Quantitative Evaluation of the Aldehyde Content in Commercially Available Coconut Oil and Olive Oil Subjected to High Temperature at Various Heating Periods

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This research paper herein entitiled:

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ABSTRACT

Aldehydes are organic compounds used in manufacturing resins and dyes and in the synthesis of organic acids. Aldehydes are usually formed during the combustion in hydrocarbons. Despite its many uses, aldehydes pose health risks such as cancer. This study aimed to determine and compare the percent aldehyde content in coconut and olive oils heated at various periods of time. The oils were heated until its smoking point and 1 hour after smoking point. Hydroxylamine titration were used to determine the percent aldehyde content. The mean percent aldehyde content of coconut oil heated until its smoking point and 1 hour after smoking point and olive oil heated until its smoking point and 1 hour after smoking point were 0.102, 0.620, 0.155, and 0.439 respectively. There is a significant difference in the mean percent aldehyde content of the samples. Heated coconut oil and olive oil pose health risks due to the fact that the amount of aldehydes exceed the tolerable intake level.

Keywords: *aldehydes, cooking oil, hydroxylamine titration, tolerable intake level*

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CHAPTER 1
INTRODUCTION

A. Background of the Study

Volatile organic compounds (VOCs) are a large group of carbon-based chemicals that easily evaporate at room temperature. Examples of commonly used volatile organic compounds are acetone, benzene, ethylene glycol, and formaldehyde (MDH 2010). Ketones and aldehydes are the functional groups usually found in VOCs.

Cooking oil is purified fat of plant origin, which is usually liquid at room temperature (Princeton University 2006). Cooking oil undergoes a process called cracking when heated at high temperatures which results to the formation of smaller molecules such as aldehyde-containing bi products (France 2008).

Aldehyde is an organic compound containing a formyl group which is widespread in nature and common in organic chemistry. Volatile aldehydes have pungent odors. Aldehydes are used in fragrances, in the manufacture of resins, dyes, and organic acids, and in preserving dead bodies from decomposing. Hundreds of individual aldehydes are also used as precursors and starting materials in the synthesis of other compounds (Britannica 2011).

Despite many desirable uses of aldehyde containing compounds, aldehydes also pose health risks. Many diseases are associated to VOC. There are short-term health effects such as headache, nausea/vomiting, dizziness, irritations, and worsening of asthma symptoms; and long-term effects such as cancer and liver, kidney, and central nervous system damage (MDH 2010). Aldehydes also cause esophageal cancer. The most common reported bad effect of aldehydes in the body is respiratory allergies (Wang et al 2001).

Several researchers have shown that aldehyde containing compounds are cancer agents which can be fatal. Biochemical studies show that aldehydes and other metabolites of alcohol cause oxidative DNA damage in a variety of organs. Oxidative DNA damage due to estrogen exposure and estrogen metabolites is closely associated to many of the established hormonal risk cancers for breast cancer according to the study of Zhu and Conney (1998).

Overheating cooking oil produces volatile aldehydes that can be inhaled. Also, foods cooked using overheated cooking oil contains aldehyde. If it can be prevented, the amount of emitted VOCs will decrease and there will be fewer cases of health problems that are associated to aldehydes (MDH 2010).

B. Statement of the Problem

This study aimed to evaluate quantitatively and compare the aldehyde content of commercially available coconut oil and olive oil after being subjected to high temperatures.

C. Objectives

This study specifically aimed to:

1. determine the amount of aldehyde present (%) in the coconut oil and olive oil after being subjected to high temperature until smoking point and 1 hour after smoking point
2. compare the amount of aldehyde content (%) of coconut oil when subjected to
   a. smoking point
   b. 1 hour after smoking point
3. compare the amount of aldehyde content (%) of olive oil when subjected to
   a. smoking point
   b. 1 hour after smoking point
4. compare the aldehyde content (%) of cooking oil and olive oil when subjected to high temperature until its smoking point and 1 hour after smoking point
5. compare the amounts of aldehyde (mg) to the tolerable intake level which is 2 mg

D. Significance of the Study

Vegetable oils are regarded as "good" fats because it helps lower cholesterol. Although vegetable oils are regarded as "good" fats, it can break down into smaller organic compounds which are also labeled as "harmful trans fats" after too much heating. Trans fats are much worse than animal oil in pushing up levels of cholesterol, potentially clogging up the arteries and causing heart disease (MDH 2010).

This study can help in informing people, especially those who are fond of eating deep fried foods, about the hazards brought about by cooking foods using oil subjected to high temperatures. The data from this study can help people assess the quality of oil that they will use in the future.

E. Scope and Delimitation

This study was conducted in Philippine Science High School-Western Visayas Campus Chemistry Laboratory. Materials and equipment that were used in this study are available in the same school. Hydroxylamine hydrochloride that was used for this study was purchased from the laboratory of University of San Agustin, Iloilo.

Coconut oil and olive oil samples were bought from Gaisano Capital City in Luna Street, Lapaz, Iloilo.

The amount of aldehyde in the cooking oil was determined by hydroxylamine titration.

F. Definition of Terms

Aldehyde - an organic compound containing a functional group which consists of a carbonyl center bonded to hydrogen and an R group (Clark 2003).

In this study, the presence of this in the cooking oil samples will be detected.

Biotransformation - process whereby a substance is changed from one chemical to another (transformed) by a chemical reaction (Monosson 2008).

In this study, this refers to cracking.

Carbonyl Group - a group of atoms that consists of a carbon atom covalently attached to an oxygen atom by a double bond: C = O (Net Industries 2010).

In this study, this refers to aldehyde but can also be referred to ketones, esters, acids, and amides.

Cracking - process of converting organic chemicals into much simpler molecule (France 2008).

In this study, cracking refers to the process when the cooking oil was heated during the frying of the fried chicken.

Formyl Group - carbonyl group joined by a single bond to a hydrogen atom (CUP 2007).

In this study, this refers to aldehydes.

High Temperature – refers to temperature above 280°C (500°F) (Webster's Online Dictionary 2011).

In this study, this refers to the temperature of the hot plate when the oil was heated until its smoking point and beyond its smoking point.

Ketone - an organic compound with the structure RC(=O)R', where R and R' can be a variety of atoms and groups of atoms (Answers Corp. 2010).

Smoking Point – specific temperature at which a substance gives off smoke or vapor (Harvard School of Public School 2011).

In this study, smoking point refers to the time smoke coming out from the oil was noticed.

Titration – method of analysis to determine the precise endpoint of reaction and therefore, the precise quantity of the reactant in the titration flask (Dartmouth College 2000).

In this study, this process will determine the precise amount of aldehyde present in the oil.

VOC - volatile organic compounds. It refers to a large group of carbon-based chemicals that easily evaporate at room temperature (MDH 2010).

In this study, VOC refers to aldehyde or ketone.

CHAPTER 2
REVIEW OF RELATED LITERATURE

A. Cooking Oil

Basically, cooking oil is a type of oil used for cooking. Cooking oils are molecules of triacylglycerides (TAGs) which are basically carbon & hydrogen atoms; each TAG consists of a glycerol 'head' joined to three fatty acid tails. The tails are hydrocarbons, and each one can vary in length depending on the plant that made the oil, so for instance rapeseed oil has longer tails than olive oil. The shape of the tail can also vary: if the tail is straight then it's a saturated fat, and if there's a kink in the tail it means that the oil is unsaturated. If oil is just labeled 'cooking oil', then it's likely to be a blend of oils from different sources, each one having slightly different properties (Answers 2010).

Cooking oil contains either saturated fat or unsaturated fat.

A.1. Saturated fat

Saturated fats have a chemical makeup in which the carbon atoms are saturated with hydrogen atoms. Saturated fats are typically solid at room temperature (AHA 2010). Dairy products such as butter and cheese; animal fats, coconut oil, palm oil, and chocolate are examples of saturated fats.

A.2. Unsaturated fat

Unsaturated fats are almost always plant-based, although there are some naturally unsaturated fats in certain meats. These unsaturated fats are perhaps better known as vegetable oils, since they remain in a liquid or oily state at room temperature (Pollick 2010).

When heated, cooking oil breaks down into simpler compounds. The bonds between in the carbon are broken due to high temperature. The cooking oil undergoes the process of cracking. This process involves thermal decomposition. The larger hydrocarbons are broken down into smaller hydrocarbons (France 2008).

B. Aldehydes

Aldehyde is one of the bi products of oil after the process of cracking. When the smoke point of certain cooking oil is reached, it can be said that the cooking oil is undergoing or has undergone the process of thermal decomposition.

Aldehydes have pungent odors. Some aldehydes are used in fragrances. Aldehydes appear to be colorless and pale yellow liquid. Aldehydes, such as cinnamaldehyde and vanillin, are used as flavor enhancers.

Aldehydes comprise a group of reactive organic compounds, characterized by the presence of a polarized carbon-oxygen double bond (carbonyl group) – an electrophilic site which reacts readily with nucleophiles. These compounds may be subdivided into 3 classes based on their structure and reactivities; saturated or simple, α,β-unsaturated; and halogenated or otherwise substituted aldehydes. Metabolic fats include conjugation with moieties such as glutathione (levels of reduced glutathione [GSH] are low in the human nose, but high [≈ 0.4mM] in the epithelial lining fluid of the lower airways), cysteine or serine and/or oxidation to the corresponding carboxylic acid, or reduction to the alcohol. Many of these compounds show DNA and protein-binding properties (COMEAP 2009).

B.1. Harmful Effects of Aldehydes

B.1.1. Sensory Irritation

Formaldehyde, acrolein and acetaldehyde vapours all show effects of eye and respiratory tract irritancy in humans. Studies of the pungency (irritation) thresholds of human volunteers to a series of aliphatic aldehydes (butanal to octanal) showed decreasing thresholds with increasing chain length up to a "partial cut off" (inability to detect pungency) at octanal, an effect which has also been observed with other organic series. Studies in mice have shown that (excluding the very potent formaldehyde) saturated aliphatic aldehydes are generally less potent than cyclic aldehydes which, in turn, are less potent than unsaturated aliphatic aldehydes in inducing decreased breathing frequency, which is used as a measure of sensory irritation. Studies in rats have suggested that the combined sensory irritation effects of mixtures of formaldehyde, acrolein

and acetaldehyde vapors are less than completely additive, probably due to competition for a common target: the trigeminal nerve (COMEAP 2009).

B.1.2. Effects on Pulmonary Function

There is very little evidence that inhalation of aldehyde vapours causes asthma, although, as for any other irritant, they may increase non-specific sensitivity to other agents in asthmatic subjects. Conversely, a small number of studies have shown that inhalation of acetaldehyde vapour may induce bronchoconstriction and potentiate non-specific bronchial responsiveness in some asthmatic patients. The *in vivo* effects of acrolein vapour on pulmonary function in humans have not been assessed. However, a small number of studies with isolated human bronchi "*ex vivo*" have shown that the compound may enhance bronchial reactivity to stimulation by allergen or various pharmacological agents.

B.1.3. Carcinogenity

Formaldehyde is classified as a probable human carcinogen. Epidemiological studies of occupationally-exposed subjects have suggested a causal association of high exposure levels with the development of nasopharyngeal cancers. There are very few human or animal data regarding the carcinogenicity of acrolein vapor. The compound is categorized as a possible human carcinogen, based on one oral study in rats, and as unclassifiable. A study in hamsters showed no compound-related tumors associated with exposure to 9 mg/m3 [4 ppm] acrolein vapor for 52 weeks. Acetaldehyde is classified as possibly/probably carcinogenic to humans, based on the observation of dose-dependent tumor incidence in inhalation bioassays in rats and hamsters. Assessments of risk to human health based on extrapolation from inhalation studies in animals are, however, limited as anatomical differences in the upper respiratory tract lead to different airflow patterns and thus the proportion of the inhaled dose supplied to a particular target tissue is difficult to predict (IARC and US EPA 1995).

C. Aldehyde Determination

There are many ways to determine aldehydes in our environment. Different tests, methods, machines, and reagents have been made and discovered to determine amount of these volatile compounds.

In a study of Thomas and others (1995), gas chromatography mass spectrometry was used in detecting and identifying volatile compounds. In a study of Vo and others (2007), aldehydes were detected using a novel colorimetric indicator pad.

D. Hydroxylamine Hydrochloride

Hydroxylamine hydrochloride is added to the oil and reacts with the aldehyde groups, thus resulting to an oxime and hydrochloric acid. The acid can then be determined by titration with a base (Googlebook 2011).

In a study of Varma and Naicker (1998), arylaldehydes were converted to nitriles using hydroxylamine hydrochloride impregnated montmorillonite K10 clay under microwave irradiation.

In a study of Zhao and Heindel (1990), formyl content was determined using colorimetric titration of the aldehyde residue in polyaldehyde dextran by the hydroxylamine hydrochloride/sodium hydroxide method.

E. Related Studies

In a study of Sjaastad and Svendsen, levels of PAH, aldehydes and particulate matter in the breathing zone of the cook were measured. The study was performed in three restaurants in the city of Trondheim in the middle of Norway. Naphthalene was detected within the range of 0.05-0.27 $\mu g\ m^{-3}$ air and the total mean value for all three restaurants was 0.18 $\mu g\ m^{-3}$ air. The measured levels of mutagenic aldehydes were between 1.03 and 17.67 $\mu g\ m^{-3}$ air. The mean mass concentration of total particles measured in the three restaurants was 1.93 $mg\ m^{-3}$, and the levels registered were within the range 0.32-7.51 $mg\ m^{-3}$ (2009).

In a study of Katsuta and others, the emission of volatile aldehydes from diacylglycerol-rich oils (DAG-OILs) and triacylglycerol-rich oils (TAG-OILs) with different degrees of

unsaturation of fatty acid moieties during the deep-frying of sliced potatoes. To examine the effect of fatty acid composition, four kinds of oils with different fatty acid compositions were selected: rape seed (RS); sunflower oil as a high oleic (HO); safflower oil as high linoleic (HL); and, perilla oil as high linolenic (HLn) oils. The emissions of volatile aldehydes were determined during the deep-frying of sliced potatoes by using the above fresh test oils or deteriorated RS oils. The statistical analysis showed no significant difference in volatile aldehyde emission and profile between the DAG-OIL and TAG-OIL with the fatty acid composition of RS, HL, and HLn. Although a statistically significant difference was noted in the volatile aldehyde emission between the DAG-OIL and TAG-OIL with HO, this difference was extremely small when compared to the variations found in the oils with four types of fatty acid composition. Finally, no difference was found in the volatile aldehyde emissions between the deteriorated DAG-OIL and TAG-OIL, although volatile aldehyde emissions increased with frying time. In addition, the acrylamide contents in potato chips prepared with RS–DAG or RS–TAG were at comparable levels (2008).

In a study of Sawicki and others, a sensitive new spectrophotometric procedure is described for the analysis of aliphatic aldehyde 2,4-dinitrophenylhydrazones. The chromogens formed in the procedure absorb at 667 mμ and are approximately three times as intense at this band as the starting aldehyde derivatives are in neutral and alkaline solvent at their wavelength maxima. With further improvement the procedure is capable of even greater sensitivity. Other aliphatic aldehyde derivatives also should be analyzable by this procedure, but 2,4-dinitrophenylhydrazones of ketones do not react (1961).

In a study of Sjaastad and others, levels of PAHs and higher mutagenic aldehydes in a model kitchen in conditions similar to those in a Western European restaurant kitchen. The levels of PAHs (16 EPA standard) and higher aldehydes (trans,trans-2,4-decadienal, 2,4-decadienal, trans-trans-2,4-nonadienal, trans-2-decenal, cis-2-decenal, trans-2-undecenal, 2-undecenal) were measured during frying on an electric or gas stove with margarine or soya bean oil as the frying fat. The number concentration of particles <100 nm in size (ultrafine) was also measured, as well as the mass concentration of total particulate matter. It was found out that levels of naphthalene were in the range of 0.15–0.27 $\mu g/m^3$ air. Measured levels of mutagenic aldehydes were between non-detectable and 61.80 $\mu g/m^3$ air. The exposure level of total aerosol was between 1.6 and

7.2 mg/m^3 air. Peak number concentrations of ultrafine particles were in the range of 6.0×10^4–89.6×10^4 particles/cm^3 air.

CHAPTER 3
METHODOLOGY

A. Overview of the Study

This study on determination of aldehyde content from commercially bought coconut oil and olive oil used laboratory techniques. Oil was heated at various heating periods. Hydroxylamine solution was added to the oil sample. Potassium hydroxide was titrated until pH reached 3.5.

B. Materials and Equipment

Equipment that was used in this study are from Philippine Science High School-Western Visayas laboratories.

Equipment:

1. Burettes
2. 150 mL beakers
3. 400 mL beakers
4. Iron stand
5. Burette clamp
6. Hotplate
7. Analytical balance
8. pH meter
9. 500 mL volumetric flask
10. Magnetic stirrer

Materials

1. Aluminum foil
2. 200 mL minola (coconut) oil
3. 250 mL olive oil
4. Detergent
5. Distilled water
6. 15g Hydroxylamine Hydrochloride
7. Tissue

C. Acquisition of Samples

Coconut oil and olive oil were bought from Gaisano Capital City at Luna Street, Lapaz, Iloilo.

D. Preparation of Potassium Hydroxide Solution

14.027 g of KOH was weighed using analytical balance. KOH was dissolved in using distilled water and filled up to 500 mL in a volumetric flask.

E. Preparation of Hydroxylamine Solution

15g $H_2NOHHCl$ was dissolved in 20 mL of hot water in a 150 mL beaker. The solution was transferred to a 1 L volumetric flask. Solution was diluted to 500 mL using 95% ethanol. pH was adjusted to 3.5 by adding NaOH. The solution was stored inside the refrigerator.

F. Preparation of Equipment

The beakers, burettes, and volumetric flasks were washed using water and detergent. One burette was rinsed with hydroxylamine solution and filled with it. The other burette was rinsed with potassium hydroxide solution and filled with it.

G. Preparation and Heating of Oil Sample

200 mL coconut oil was divided into two and was placed in two 400 mL beakers. 250 mL olive oil was also divided into two and was placed in two 400 mL beakers. Oil was heated in the hot plate until its smoking point. A beaker containing coconut oil and a beaker containing olive oil was taken from the hot plate and covered with aluminum foil. The remaining beakers were heated for 1 hour and covered with aluminum foil after heating. The beakers were labeled properly.

H. Hydroxylamine Titration

10 g of oil sample was weighed into a 150-mL beaker using analytical balance. 30 mL of hydroxylamine solution was added to the sample and was swirled for 15-30 min using the magnetic stirrer. 0.5M KOH was titrated to pH 3.5. Initial and final readings were noted.

I. Determination of Amount of Aldehyde

The total amount will be calculated using the equation:

%aldehydes= (x mL titrated) x CF x 100% x (1/oil weight)

Where CF(correction factor)= 0.0781 g decanal/1 ml 0.5N KOH.

J. Handling and Disposal

Gloves were worn in disposing the chemicals. The oil solutions, oil remnants, and excess hydroxylamine hydrochloride were placed into different sealed containers. Excess KOH were disposed in the sink. Hands were washed after handling the chemicals. Beakers, burettes, and volumetric flask were washed thoroughly with water and detergent.

CHAPTER 4
RESULTS AND DISCUSSION

This study was conducted to quantitatively determine and compare the amount of aldehyde in cooking oil after being subjected to high temperature. Two cooking oils, coconut oil and olive oil were heated until smoking point and 1 hour after smoking point. The amount of aldehyde present was determined by titration with hydroxylamine solution. Percent aldehyde content was calculated using the equation:

%aldehydes= (x mL titrated) x CF x 100% x (1/oil weight),
where CF (correction factor) =0.0781g decanal/1 mL 0.5N KOH.

The percent aldehyde content of the following were compared using t-test: coconut heated until smoking point and 1 hour after smoking point, olive oil heated until smoking point and 1 hour after smoking point, coconut and olive oil heated until smoking point, and coconut and olive oil heated 1 hour after smoking point. The percent aldehyde content of coconut oil and olive oil heated until its smoking point and 1 hour after its smoking point were also compared using ANOVA.

A. Results

A.1. Mean Percent Aldehyde Content

The mean percent aldehyde content of the four samples was compared. Coconut oil heated 1 hour after its smoking point yielded the highest percent aldehyde mean. Table 1 shows the mean percent aldehyde of the four samples.

Table 1. Mean percent aldehyde content of coconut and olive oil heated at various periods

Sample	Mean percent aldehyde content (%)
Coconut Oil (Smoking Point)	0.102 (10.2 mg)
Coconut Oil (1 hour after smoking point)	0.620 (62.0 mg)
Olive Oil (Smoking Point)	0.155 (15.5 mg)
Olive Oil (1 hour after smoking point)	*0.439 (43.9 mg)*

A.2. Comparison of the Samples Heated at Various Periods

Table 2 shows the comparison of the aldehyde content in coconut and olive oil heated until its smoking point and 1 hour after smoking point.

Table 2. Significant difference in the aldehyde content of coconut and olive oil heated until its smoking point and 1 hour after smoking point.

Comparison between samples		Significant difference
Coconut Oil	Smoking Point	Significant
	1 hr after smoking pt.	
Olive Oil	Smoking Point	Significant
	1 hr after smoking pt.	
Smoking Point	Coconut Oil	Not Significant
	Olive Oil	
1 hr after smoking pt.	Coconut Oil	Significant
	Olive Oil	

B. Discussion

Oils heated 1 hour after their smoking point yielded the greatest aldehyde percentage. This must have been attributed to the chemical properties of both oils. Coconut oil and olive oil are both unsaturated fats and contain double bonds (Pollick 2010). The greater the number of double bonds in a fatty acid, the more unstable they are and easily broken down (The Olive Oil Source 2011).

Coconut oil has more percent aldehyde content than olive oil when it was heated 1 hour after its smoking point. But on its smoking point, coconut oil has lesser percent aldehyde content than olive oil. The significant difference between the coconut oil and olive oil heated 1 hour after its smoking point must have been attributed to the fact that coconut oil is a polyunsaturated fat and olive oil is a monounsaturated fat (Posch 2008). Coconut oil contains more double bonds than olive oil, so they tend to break down easily into smaller compounds.

There is a significant difference in the percent aldehyde content of oil samples heated until its smoking point and 1 hour after smoking point. There is a significant difference in the percent aldehyde content of coconut oil heated until its smoking point and 1 hour after its smoking point. There is also a significant difference in the percent aldehyde content of olive oil heated until its smoking point and 1 hour after its smoking point. This shows that temperature and heating period are also factors that attributes to the formation of aldehyde. The longer the oil was exposed to high temperatures, the more aldehydes it produced. Tolerable intake level of aldehydes is 2 mg (Blake, 2011). The results showed that the amounts of aldehydes in the heated oils are above the tolerable intake level, making it dangerous to be induced.

Color change in the oil heated 1 hour after its smoking point was noticed. Coconut oil turned into dark yellow while olive oil turned dark brown. Color change of oil is an indication of oil deterioration, resulting to formation of aldehydes (Serjouie, 2010). Also, both oils gave off a foul odor when it was heated 1 hour after its smoking point. Volatile aldehyde emission must have been the cause of this since aldehydes have pungent odor.

CHAPTER 5
SUMMARY, CONCLUSION, AND RECOMMENDATION

This study aimed to quantitatively evaluate and compare the amount of aldehyde in commercially available coconut and olive oil after subjected to high temperatures.

It specifically aimed to:

1. Determine the amount of aldehyde present (%) in the coconut oil and olive oil after being subjected to high temperature until smoking point and 1 hour after smoking point.
2. Compare the amount of aldehyde content (%) of coconut oil when subjected to smoking point and 1 hour after smoking point.
3. Compare the amount of aldehyde content (%) of olive oil when subjected to smoking point and 1 hour after smoking point.
4. Compare the aldehyde content (%) of cooking oil and olive oil when subjected to high temperature until its smoking point and 1 hour after smoking point.
5. Compare the amounts of aldehyde (mg) to the tolerable intake level which is 2 mg.

A. Summary of Results

1. The mean percent aldehyde of coconut oil heated until smoking point, coconut oil heated 1 hour after smoking point, olive oil heated until smoking point, and olive oil heated 1 hour after smoking point were *0.102*, *0.620*, *0.155*, and *0.439* respectively.
2. There is a significant difference in the percent aldehyde content of coconut oil heated at smoking point and 1 hour after smoking point.
3. There is a significant difference in the percent aldehyde content of olive oil heated at smoking point and 1 hour after smoking point.
4. There is a significant difference in the percent aldehyde content of coconut oil and olive oil heated at their smoking point and 1 hour after smoking point.
5. Aldehyde content (mg) of coconut oil and olive oil heated at smoking point and 1 hour after smoking point are above the tolerable intake level.

B. Conclusion

Coconut oil and olive oil heated at high temperatures produced aldehydes that are above the tolerable intake level. In their smoking point, olive oil has greater percent aldehyde content than coconut oil. But, when heated 1 hour after its smoking point, olive oil showed lesser percent aldehyde content than coconut oil.

C. Recommendations

It is recommended that future studies would:

1. Consider other brands of oil to be analyzed.
2. Use more accurate method or equipment in analyzing the amount of aldehyde present in the oil, such as gas chromatography, colorimetry, and mass spectrometry.
3. Consider other factors, such as light intensity, in the formation of aldehydes.
4. Use time intervals lesser than 1 hour in oil heating.
5. Use a hotplate that shows the exact temperature in heating.

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158&_user=10&_coverDate=12/31/1962&_rdoc=1&_fmt=high&_orig=search&_sort=d&_doca nchor=&view=c&_searchStrId=1438929923&_rerunOrigin=google&_acct=C000050221&_vers ion=1&_urlVersion=0&_userid=10&md5=120a31a7b6d43edbe88b99ccb45974ee. Accessed 2010.

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APPENDIX A

RAW DATA

Coconut Oil (Smoking Point)	
Trials	Aldehyde Content (%)
Trial 1	0.151945525
Trial 2	0.077634194
Trial 3	0.077480158

(Smoking Point)	
Trials	Aldehyde Content (%)
Trial 1	0.155422885
Trial 2	0.155268389
Trial 3	0.155577689

Coconut Oil ()	
Trials	Aldehyde Content (%)
Trial 1	0.619841269
Trial 2	0.623552894
Trial 3	0.618001978

Olive Oil (1 Hour After Smoking Point)	
Trials	Aldehyde Content (%)
Trial 1	0.383218842
Trial 2	0.465805169
Trial 3	0.466733067

APPENDIX B
PLATES

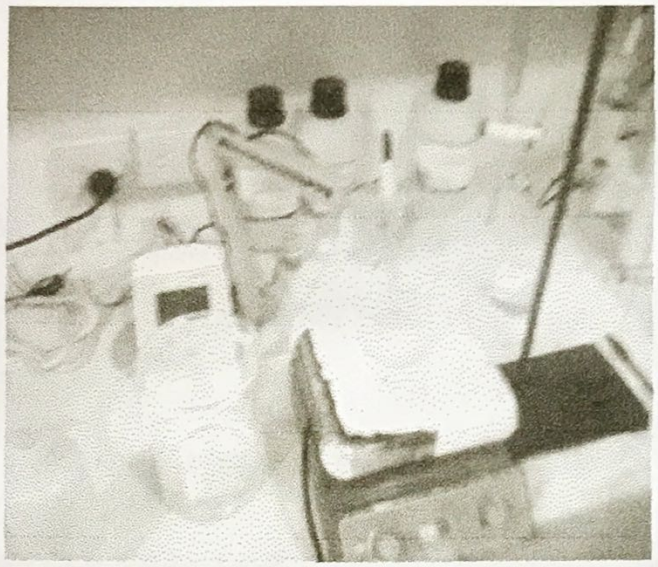

Plate 1. Titration with Potassium Hydroxide Solution

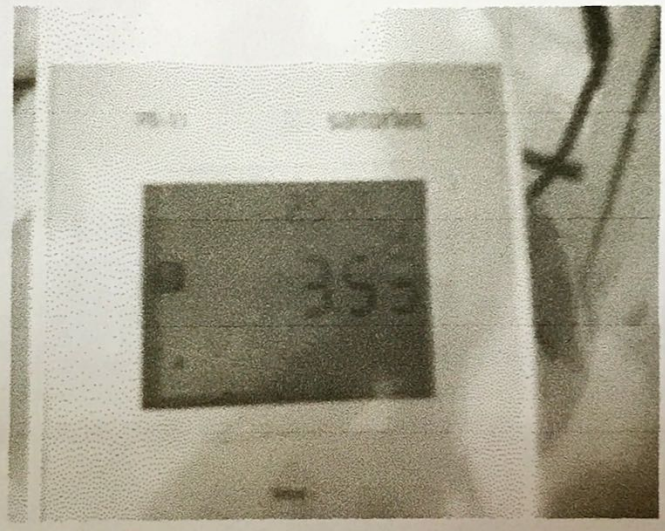

Plate 2. pH meter showing pH = 3.5

Plate 3. Weighing of Oil Samples

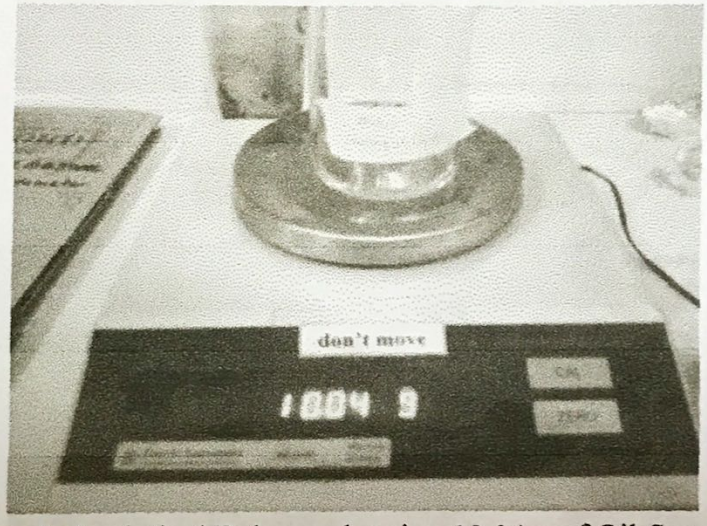

Plate 4. Analytical Balance showing 10.04 g of Oil Sample

Plate 5. Addition of Hydroxylamine Solution

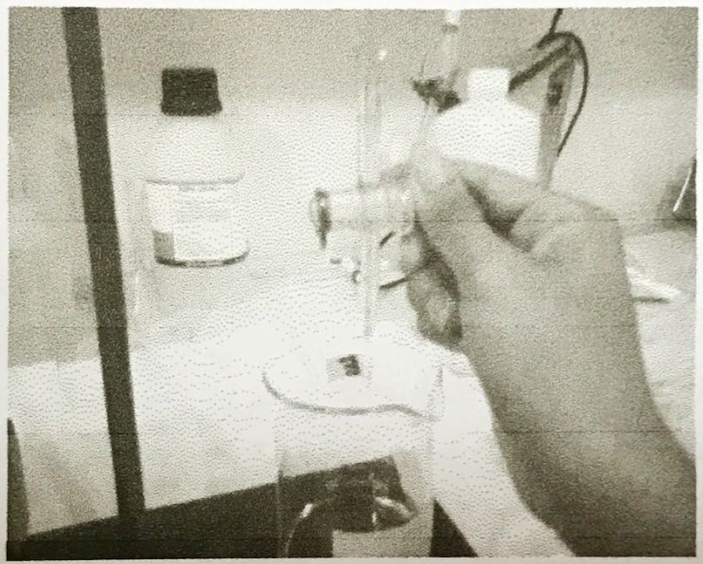

Plate 6. Addition of Hydroxylamine Solution

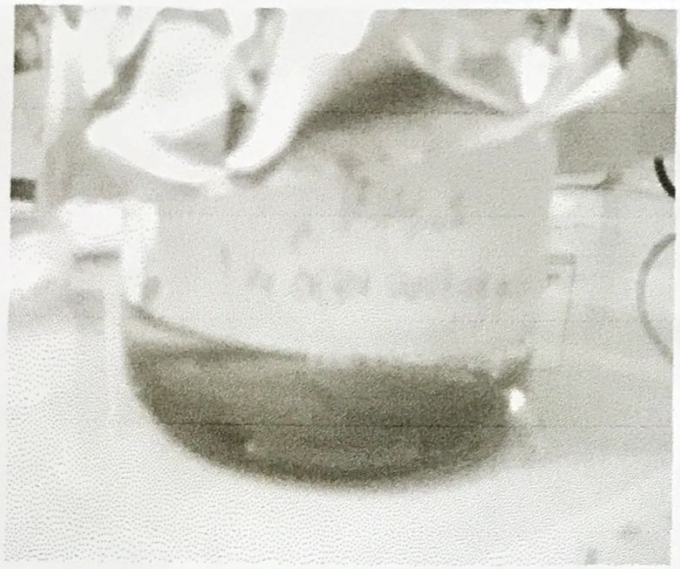

Plate 7. Covering and Labeling of Beakers

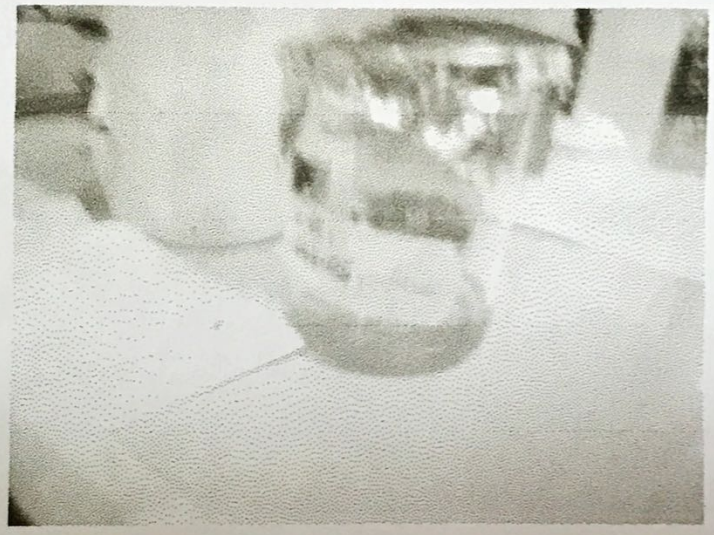

Plate 8. Covering of Beakers

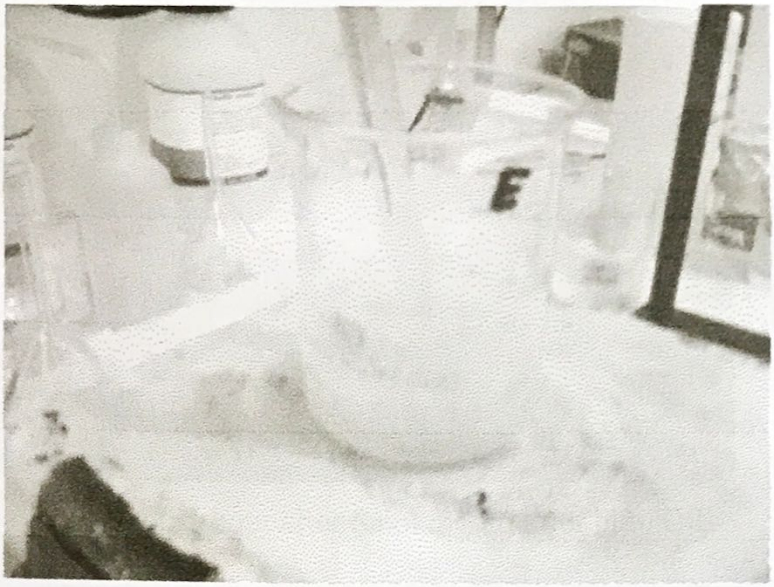

Plate 9. Swirling of Samples

Plate 10. Swirling of Samples using Centrifuge

Plate 11. 1 hour after Smoking Point of both Oils

Plate 12. 1 hour after Smoking Point of Both Oils

Plate 13. Brands used

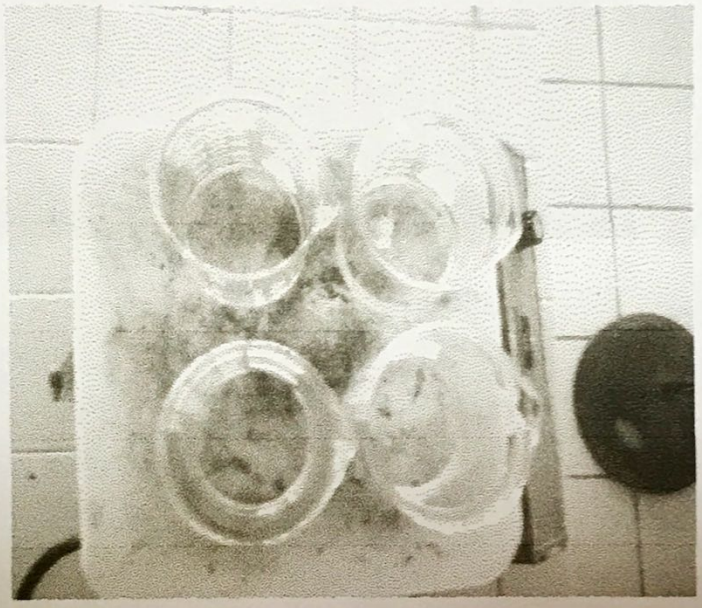

Plate 14. Heating of Cooking Oils

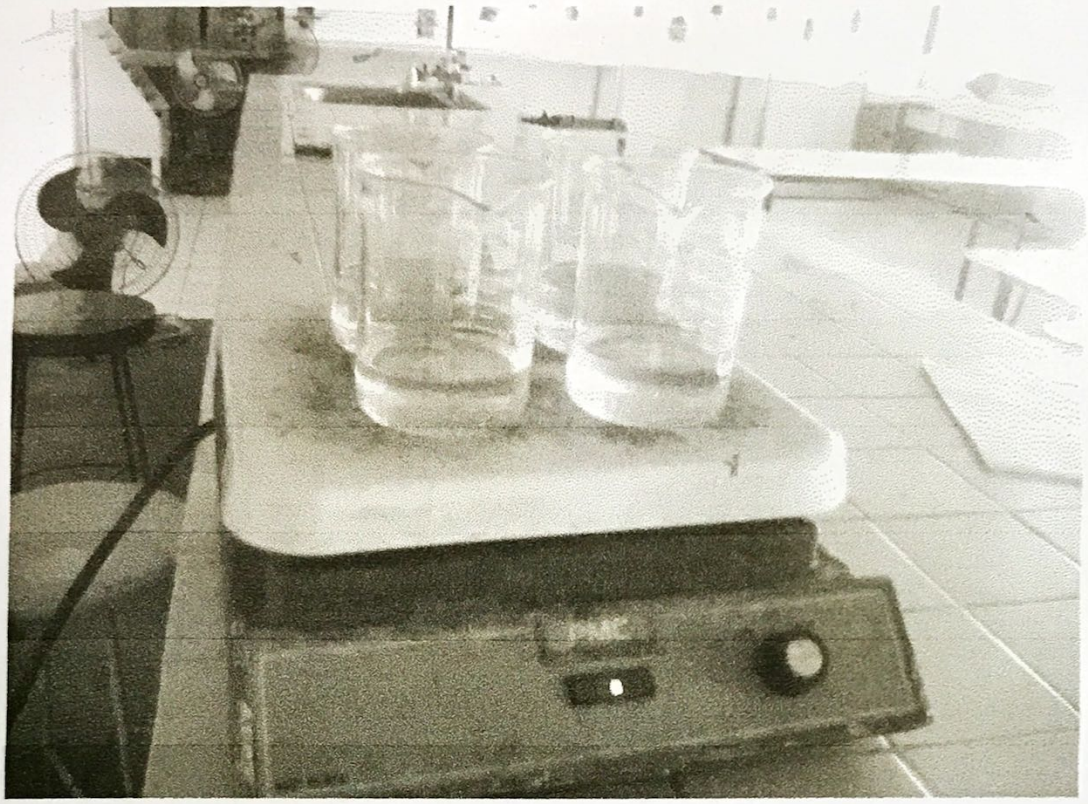

Plate 15. Heating of Oils