

**THE EFFECT OF DIFFERENT FRYING OILS ON
THE PHYSICOCHEMICAL AND SENSORY
PROPERTIES OF DEEP-FRIED DOUGHNUTS**

MUHAMMAD AFIF AIMAN BIN NAZRI

UNIVERSITI SAINS MALAYSIA

2025

THE EFFECT OF DIFFERENT FRYING OILS ON THE PHYSICOCHEMICAL AND SENSORY PROPERTIES OF DEEP-FRIED DOUGHNUTS

by

MUHAMMAD AFIF AIMAN BIN NAZRI

Dissertation submitted in partial fulfilment of the requirements for the degree
of Bachelor of Health Science (Honours) (Nutrition)

2025

CERTIFICATE

This is to certify that the dissertation entitled “THE EFFECT OF DIFFERENT FRYING OILS ON THE PHYSICOCHEMICAL AND SENSORY PROPERTIES OF DEEP-FRIED DOUGHNUTS” is the bona fide record of research work done by Mr “MUHAMMAD AFIF AIMAN BIN NAZRI ” during the period from May 2025 to January 2026 under my supervision. I have read this dissertation and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation to be submitted in partial fulfilment for the degree of Bachelor of Health Science (Honours) (Nutrition).

Main supervisor,

.....
Dr. Marina binti Abdul Manaf
Lecturer
School of Health Sciences
Universiti Sains Malaysia Health
Campus
16150 Kubang Kerian Kelantan,
Malaysia

Date:

DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated and duly acknowledged. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at Universiti Sains Malaysia or other institutions. I grant Universiti Sains Malaysia the right to use the dissertation for teaching, research and promotional purposes.

Muhammad Afif Aiman Bin Nazri

Date: 28 December 2025

ACKNOWLEDGEMENT

In the name of Allah, the Most Gracious and the Most Merciful, Alhamdulillah, all praise to Allah for His Greatness and His Blessing, for the strength and courage granted to me in completing this thesis.

First of I would like to express my heartfelt to my supervisor, Dr. Marina Binti Abdul Manaf, for her unwavering support and insightful guidance throughout the course of my final year project. Her encouragement, patience and problem-solving advice were instrumental during the more challenging phases of my research and writing process. I would also like to extend my sincere thanks to all the dedicated lectures at USM health campus who have generously share their expertise and knowledge. Their commitment to teaching and their constructive feedback played a significant role in enhancing my understanding and also helping me develop the skills for completing this final year project. Special thanks and deep gratitude to all lab assistants of the Nutrition, Functional Food, Food Preparation, and Analytical Laboratory for their guidance of using the equipment for analyses and for allowing and trusting me in handling the instruments. Without their technical expertise and cooperation, I may not complete my project on time. Next, I would like to thank my friends, especially Siti 'Alyaa Maisarah, Nur Izzati Dalili, Munira Adleena, Elhanna Tasnim, Alya and even Aina for their support and assistance in my laboratory work. I would also especially like to thank my teammates, Blup Blup and Masam, whose encouragement, tolerance, and good energy made every stage of this journey easier to handle and more significant. Thank you for the motivation, the laughter, and the countless moments that kept me going. I am truly grateful to have shared this experience with all of you. Last but not least, I am really thankful for my family especially my mother, Che Wan Patimah for their endless support and encouragement throughout my study especially my research. Without her support I will not be here finishing strong as a degree student.

Table of Contents

CERTIFICATE.....	3
DECLARATION.....	4
ACKNOWLEDGEMENT	5
ABSTRAK.....	8
ABSTRACT	9
CHAPTER 1	10
1.1 Background of study.....	10
1.2 Problem Statement.....	12
1.3 Research Question	13
1.4 Research Objectives	13
1.4.1 General Objectives	13
1.4.2 Specific Objectives.....	13
1.5 Research hypothesis	14
Hypothesis I:	14
Hypothesis II:	14
Hypothesis III:.....	14
1.6 Significant of The Study	15
1.7 Scope and Limitation of The Study	16
Scope.....	16
CHAPTER 2	17
2.1 Overview of Doughnuts as Popular Snack.....	17
2.2 Deep Frying as a Cooking Technique	19
2.3 Types of Frying Oils Used in Food Processing	20
2.4 Physicochemical Properties of Deep-Fried Products.....	21
2.5 Sensory Characteristics of Deep-Fried Products	23
2.6 Relationship Between Oil Type and Doughnut Quality	24
2.7 Summary of Literature Gaps.....	25
Chapter 3 : Methodology	27
3.1 Research Design.....	27
3.2 Study Area	27
3.3 Subject Criteria (For Sensory Evaluation).....	28
3.3.1 Inclusion criteria	28
3.3.2 Exclusion criteria	28
3.4 Sample size estimation.....	28
3.5 Research tool.....	29
3.6 Materials and Equipment	29

3.6.1 Raw ingredient	29
3.6.2 Frying Oils	29
3.6.3 Lab Equipment.....	30
3.7 Sample Preparation	30
3.7.1 Types of Frying Oils Used	32
3.8 Physicochemical Analysis	33
3.8.1 Moisture Content	34
3.8.2 Fat Content.....	34
3.8.3 Physical Properties.....	35
3.8.4 Texture Profile Analysis (TPA)	36
3.8.5 Color Measurement.....	37
3.8.6 Caloric Value	37
3.9 Sensory Evaluation	38
3.10 Data Analysis	39
3.11 Study Flowchart.....	40
CHAPTER 4	41
RESULT AND DISCUSSION	41
4.1 Introduction	41
4.2 Physicochemical Properties of Doughnuts.....	41
4.2.1 Moisture Content	42
4.2.2 Fats Content	44
4.2.3 Calories Content.....	45
4.3 Texture Profile Analysis	48
4.4 Physical Properties of Doughnuts.....	50
4.4.1 Color Properties	50
4.4.2 Diameter, Thickness and Spread Ratio	52
4.5 Sensory Evaluation	54
CHAPTER 5	57
5.1 CONCLUSION	57
5.2 LIMITATION	58
5.3 RECOMMENDATION	59
REFERENCE	60
APPENDICES	68

THE EFFECT OF DIFFERENT FRYING OILS ON THE PHYSICOCHEMICAL AND SENSORY PROPERTIES OF DEEP-FRIED DOUGHNUTS

ABSTRAK

Kajian ini menilai kesan empat jenis minyak penggorengan—minyak sawit, minyak kelapa, minyak bunga matahari dan minyak kanola—terhadap sifat fizikokimia, ciri fizikal, profil tekstur, ciri warna dan penerimaan sensori donat yang digoreng secara rendaman. Analisis fizikokimia menunjukkan bahawa donat yang digoreng menggunakan minyak sawit mempunyai kandungan kelembapan tertinggi (32.72%), kandungan lemak tertinggi (20.82%) dan nilai kalori tertinggi (3685.67 cal/g), diikuti oleh minyak kelapa (31.22% kelembapan; 17.88% lemak; 3509.67 cal/g), manakala minyak bunga matahari dan minyak kanola menghasilkan kandungan lemak yang lebih rendah (masing-masing 13.74% dan 11.89%) serta nilai tenaga yang lebih rendah ($p < 0.05$). Analisis profil tekstur menunjukkan tiada perbezaan signifikan bagi kekerasan dan ketahanan ($p > 0.05$); namun, kekenyalan donat yang digoreng menggunakan minyak kelapa adalah lebih rendah (57.48) berbanding minyak sawit (62.02) ($p < 0.05$). Analisis warna menunjukkan perbezaan signifikan bagi kecerahan (L^*) dan kekuningan (b^*) ($p < 0.05$), dengan minyak kelapa menghasilkan donat yang lebih gelap ($L^* = 52.49$) dan lebih kuning ($b^* = 35.85$), manakala kemerahan (a^*) tidak menunjukkan perbezaan signifikan antara minyak. Ciri fizikal termasuk diameter, ketebalan dan nisbah sebaran tidak menunjukkan perbezaan signifikan ($p > 0.05$). Penilaian sensori menunjukkan tiada perbezaan signifikan bagi rasa, tekstur, warna dan penerimaan keseluruhan antara minyak ($p > 0.05$), walaupun minyak kelapa mencatat skor aroma yang lebih tinggi secara signifikan ($p < 0.001$). Secara keseluruhan, pemilihan minyak penggorengan memberi kesan signifikan terhadap kualiti fizikokimia tetapi mempunyai kesan terhadap penerimaan pengguna secara keseluruhan.

THE EFFECT OF DIFFERENT FRYING OILS ON THE PHYSICOCHEMICAL AND SENSORY PROPERTIES OF DEEP-FRIED DOUGHNUTS

ABSTRACT

The research has compared the impacts of four different frying oils, palm oil, coconut oil, sunflower oil and canola oil on the physicochemical, physical, textural, colour and sensory attributes of deep-fat-fried doughnuts. Physicochemical analysis showed that doughnuts fried in palm oil contained the highest amount of moisture (32.72%), fat content (20.82%), and energy (3685.67 cal/g), followed by coconut oil (31.22% moisture; 17.88 fat; 3509.67 cal/g), and sunflower and canola oils contained significantly lower amounts of fat (13.74% and 11.89% respectively), and lower energy values ($p < 0.05$). Analysis of texture profile did not indicate significant differences in firmness and resilience ($p > 0.05$); but springiness was significantly less in doughnuts fried in coconut oil (57.48) than in palm oil (62.02) ($p < 0.05$). Colour analysis showed that there were significant differences in lightness (L) and yellowness (b) ($p < 0.05$) with coconut oil yielding darker (L = 52.49) and yellower doughnuts (b = 35.85) and no significant differences in redness (a) among oils. Both physical properties such as diameter and thickness and spread ratio did not differ significantly ($p > 0.05$). Sensory analysis showed that there were no major differences in taste, texture, colour, or acceptability between oils ($p > 0.05$) but coconut oil scored significantly higher in aroma evaluation ($p < 0.001$). In general, frying oil choice had a strong impact on the physicochemical quality, but only a small effect on the overall consumer acceptance.

CHAPTER 1

INTRODUCTION

1.1 Background of study

In today's fast-paced world, deep-frying serves as a commonly used cooking method which improves food products by enhancing their flavor as well as their texture and appearance. The method of cooking is extensively used in preparing all kinds of snack foods because of its efficiency and capacity to incorporate desirable sensory attributes, including crispness and depth of flavour. Sweet fried foods are also becoming more popular among fried snack products due to their combination of indulgent flavor with convenience. Doughnuts have achieved widespread popularity among fried products because of their pleasant combination of sweet flavors and tender eating experience.

Deep-frying causes foods to absorb substantial oil amounts that raises both fat percentage and nutrition value of the prepared product (Valled *et al.* 2024). Choe and Min (2007) show that frying oil selection determines how food turns out especially when considering fat content texture and color issues.

The fatty acid content, oxidation rate, and heat stability all determine the type of frying oil. The high cooking temperature tolerance of saturated fats in palm and coconut oils enables their usage in frying applications. (Gertz *et al.*, 2000) However, despite their health benefits, unsaturated oils like sunflower and canola are more susceptible to oxidation when exposed to prolonged high-temperature frying, which can compromise both oil quality and the safety of the final product (Corliss, 2025). This variation in oil characteristics substantially affects fried product properties regarding oil uptake and crust generation along with sensory changes. (Mahmud *et al.*, 2023)

The market offers many frying oils yet scientists have conducted minimal research to understand oil effects on deep-fried doughnut qualities. Therefore, the aim of this study is to determine the effects of these oils so that it helps to improve both nutritional content and attractiveness characteristics of fried foods to consumers

1.2 Problem Statement

Deep-fried doughnuts are popular because of their delicious flavor and texture combination but the deep-frying method leads to oil absorption with additional calorie content (Bordin *et al.*, 2013). As obesity awareness rises dietary risks pose concerns about the usage of frying oils for both food quality attributes and nutrient composition (Saguy & Dana, 2003). The composition of fatty acids together with oil thermal behavior determines the oil absorption levels and crust formation while influencing product quality (Paul & Mittal, 1997).

Scientific investigations of deep-frying oil utilization primarily concentrate on savory content like potato chips and fish and meat (Shyu & Hwang, 2001) instead of doughnuts and other sweet flour-based products. Research either focuses on physical properties or sensory evaluations of frying products but almost never converges these approaches within one comprehensive analysis. Only a scarce number of studies examine caloric contents through bomb calorimetry testing in relation to various frying oils. (Black, 2017)

Study of different frying oils on deep-fried doughnut not only affect nutritional composition but also consumer acceptability of doughnut and will help food producers to prepare the quality food material and provide an opportunity for consumer to make better choice in their diet. Hence, this study are seeking to fill the gap of knowledge on the effects of different frying oils and to systematically compare oil types commonly used in frying (palm, coconut, sunflower and canola) on the physicochemical and sensory characteristics of deep-fried doughnuts.

1.3 Research Question

1. How do different frying oils affect the physicochemical properties of deep-fried doughnuts?
2. Is there a significant difference in sensory evaluation scores between doughnuts fried in different oils?
3. Which type of frying oil produces doughnuts with the lowest fat content and caloric value?

1.4 Research Objectives

1.4.1 General Objectives

To evaluate the effect of different frying oils on the physicochemical and sensory properties of deep-fried doughnuts.

1.4.2 Specific Objectives

1. To determine the physicochemical properties of doughnuts (fat content, color, moisture content, and caloric value) fried in palm, coconut, sunflower, and canola oils.
2. To assess the sensory acceptability (appearance, aroma, taste, texture and overall acceptability) of the doughnuts fried in palm, coconut, sunflower, and canola oils, using untrained panels.
3. To analyze the texture profile analysis of doughnuts fried in different oils (palm, coconut, sunflower and canola oil) using instrumental texture analysis.

1.5 Research hypothesis

Hypothesis I:

Null Hypothesis (H_0): There is no significant difference in the physicochemical properties (fat content, color, moisture content, and caloric value) of doughnuts fried in palm, coconut, sunflower, and canola oils.

Alternative Hypothesis (H_a): There is a significant difference in the physicochemical properties (fat content, color, moisture content, and caloric value) of doughnuts fried in palm, coconut, sunflower, and canola oils.

Hypothesis II:

Null Hypothesis (H_0): There is no significant difference in the sensory attributes of doughnuts fried in palm, coconut, sunflower, and canola oils.

Alternative Hypothesis (H_a): There is a significant difference in the sensory attributes of doughnuts fried in palm, coconut, sunflower, and canola oils.

Hypothesis III:

Null Hypothesis (H_0): There is no significant difference in the texture profile of doughnuts fried in palm, coconut, sunflower, and canola oils.

Alternative Hypothesis (H_a): There is a significant difference in the texture profile of doughnuts fried in palm, coconut, sunflower, and canola oils.

1.6 Significant of The Study

There are multiple important factors that justify this research. The study reveals the effects which palm oil together with coconut oil, sunflower oil, and canola oil have on deep-fried doughnuts regarding their physicochemical properties and sensory qualities. The product quality along with the consumer perception depends on four main factors which are fat content, caloric value, texture and acceptability (Pedreschi & Moyano, 2005).

Doughnuts were selected as the test product in this study due to their popularity in Malaysia, where they are commonly consumed as sweet snacks and are commercially available through numerous established brands such as Big Apple and Dunkin' Donuts. The rapid growth and nationwide presence of these chains reflect high consumer demand and cultural familiarity with doughnuts as a daily or occasional treat.(Inspire , 2023).Besides commercial outlets, doughnuts are also widely sold as frozen ready-to-eat products in retail markets, with consumer preference for such convenient snacks increasing.(GMI Research, 2024).

In addition, the research output also can helps food producers together with small bakery owners to pick frying oils which provide optimal balance between sensory quality and nutritional value of their fried products. Fried product characteristics regarding fat uptake together with oxidative stability and flavor development are directly influenced by the selection of frying oil (Soukup *et al.*, 2022). Research identifies suitable oils which reduce fat uptake especially while improving taste attributes thus supporting the industry to adopt healthier frying methods.

The research findings also help consumers understand the relationship between fried food nutrition quality and sensory attributes through their preference choices of frying oil particularly for doughnuts. This is especially relevant given that doughnuts are not only deep-fried but also high in sugar content, especially

those with external coatings like glaze or powdered sugar. Excessive consumption of sugary and high-fat snacks like doughnuts has been linked to obesity and increased risk of chronic diseases such as diabetes and cardiovascular disorders. (Norimah Jr, 2016) The escalating public health crisis pertaining to obesity and fat-related ailments further justify the necessity for promoting better food preparation techniques. (Faruque *et al.*, 2019).

The study adds value to academic knowledge by merging sensory evaluation techniques with laboratory substance assessments like bomb calorimetry and texture profile analysis in one research project. The measurement set provides complete knowledge of fried food quality although it remains poorly understood in sweet bakery goods (Debnath *et al.*, 2003).

1.7 Scope and Limitation of The Study

Scope

The research investigates the differences between four oil types used for deep-fried doughnuts including palm oil, coconut oil, sunflower oil and canola oil. The doughnuts were examined through assessments of their fat content, moisture levels, color attributes, caloric measurements, along with instrumental texture analysis and sensory evaluations focused on appearance and aroma followed by taste assessment and texture evaluation and total acceptance ratings (Dogan *et al.*, 2005).

A standardized recipe and frying process was produced in all doughnuts for testing purposes to maintain sample uniformity. Available laboratory instruments such as bomb calorimeters and texture analyzers were used to perform analysis on the samples while untrained panelists using their senses to evaluate the doughnuts (Stone & Sidel, 2004)

CHAPTER 2

LITERATURE REVIEW

2.1 Overview of Doughnuts as Popular Snack

People across the globe recognize doughnuts as one of the most popular sweet pastries which they frequently enjoy. The traditional leavened dough ring or ball deep-fried doughnuts have now become fundamental products in global snack and dessert markets. These pastries delight people through their sweet flavor as well as their tender consistency which allows a wide variety of flavor contents and toppings. The versatility of doughnuts allows for a broad range of fillings and glazes, such as chocolate, vanilla, jam, and even savory variations, which have increased their popularity globally. (International Bakery, 2024) Doughnuts serve as popular sweets in Malaysian markets through their production as fresh goods and frozen packaged products. The modern Malaysian diet shows evidence of widespread acceptance for doughnuts through the leading international brands alongside J.CO and Dunkin' Donuts and Big Apple.(Shathana Kasinathan, 2024) A report from Euromonitor International had reveals that Malaysian consumers increasingly buy bakery products including doughnuts which they prefer because of their portability and delicious taste.This trend is particularly evident in urban areas, where busy lifestyles create a demand for convenient snacks that can be enjoyed on-the-go.(*Baked Goods in Malaysia*, 2024)

Due to rising home consumption behavior the market has demanded more frozen doughnut products that supermarkets and convenience stores offer to consumers. Busy urban consumers whose busy lifestyles benefit from these frozen doughnuts because they provide convenience while maintaining a long shelf life.(Research and Markets, 2024) Doughnut products maintain their market expansion because they serve both retail establishments and food service outlets which makes them an optimal research model for food quality investigations.The expansion of doughnut consumption in emerging markets, such as Southeast

Asia, is also driven by the growing number of coffee shops and fast-food chains incorporating doughnuts into their product offerings.

The nutritional aspect of doughnuts stands out because they include large quantities of sugar together with fats. The deep-frying technique in the production of doughnuts increases their oil content and the normal topping in the production process is sugar and the filling used in it is also of high calorie content. Cream, custard, or chocolate also fill many doughnut products, further boosting their caloric value and contributing to the emerging health issues in the whole world. The mix of doughnuts has nutritional qualities that qualify these pastries as candidates in leading to unnecessary energy intake particularly with frequent eating patterns. Subsequently, various studies found a correlation between frequent intake of such high-energy snacks to the development of obesity in addition to the risks of type 2 diabetes and heart diseases (Malik *et al.*, 2010). In fact, some studies suggest that doughnuts, due to their high sugar and fat content, can be considered a major contributor to the increasing prevalence of metabolic diseases worldwide. Because of their widespread consumption, dual commercial and household relevance, and health implications, doughnuts serve as an appropriate and significant model for evaluating the impact of frying oils on physicochemical and sensory properties. In view of the worldwide problem of diet-related diseases, knowledge about how diverse frying oils affect nutritional and sensory properties of doughnuts is important in drafting healthier and more sustainable nutrition production. This is also consistent with recent trends in the food industry where health-conscious formulations and healthier methods for preparing foods are encouraged, such as using healthier frying oils and cutting down sugar levels in doughnut recipes.

2.2 Deep Frying as a Cooking Technique

Deep frying acts as a common culinary technique which puts food pieces into boiling oil at 160°C to 190°C temperature range. The cooking technique is used both in commercial and home kitchens as it helps to keep the moisture in the food through the browning process giving the food a crispy outer space but a tender inside. Besides moisture retention, deep frying also improves the flavor profile of the foods because of the high temperature, which promotes complex chemical reactions that help create an overall texture and taste. Deep frying is especially widely applied in the production of doughnut snacks and other snacks due to the appeal of a quick cooking speed and flavor (Hatae, 2023). Between food items and the deep-frying medium, several physicochemical changes occur. Its texture is formed by the heating process which evaporates food water to create steam that gives the food its texture. Water loss through the food structure leaves room to take in oil that increases the fat level and overall calorie content of food (Dana & Saguy, 2006). The process of oil absorption also makes the food crisper on the surface and keeps it hydrated on the inside, which adds to the unique feel of the deep-frying foods. Maillard reaction and caramelization have the role of forming taste and color properties that enhance the sense of taste in fried foods (Zhang et al., 2025). These reactions contribute to the pleasing brown color and the intricate flavors in the deep-fried food that is much preferred by the consumer. The quality of fried products greatly relies on the choice of the best type of oil. The presence of fatty acids in oil influences their characteristics like the ability to withstand high temperatures and oxidative resistance in addition to the ability to withstand high smoke tolerance. The oxidation reactions during successive usages gradually inflict the taste and hue in addition to the nutritional value of sunflower and canola oils since the fatty acid structures within them comprise a large amount of unsaturated acids (Choe and Min, 2007). These oils are also more likely to be degraded in high temperatures over prolonged periods resulting in the development of harmful substances that have the negative impacts on taste and health. This stability in frying of palm and coconut oil is due to the fact that

these saturated-fat rich oils have greater thermal stability. Coconuts and palm oils are saturated oils that are more resistant to oxidation and thus are more stable and can support longer periods of frying. Deep frying has been an issue of concern among public health campaigners as it influences the wellbeing of human beings. Deep frying food results in higher fat concentration but exposes users to potentially dangerous substances that develop when oils are further used beyond the recommended smoking points. These substances (e.g., acrolein, aldehydes) are not only detrimental to human health, but they also can result in chronic conditions like heart disease, cancer and diabetes. The degradation of antioxidants due to the long-term use of oils also contributes to the rapid development of harmful substances (Saguy & Dana, 2003). The evaluation of oil implications on fried results is a crucial demand due to the dual quality of food control and nutrition security. Such evaluations not only ensure the safety of the final product but also help in formulating guidelines for healthier frying practices, reducing the intake of trans fats and oxidative compounds that adversely affect health outcomes (Pedreschi & Moyano, 2004)

2.3 Types of Frying Oils Used in Food Processing

Deep-fried product quality depends heavily on the properties of frying oils. The individual fatty acid breakdown of different oils determines their thermal resistance along with their oil-bearing flavor strength and their ability to resist oxidation while dictating health metrics. Palm oil, Coconut oil, Sunflower oil and Canola oil represent the main frying oils that bring diverse features suitable and unsuitable for food production processes. Among Southeast Asian nations especially Malaysia palm oil serves as a primary vegetable oil that consists primarily of saturated and monounsaturated fat acids. The oil's high chemical stability with extended storage time makes it adaptable for obtaining superior performance during commercial deep frying. Medical experts have expressed cardiovascular health issues due to palm oil's high saturated fat content according to Loganathan et al. (2017). Coconut oil consists mostly of saturated fats including medium-chain triglycerides (MCTs) that offer both strong heat tolerance and distinct flavors.

People have become increasingly interested in coconut oil from around the world because of its frying capabilities and its relationship to health benefits despite its traditional tropical food background. The repeated frying process does not damage coconut oil. (Marina *et al.*, 2009) Health benefits from sunflower oil stem from its polyunsaturated fatty acid content especially linoleic acid because they help reduce cholesterol in the body. The poor oxidative stability of sunflower oil makes it generate polar compounds together with off-flavors during prolonged frying usage (Zribi *et al.*, 2014). People prefer canola oil because it carries both low saturated fat content and well as high monounsaturated fat content. This healthy fat product shows excellent stability against oxidation as well as a clean taste that works perfectly with frying needs. The research suggests that canola oil offers health benefits for lipid profiles according to Lin *et al.* (2013) therefore scientists view it as a healthier option. Different frying conditions and product quality effects require specific oil choices according to their performance abilities. Food processing industries select frying oils based on the needed characteristics which include flavor retention alongside shelf stability and low oil absorption and positive consumer health perceptions.

2.4 Physicochemical Properties of Deep-Fried Products

Deep-fried items should undergo thorough physicochemical examinations to determine their quality levels and shelf stability and consumer receptiveness. All quality marker properties such as moisture content, fat content, color, texture and caloric value depend heavily on the choice of frying oil and the frying conditions. Deep-fried products strongly depend on the fat content as a fundamental quality element. Frying leads to dough moisture evaporation which lets oil penetrate the food structure. What happens to oil absorption depends on oil viscosity and polarity in combination with the frying temperature according to Bouchon (2009). The large amount of absorbed oil causes textural problems while increasing caloric content which produces health risks for the consumer. Increased oil absorption also influences the mouthfeel of the

product, potentially leading to an undesirable greasy texture. The process of moisture escaping into the atmosphere acts as a primary factor in creating crust during preparation. When water leaves the exterior of the product it creates a crisp barrier that helps build the fried doughnut texture. The product develops excessive greasiness when the frying temperature remains too low (Pedreschi & Moyano, 2004).

The main factors behind color development in the doughnut arise from Maillard reactions combined with caramelization mechanisms. Surface temperature together with dough sugar and amino acid levels control the production of non-enzymatic aged-based browning complexes. The selected oil affects how heat transfers which determines brown crust intensity (Bordin *et al.*, 2013). Customers tend to prefer golden-brown items in their perception of superior taste combined with appealing characteristics. Crispiness together with firmness and springiness represent the texture attributes. The analysis method called (Texture profile analysis (TPA) helps measure dough characteristics for the resilience and springiness under different frying conditions, batter compositions and oil varieties (Sabiha Abbas, 2021). Crispiness should exist on the outside of the doughnut while the inside remains soft. Texture is also influenced by the oil type, as oils with higher saturation tend to produce firmer textures, while oils with higher unsaturation levels may result in a softer, more delicate crumb structure. People typically fail to accurately determine how much energy food contains.

A bomb calorimeter serves as a laboratory instrument to calculate total caloric value more precisely than general nutrition labels do. The nutritional effects of fried products depend significantly on the oil absorption during food preparation thus making this parameter critical to understand (Patra *et al.*, 2022). In addition, the energy value may differ according to oil type, in that some oils with a fatty component can make a greater contribution to total calories. The knowledge of such physicochemical properties would assist the food industry in formulation and processing for optimization with respect to health and sensory aspects. Consumers generally prefer snack foods that are not excessively oily and are crispy and light in texture.

Manufacturers who sell these products must be able to produce the correct appearance and textural characteristics demanded by consumers, yet must also appeal to a consumer group increasingly concerned with fat contents of such fried snack food items due to health concerns

2.5 Sensory Characteristics of Deep-Fried Products

The sensory attributes including look, smell, taste and touch and total satisfaction of a doughnut determine consumer choice in deep-fried products. The sensory characteristics show response to product formulation ingredients while the frying environment together with oil selection produces substantial alterations in these attributes. Appearance is especially important for consumer marketing because color and surface texture matter most to customer choices. Uniform golden-brown surfaces are recognized by consumers as more preferable since they attract positive reactions to deep-fried products. The visual attractiveness resulting from Maillard reaction and caramelization depends strongly on surface temperature alongside frying oil features (Mendonça *et al.*, 2013). Fried food products rely heavily on their flavor and aroma potential for customers to develop a positive sensation. The thermal degradation process of frying oils produces volatile compounds that generate specific fried aromas. Sunflower oil delivers no distinct flavor to fried goods but coconut oil creates a sweet nutty fragrance which modulates or conceals the main doughnut bases (Warner & Gupta, 2003). The stability of heating defines the quality of oil since it influences the development of off-flavors due to the process of oxidation and polymerization. The concept of texture is one of the essential elements in consumer satisfaction as it touches upon such critical implications as crispiness and softness. An ideal doughnut is a combination of the outer crispness and interior tenderness depending on the temperature and water evaporation and oil intake during frying. When quick crust forms formed by oils preserve more moisture of the products resulting in perfect internal features (Bouchon *et al.*, 2001). The standard overall acceptability measure integrates sensory qualities at the process culmination.

The information assists in establishing marketing success potentials when the consumers rate food using structured professional scales. One of the significant demands when conducting oil tests is the product acceptability to determine which frying technique is the most advantageous. The property of oils and sensory perception form an underlying relationship that proves the importance of selecting suitable frying oil not only in terms of health advantages but also in terms of consumer satisfaction. It has been shown that consumer acceptance strongly depends on the type of frying oil used in the production despite the remaining ingredients remaining unchanged (Mendonça et al., 2013).

2.6 Relationship Between Oil Type and Doughnut Quality

The selection of oil for deep-frying determines the entire quality outcome of doughnuts. The sensory attributes of deep-fried food depend on multiple oil properties such as fatty acid profile and smoke point along with viscosity and resistance to oxidation because these factors influence heat transfer efficiency and the amount of oil absorbed by doughnuts and their texture development and sensory characteristics. Palm and coconut oil fats remain stable during heating because they exhibit high thermal resistance which prevents oxidative damage while frying. The process improves texture while extending oil lifespan although it produces higher fat amounts within the finished product (Gertz *et al.*, 2000). The healthier reputation of unsaturated oils like canola and sunflower makes them desirable but these fats have sensitivity to high heat thus producing off-flavors during the doughnut production process (Ayodeji Falade *et al.*, 2016). Fried doughnuts tend to have a lighter texture and less oily surface when cooked in unsaturated oil such as sunflower oil yet saturated fats would create a more even crust surface and exhibit richer feel (Arash Ghaitaranpour *et al.*, 2024). Further, oils such as that from palm and coconut are stable to oxidation, so they do not break down in flavor profile and texture quality with repeated frying cycles as much as other oils would providing a better fit for operational environments of high fail oil replacement. Balancing oil