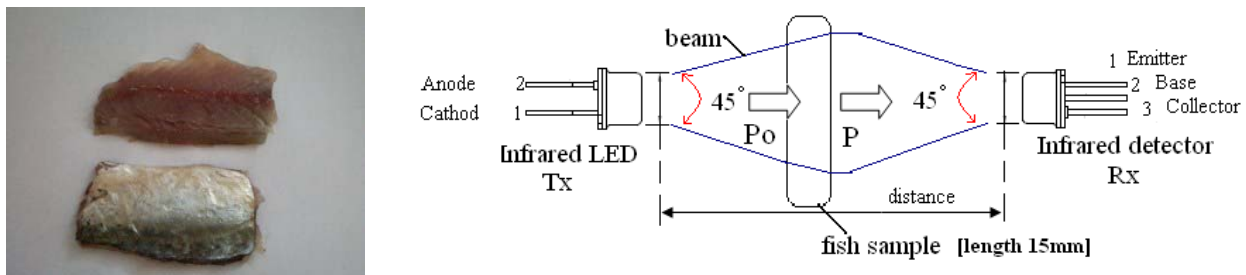


Fig. 1: Fish samples and measurement set up.

### 2.1. Fish Fillet and Sample

The fish used for the investigation is Sardine (*Dussumieria Acuta*). In Malaysia, sardine has a high commercial value due to its low and reliable price. Several precautions were undertaken to ensure accuracy of the experiments. For example, the thickness of the fish sample was kept to the same width as best as possible. In this preliminary experiment, six samples were used in the experiment.

### 2.2. Fish fat measurement using NIR radiation and Soxlet

Figure 2 shows the circuit diagram and a picture of the experimental set-up for NIR radiation measurement method. The fish fillet samples are placed between the infrared receiver and transmitter. The fish fillet samples are placed between the infrared receiver and transmitter. The infrared radiation emitted by the LED (TX) transmitter will pass through the fish sample. The fish fat in the sample will absorb the infrared radiation until the sample is saturated. The remaining radiation that is not absorbed by the fish sample will be detected by the infrared sensor /detector (RX). The output Voltage ( $V_{out}$ ) from the circuit is then measured. It was hypothesized that the fish fillet samples with the higher fat content will absorb more radiation thus a smaller output voltage  $V_{out}$  will be measured.

### 2.3. Fish Fat Measurement using Soxhlet method

Figure 3 shows the apparatus used for fat measurement using the Soxhlet method. Before weighing, the fish fillet samples were dried thoroughly and then the fat was extracted using an electro thermal extraction unit and condenser. The percentage of fat was then calculated using the equation below.

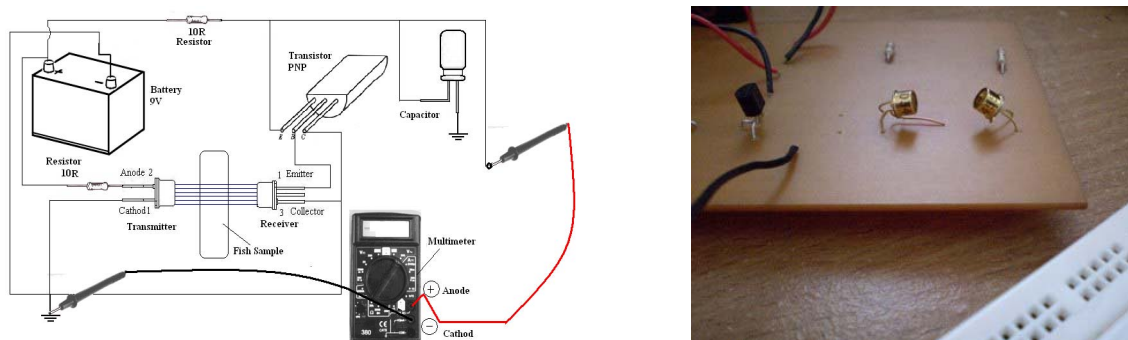


Fig. 2: Circuit diagram and picture for infrared radiation.

$$\% \text{ Fat in sample} = \frac{\text{Weight of fat in sample (g)}}{\text{Weight of sample (g)}} \times 100$$



Fig.3: Set-up for the Soxhlet method for fat content measurement.

### 3. Results and Discussions.

Table 1 shows the results of the experiments using NIR radiation and the Soxhlet fat measurement method. To ensure accuracy of the results, the measurements for  $V_{out}$  were taken five times and the averages were then calculated.

From Table 1, it can be seen that the weight of the samples do not indicate the percentage of fat. However the value of output voltage  $V_{out}$  from the NIR radiation circuit can to a certain extent be used to identify the percentage of fat.

Figure 4 shows that there is correlation between the results from the two measurement methods. As the fat content increases, that is a high fat percentage, more of the radiation is absorbed thus less output voltage  $V_{out}$  will be detected as depicted in Fig 4. A regression analysis was then carried out to determine the relationship between the two variables, which is  $V_{out}$  and fish fat percentage as shown in Fig. 5.

The relation between  $V_{out}$  and percentage of fat is described by the simple linear regression model with true regression line  $\% \text{ of fat} = 40 - 5.08V_{out}$  and  $\sigma = 0.868$ . The calculations indicate the probability of percentage of fat towards and on the true linear regression line is at 99.94%. The reason for the slight inaccuracy i.e. the line is slightly not linear could be due to the small number of samples and the difference in thickness of the samples used. Although precautions were undertaken to ensure the same thickness and size for all samples, slight different in thickness and size could possibly occurred. The experiment requires samples with the same thickness as the amount of absorbance of the radiation by a sample is proportional to the thickness of the sample.

Table 1. Experimental results from NIR radiation circuit and Soxhlet method for fat measurement

Fish Samples	Weight (g)	Vout (volts)					Average Vout	% of fat using Soxlet
		1st	2nd	3rd	4th	5th		
1	3.1	4.06	3.98	4.14	3.99	4.13	4.06	19.39
2	5.22	4.30	3.98	4.19	4.15	4.43	4.21	18.12
3	5.27	4.59	4.77	4.55	4.74	4.60	4.65	16.57
4	6.1	5.21	5.31	5.20	4.98	5.00	5.14	13.9
5	7.62	5.98	5.86	6.01	6.18	6.12	6.03	13.65
6	8.33	6.41	6.25	6.30	6.35	6.47	6.36	12.18

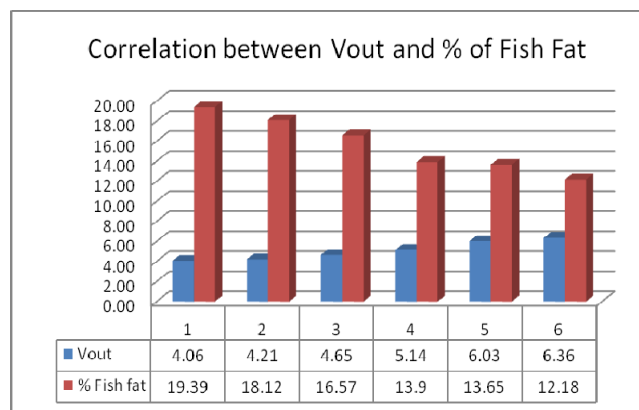


Fig.4: Set-up for the Soxhlet method for fat content measurement

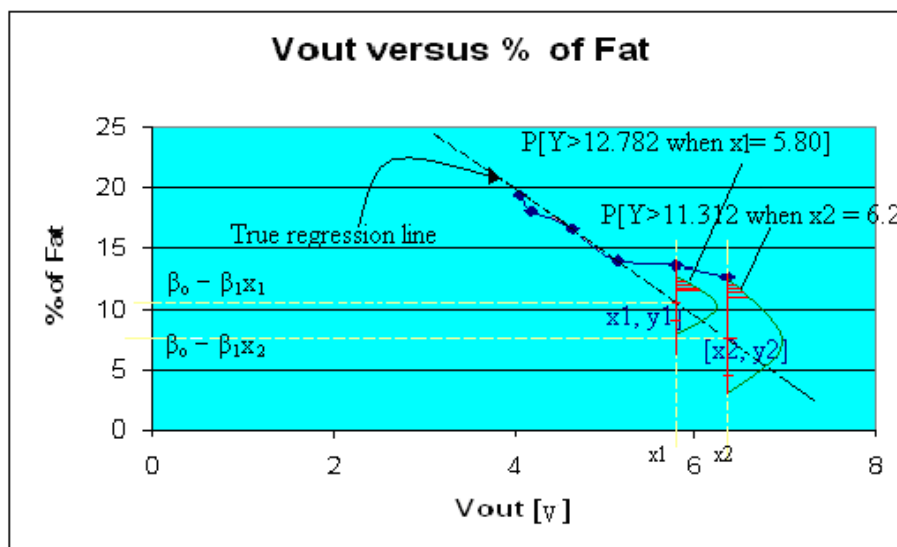


Fig.5: Graph of fat percentage Vs Voltage output

#### 4. CONCLUSIONS

Results from the preliminary experiment indicated that it is possible to measure fish fillet fat content using a non destructive infrared radiation technique. The slight non linearity of the fish fat percentage versus output voltage (Vout, from the infrared detector) graph is probably due to the small number of samples and slight variation in sample thickness. Future work will be to investigate the sensitiveness of detecting and measuring fish fat content using different wavelengths within the wide electromagnetic radiation wavelength and different types of detectors that are currently available such as the silicon based detector which covers

the range of 400 – 1100nm, an indium gallium arsenide detector that covers the range of 800 – 1700nm and the lead sulfide based detector that covers the range of 1100 – 2500nm.

## 5. References

- [1] M. David S. Siscovick, MPH; T. E. Raghunathan, et. al., "Dietary Intake and Cell Membrane Levels of Long-Chain n-3 Polyunsaturated Fatty Acids and the Risk of Primary Cardiac Arrest," *The Journal of the American Medical Association (JAMA)*, vol. 274, pp. 1363-1367, 1995.
- [2] B. T. Ho, Paul D. R., "Fatty acid profile of Tra Catfish (*Pangasius hypophthalmus*) compared to Atlantic Salmon (*Salmo solar*) and Asian Seabass (*Lates calcarifer*)," *International Food Research Journal*, vol. 16, pp. 501-506, 2009.
- [3] D. Ringgau, "Detection of Fish Fat Using Infrared Sensor," in Faculty of Electrical Engineering, Thesis, B. Eng. Shah Alam: University Teknologi MARA (UiTM), 2007, pp. 60.
- [4] S. T. Ritter, "An eye on food." *Chemical Engineering News*, vol. 83, 2005.
- [5] D. H. Clark, Short, R. E., "Comparison of AOAC and light spectroscopy analyses of uncooked ground beef. ," *Journal of Animal Science*, vol. 72, pp. 925-931, 1994.
- [6] K. Khodabux, M. S. S. L'Omelette , S. J. L'Omelette ,P.Ramasamy, P. Rondeau, "Chemical and near-infrared determination of moisture, fat and protein in tuna fishes," *Food Chemistry* vol. 102 pp. 669-675, 2007.
- [7] R.A. Shannon, Probert-Smith P.J., J. Lines,F. Mayia, "Ultrasound velocity measurement to determine lipid content in salmon muscle; the effects of myosepta " *Food Research International*, vol. Vol. 37, pp. pp. 611-620 2004.