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Extraction, Chemical Analysis, and Smoke Point Determination of *Terminalia catappa Linn* Seed Oil

Rachel Ann Joy D. Go[1], Rose Adrienne A. Dayo[2], and Gladys Mae R. Laborde[3,*]
[1,2,3]Adventist University of the Philippines, Philippines
*Corresponding author: GRLaborde@aup.edu.ph

Abstract

Terminalia catappa Linn fruit, also known as tropical almond, is under-utilized. This study on food product development aimed to produce cooking oil out of the *Terminalia catappa Linn* seeds and determine its properties. The fruits were gathered and dehydrated for 16 hours using the Multi-Commodity Heat Pump Dryer. Each dehydrated *Terminalia catappa* Linn fruit was crushed to get the seed inside. The seeds were roasted and pulverized. Seeds were then subjected to oil extraction and chemical analysis. The smoke point of the oil extracted was tested in the chemistry laboratory. Based on the results, *Terminalia catappa Linn* seed yields 53.4% of fat. The distribution of the fatty acids in *Terminalia catappa Linn* oil is close to the optimum fatty acid balance ratio of saturated fatty acid (38%), monounsaturated fatty acid (MUFA 29%), polyunsaturated fatty acid (33%) of 1:1:1. The smoke point of the *Terminalia catappa* Linn oil is 392 °F or 200 °C, which is comparable to the smoke points of other common cooking oils. Therefore, *Terminalia catappa Linn* seed oil can be a healthy and practical option for cooking. Market studies and microbiological tests of the *Terminalia catappa* Linn oil are recommended.

Keywords: chemical analysis, cooking oil, extraction, smoke point, *Terminalia catappa Linn* seed

INTRODUCTION

Terminalia catappa Linn, also known as Talisay, is a naturally occurring plant that belongs to the Combretaceae family. They are widespread in subtropical and tropical countries (Weerawatanakorn et al., 2015). *Terminalia catappa* Linn has different common names in every country where it is found. It is known as *Talisay* in the Philippines, and for some countries, it is called Indian almond, Tropical almond, Umbrella tree, among others (Philippine Medicinal Plants, 2013).

Terminalia catappa Linn seeds have been known as edible; however, it is not commonly consumed. In some countries, specifically in Thailand, mature seeds are usually eaten by children. They will hit the mature fruits with a stone or cut them with a knife (Weerawatanakorn et al., 2015). A study reported that *Terminalia catappa Linn* seeds have high-fat content and have higher protein content than legumes such as lentils, mung beans, and chickpeas. *Terminalia catappa Linn* seeds oil content is also close to the oil content of oilseeds such as peanuts, rapeseeds, and sunflower (Oliveria et al.,2000)

Fats cannot be discarded from the human diet because it is as essential as proteins and carbohydrates; people must choose healthier sources of fats. Nowadays, there are many types of cooking oil from different sources, from various plants and animals. Fatty acids from different oils of various sources are certainly different from each other. Some are rich in saturated fatty acids, which makes the oil unhealthy, and some are abundant in unsaturated fatty acids, which is beneficial to the consumers' health (Madell, 2016).

Cooking oil plays a vital role in everyone's kitchen. It is widely used for many purposes and myriad types of cookery, which make foods more palatable. *Terminalia catappa Linn* seed has been known as edible, but only a few research were done to be consumed as food. Thus, this research would want to introduce an alternative source of cooking oil from *Terminalia catappa Linn* seeds.

Goal of the Study

The goal of this research was to produce cooking oil from the *Terminalia catappa Linn* seeds and determine their properties.

Objectives:

1. Extracted oil from *Terminalia catappa* Linn seeds using Soxhlet extraction method
2. Identified proximate composition and fatty acid profile of *Terminalia catappa* Linn seed oil
3. Determined the smoke point of *Terminalia catappa* Linn seed oil
4. Compared the characteristics of *Terminalia catappa* Linn seed oil with other cooking oil

METHODOLOGY

This study on food product development is an experimental research and involves the extraction, chemical analysis, and smoke point determination of *Terminalia catappa* Linn seed oil. Figure 1 shows the process flow of how the research was done. *Terminalia catappa* Linn fruits were gathered inside a university in the Philippines. The researchers picked the matured seeds that fell on the ground. *Terminalia catappa* Linn fruits were cleaned with running water and placed in the Multi-commodity heat pump dryer. The dehydration process was done for 16 hours at a temperature of 50 °C. Through a hammer, knife, and pestle, dehydrated *Terminalia catappa* Linn fruits were crushed, and seeds were collected from each of the fruits. The seeds were roasted in the convection oven for 7 hours at 60 °C. The roasted seeds were then pulverized using a food processor

Terminalia catappa Linn seeds oil was extracted upon the submission of 98g *Terminalia catappa* Linn seeds powder to the Department of Science and Technology (DOST) Industrial Technology Development Institute (ITDI) Standards and Testing Division (STD). The oil was extracted by Soxhlet extraction using petroleum ether as the solvent. The oil extracted was used for fatty acids profile and nutrient analysis.

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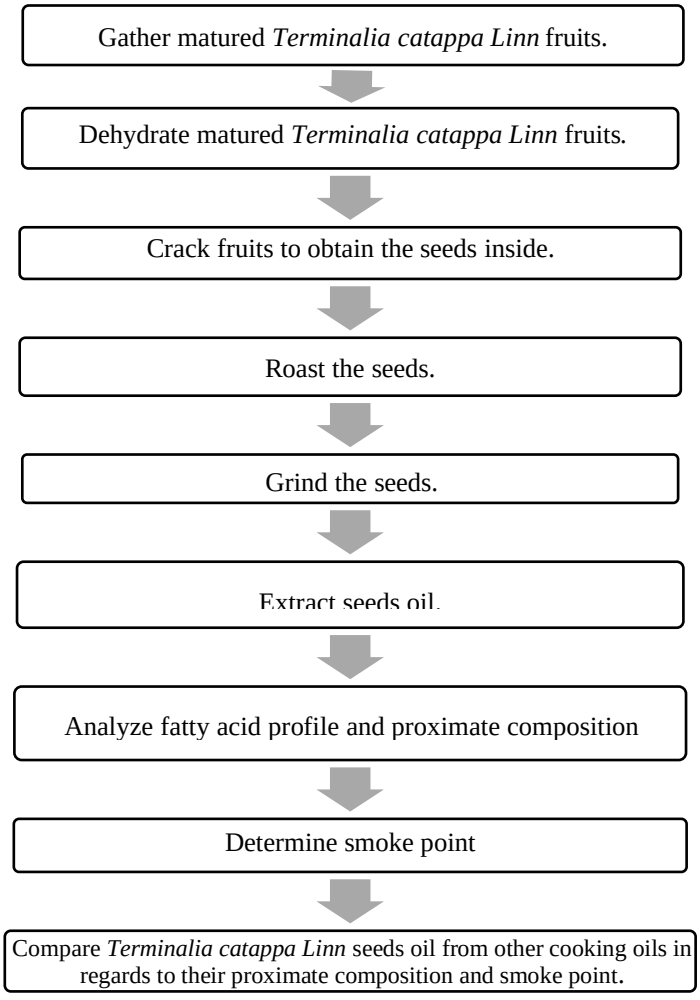
Another batch of *Terminalia catappa* Linn seeds oil was extracted at the Institute of Food Science and Technology, College of Agriculture at the University of the Philippines, Los Baños. The oil was extracted from 207g *Terminalia catappa* Linn seeds powder by the Soxhlet extraction method using petroleum ether as the solvent. The oil was used for smoke point determination and presentation.

Smoke point determination of *Terminalia catappa* Linn seeds oil, palm oil, and canola oil was done in the laboratory of the Chemistry Department of Adventist University of the Philippines. A direct heat method was done to determine the smoke points of the cooking oils. Five 50 ml beakers were used. Each was directly placed on top of a hot plate with a temperature regulator. Every three beakers contain 20 ml of *Terminalia catappa* Linn seeds oil. The other two beakers contain 20 ml of canola oil and 20 ml of palm oil. A Laboratory thermometer was hung above the beaker that was placed on the hot plate. The temperature was recorded when the oil started to produce continuous wisps of smoke. After obtaining the needed information about *Terminalia catappa* Linn seeds oil, information from other common cooking oils was gathered. Their fatty acids composition, such as Saturated Fatty Acids (SFA), Monounsaturated Fatty Acids (MUFA), Polyunsaturated Fatty Acids (PUFA), and smoke points, were compared using a chart.

Figure 1: Process Flow



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The study used high-quality and appropriate equipment for oil extraction to obtain quality oil. Below are the equipment used for the research.

Equipment

Multi-Commodity Heat Pump Dryer. It was used to dehydrate matured fruits of *Terminalia catappa* Linn seeds before it was cracked to obtain the seeds.

Convection Oven. It was used to roast *Terminalia catappa* Linn seeds.

***Food Processor*.** It was used to crush *Terminalia catappa* Linn seeds and produce a fine powder.

Gas Chromatograph. The extracted oil was placed here for fatty acids profile and nutrient analysis.

***Soxhlet Extractor*.** The apparatus was used to extract fat from *Terminalia catappa* Linn seeds.

Utensils

***Hammer, knife, and pestle*.** These were used to crack and open the shells of the matured fruits of the *Terminalia catappa* Linn to get the seeds inside.

***Utility Tray*.** A flat rectangular tray with raised edges to stop things from sliding off. Collected *Terminalia catappa* Linn seeds were placed in the utility tray while dehulling the fruits.

***Weighing scale*.** It was used to measure the *Terminalia catappa* Linn seeds for the experiment

Electric hot plate. It was used to raise the temperature of the oil.

Test tube rack. It was used to hold the test tubes containing *Terminalia catappa* Linn seeds oil and other common cooking oils.

Test tubes. The oils that were subjected to experimentation were placed in the test tubes.

***Test tube holder*.** This was used to hold the test tubes while doing the experiment

***Laboratory thermometer*.** to monitor the temperature of *Terminalia catappa* Linn seeds oil and other common cooking oils

***Graduated cylinder*.** This was used to measure the amount of oil needed for the experiment.

RESULTS AND DISCUSSION

Fat Extraction

Out of the 207g of roasted and pulverized *Terminalia catappa* Linn seeds, 110mL of oil was extracted. The extracted oil is crude since there are compounds that are soluble in the extracting solvent used, which is petroleum ether. Examples of these compounds are pigments and lipid-soluble vitamins (Vitamins A, D, E, K). Moreover, there is a possible recovery loss of less than

1% due to the adherence of extracted oil to the filter cloth and glassware during subsequent transfer. Table 1 shows the *Terminalia catappa* Linn seed crude oil extraction results.

Table 1: Terminalia catappa Linn Nut Crude Oil Extraction Result

Sample	Initial Wt. (g)	Volume of Extracted Oil (ml)
Terminalia catappa Linn Seeds powder	207	110

Fatty Acid Profile

There are several types of Fatty Acids found in the *Terminalia catappa* Linn seed oil. These are SFA, MUFA, and PUFA. *Terminalia catappa* Linn oil contains the following saturated fatty acids: caproic, caprylic, myristic, palmitic, heptadecanoic, stearic, arachidic, and behenic and contains no butyric, capric, undecanoic, lauric, tridecanoic, pentadecanoic, heneicosanoic, tricosanoic, and lignoceric. Table 2 shows the amounts of saturated fatty acids found in *Terminalia catappa* Linn oil.

Table 2: Amounts of Saturated Fatty Acids Found in Terminalia catappa Linn Seed Oil

Fatty Acids		Fatty Acid Profile, %w/w
Butyric	C4	ND
Caproic	C6	0.588
Caprylic	C8	0.034
Capric	C10	ND
Undecanoic	C11	ND
Lauric	C12	ND
Tridecanoic	C13	ND
Myristic	C14	0.090
Pentadecanoic	C15	ND
Palmitic	C16	32.1
Heptadecanoic	C17	0.058
Stearic	C18	4.11
Arachidic	C20	0.499
Heneicosanoic	C21	ND
Behenic	C22	0.275
Tricosanoic	C23	ND
Lignoceric	C24	ND
TOTAL		**37.75**

ND- None Detected

Test Method: AOAC Official Method 963.22, 19th Ed., 2012

Monounsaturated Fatty Acids (MUFA). *Terminalia catappa* Linn oil contains the following monounsaturated fatty acids: palmitoleic, cis-10-Heptadecanoic, oleic, and cis-11-Eicosenoic and contains no myristoleic, cis-10-pentadecanoic, elaidic, erucic, and nervonic. Table 3 shows the amounts of monounsaturated fatty acids found in *Terminalia catappa* Linn oil.

Table 3: Monounsaturated Fatty Acids Amount in Terminalia catappa Linn Seed Oil

Fatty Acids		Fatty Acid Profile, %w/w
Myristoleic	C14:1	ND
cis-10-Pentadecanoic	C15:1	ND
Palmitoleic	C16:1	0.377
cis-10-Heptadecanoic	C17:1	0.035
Elaidic	C18:1n9t	ND
Oleic	C18:1	28.7
cis-11-Eicosenoic	C20:1	0.102
Erucic	C22:1n9	ND
Nervonic	C24:1	ND
TOTAL		**29.21**

ND- None Detected

Test Method: AOAC Official Method 963.22, 19th Ed., 2012

Polyunsaturated fatty acids found in the *Terminalia catappa* Linn oil are linoleic, linolenic, cis-11, 14, 17-Eicosatrienoic, and cis-5, 8, 11, 14, 17-Eicosapentaenoic and contains no Linolelaidic, γ- Linolenic, cis-11, 14-Eicosadienoic, cis-8, 11, 14-Eicosatrienoic, Arachidonic, cis-13, 16-Docosadienoic, and cis-4, 7, 10, 13, 16,19- Docosahexaenoic. Table 4 shows the amounts of polyunsaturated fatty acids found in *Terminalia catappa* Linn oil.

Table 4: Polyunsaturated Fatty Acids Amount in Terminalia catappa Linn Seed Oil

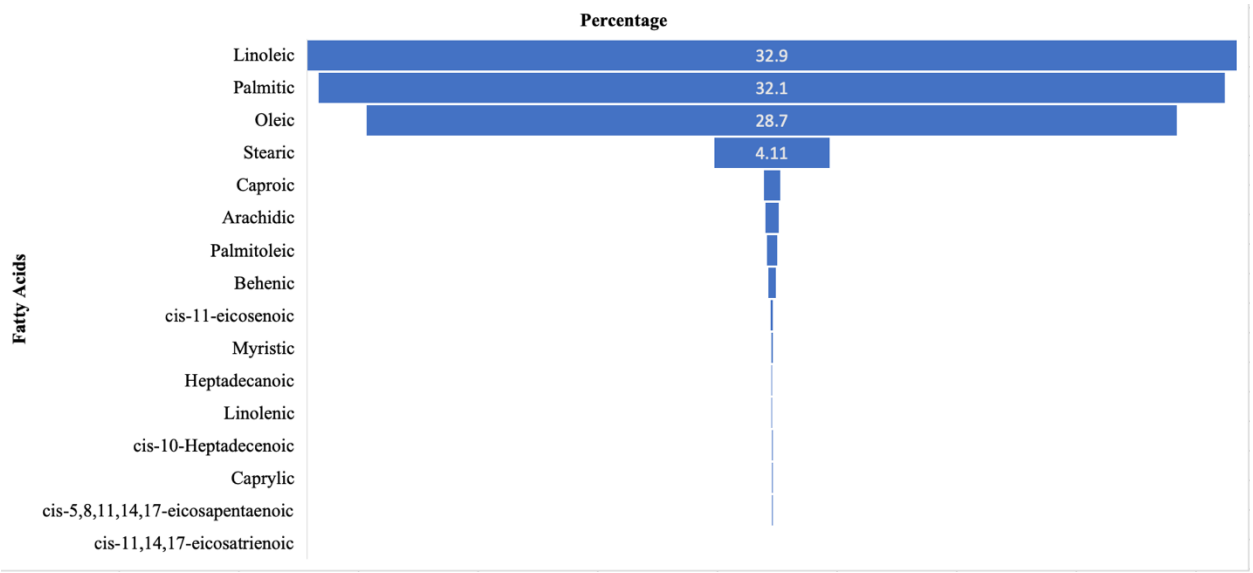
Fatty Acids		Fatty Acid Profile, %w/w
Linolelaidic	C18:2n6t	ND
Linoleic	C18:2	32.9
γ- Linolenic	C18:3n6	ND
Linolenic	C18:3	0.055
cis-11, 14-Eicosadienoic	C20:2	ND
cis-8, 11, 14-Eicosatrienoic	C20:3n6	ND
Arachidonic	C20:4	ND
cis-11, 14, 17-Eicosatrienoic	C20:3n3	0.007
cis-5, 8, 11, 14, 17-Eicosapentaenoic	C20:5	0.018
cis-13, 16-Docosadienoic	C22:2	ND
cis-4, 7, 10, 13, 16,19- Docosahexaenoic	C22:6	ND
TOTAL		**32.98**

ND- None Detected

Test Method: AOAC Official Method 963.22, 19th Ed., 2012

Different types of fatty acids were found in *Terminalia catappa* Linn oil. The highest fatty acid found was Linoleic followed by palmitic, oleic, stearic, caproic, arachidic, palmitoleic, behenic, cis-11-eicosenoic, myristic, heptadecanoic, Linolenic, cis-10-heptadecanoic, caprylic, cis-5,8,11,14,17-eicosapentaenoic, and cis-11,14,17-eicosatrienoic. Figure 2 shows the fatty acids of *Terminalia catappa* Linn oil.

Figure 2: Fatty acids of Terminalia catappa Linn seed oil



Proximate Composition

Terminalia catappa Linn seed oil contains 2.58% moisture, 5.30% ash, 20.6% protein, 53.4% fat, 18.2g of carbohydrates, and 632 kcal per 100g. Since a *Terminalia catappa* Linn seed yields 53.4% of fat, it can be an efficient source of oil. Table 5 shows the proximate composition analysis of *Terminalia catappa* Linn seeds oil.

Table 5: Proximate Composition Analysis of Terminalia catappa Linn Seeds Oil

	Result	Test Method
Moisture, %w/w	2.58	925.40[a]
Ash, %w/w	5.30	950.49[a]
Protein (N x 5.30), %w/w	20.6	Block Digestion, Kjeldahl
Fat, %w/w	53.4	Direct Petroleum Ether Extraction
Total Carbohydrates	18.2	By difference
Food Energy, kcal/100g	635	By calculation

Test Method: [a]AOAC Official Methods, 19th Ed., 2012

Smoke Point Determination

The researchers were able to determine the smoke point of *Terminalia catappa* Linn oil through a direct heating method. During the first trial, *Terminalia catappa* Linn oil started to produce continuous wisps of smoke at 200 °C. For the next trial, it started to emit smoke at 202°C,

and for the last trial, smoke developed at 200 °C. Table 6 shows the smoke point temperatures of *Terminalia catappa* Linn seeds oil when directly heated.

Table 6: Smoke Point Temperatures of Terminalia catappa Linn Seed Oil by Direct Heat Method

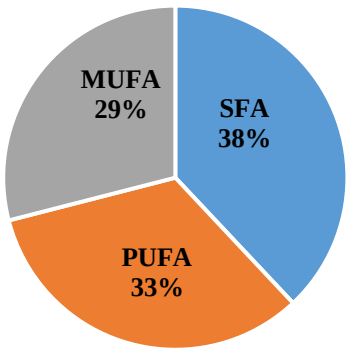
Trial	Smoke Point
Trial 1	200 °C.
Trial 2	202 °C.
Trial 3	200 °C.

The recommended frying temperature is 180 °C. However, studies show that food establishments fry at temperatures higher than the recommended one (Teicholz, 2014). For having a smoke point of 392 °F or 200 °C, *Terminalia catappa* Linn oil is comparable to the smoke points of other common cooking oils that range from 225°F or 107.2 °C to 485 °F or 251.7°C (Cholin, 2012).

Fatty Acids Profile Comparison of Common Cooking Oils from *Terminalia catappa* Linn Seeds Oil

According to the results, it can be interpreted that *Terminalia catappa* Linn oil is composed of 38% SFA, 29% MUFA, and 33% PUFA. Compared to other cooking oils, the distribution of the said fatty acids in *Terminalia catappa* Linn oil is the closest to the optimum fatty acid balance ratio of SFA to MUFA to PUFA — 1:1:1 — that is recommended by the current National Cholesterol Education Program and American Heart Association to keep the best LDL/HDL ratio. Figure 3 shows the distribution of the fatty acids of *Terminalia catappa* Linn seeds oil.

Figure 3: Fatty Acids Distribution of Terminalia catappa Linn Seeds Oil



There are three dominant fatty acids found in the composition of *Terminalia catappa* Linn seeds oil. They are Palmitic, Oleic, and Linoleic. *Terminalia catappa* Linn contains 32.1%, 28.7%, and 32.9% respectively. Comparing it with other cooking oil, Canola contains 4%, 22%, and 62%, and Palm contains 45%, 40%, and 10%, respectively.

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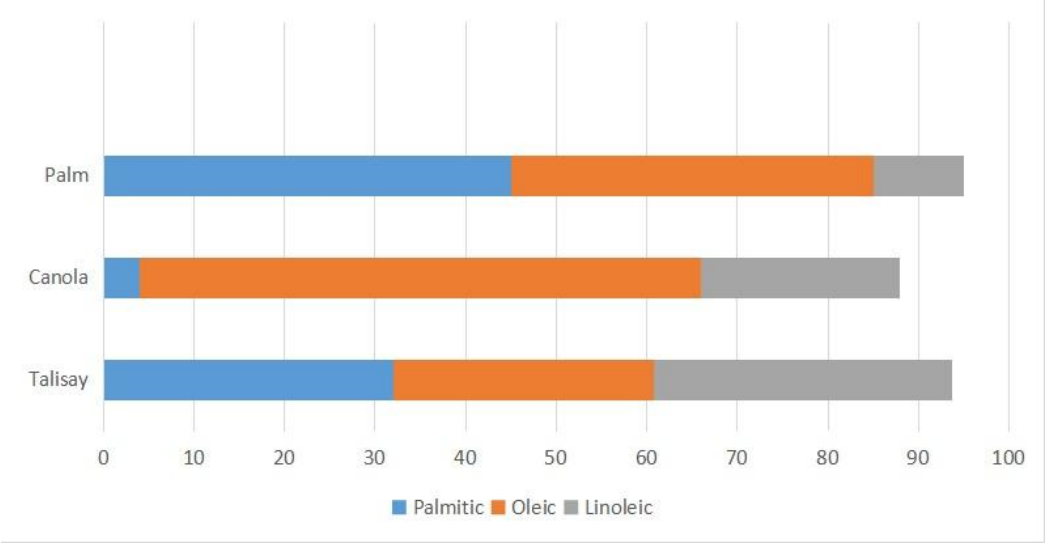
The data shows that *Terminalia catappa* Linn oil has the highest amount of linoleic or omega-6, which is an essential fatty acid. Linoleic decreases the plasma cholesterol levels by replacing the part of saturated fats in the diet, reducing the amount of LDL in the blood (Farmid et al., 2014). Figure 4 shows the amounts of palmitic, oleic, and linoleic fatty acids in Canola, Palm, and *Terminalia catappa* Linn oil.

Figure 4: Bar graph showing the comparison of the percentage weight of Palmitic, Oleic, and Linoleic fatty acids between Palm, Canola, and Terminalia catappa Linn Seed Oil.



Source: Scientific Psychic by Arnold Zamora (2016) for Palm and Canola. Reprinted with permission. (Graph of Terminalia catappa Linn seed oil (Talisay) was based on the test results.

CONCLUSION

Based on the results, it can be concluded that *Terminalia catappa* Linn seed oil can be a healthy cooking alternative. When comparing it with other cooking oils, *Terminalia catappa* Linn oil's fatty acid composition is the closest optimum fatty acid balance ratio which is 1:1:1. Its smoke point is also higher than the other cooking oils. Therefore, from fruits that are just falling to the ground, it is possible to produce cooking oil from its seeds.

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