NUTRITIONAL, PHYSICAL, AND ANTI-OXIDATIVE PROPERTIES OF OLIVE OIL-FIG BLEND SUPPLEMENTARY FOOD

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NUTRITIONAL, PHYSICAL, AND ANTI-OXIDATIVE PROPERTIES OF OLIVE OIL-FIG BLEND SUPPLEMENTARY FOOD

by

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CERTIFICATE

This is to certify that the dissertation entitled “Nutritional, Physical, and Anti-Oxidative Properties of Olive Oil-Fig Blend Supplementary Food” is the bona fide record of research work done by Farah Farzana Binti Romi during the period from April 2025 to January 2026 under my supervision. I have read this dissertation and that in my opinion it conforms to acceptable standard of scholarly presentation and is fully adequate, in scope, quality, as a dissertation to be submitted in partial fulfilment for the degree of Bachelor of Nutrition.

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DECLARATION

I hereby declare that this dissertation is the result of my own investigation, 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.

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Date: …………………………..

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LIST OF ABBREVIATIONS

ALA	Alpha-Linolenic Acid
ANOVA	One-way Analysis of Variance
CHD	Coronary Heart Disease
CRP	C-Reactive Protein
CVD	Cardiovascular Disease
DPPH	2,2-diphenyl-1-picrylhydrazyl
ESR	Erythrocyte Sedimentation Rate
EVOO	Extra Virgin Olive Oil
FRAP	Ferric Reducing Antioxidant Power
HDL	High-Density Lipoprotein
HT	Hydroxytyrosol
LDL	Low-Density Lipoprotein
MUFA	Monounsaturated Fatty Acids
OOPs	Olive Oil Polyphenols
PUFA	Polyunsaturated Fatty Acids
ROO	Refined Olive Oil
ROS	Reactive Oxygen Species
SBP	Systolic Blood Pressure
SCFAs	Short-Chain Fatty Acids
SFA	Saturated Fatty Acids
SPSS	Statistical Package for Social Sciences

TAC	Total Anthocyanin Content
TFC	Total Flavonoid Content
TPC	Total Phenolic Content
VOO	Virgin Olive Oil
WHO	World Health Organization

LIST OF SYMBOLS

%	Percentage
$>$	More than
$<$	Less than
g	Gram
mmol	Millimol
Fe^{2+}	Ferrous iron

%	Percentage
>	More than
<	Less than
g	Gram
mmol	Millimol
mg	Milligram
GAE	Gallic Acid Equivalent
±	Plus minus
RPM	Revolution Per Minutes
°C	Degree celcius
w	Weight
L*	Lightness
a*	Red/Green
b*	Yellow/Blue

CIRI NUTRITSI, FIZIKAL, DAN ANTI-OKSIDATIF MAKANAN TAMBAHAN CAMPURAN MINYAK ZAITUN-BUAH TIN

ABSTRAK

Minyak zaitun extra virgin (EVOO) dan buah tin dikenali secara meluas sebagai makanan super kerana sifatnya yang kaya dengan nutrien dan manfaat kesihatan, seperti anti-keradang dan kardioprotektif. Kajian ini menyiasat campuran minyak zaitun-buah tin sebagai satu formulasi baru. Kajian ini bertujuan untuk menganalisis kesan sinergistik minyak zaitun dan buah tin kering dari segi komposisi nutrient, sifat fizikal, dan aktiviti antioksida EVOO dan buah tin kering apabila dicampur dan dirumus sebagai makanan tambahan. Empat nisbah campuran minyak zaitun-ara telah dirumuskan dengan jumlah EVOO yang berbeza-beza, dengan nisbah yang berbeza antara buah tin kering kepada EVOO: 1:1 (150:150), 1:3 (75:225), 1:5 (50:250), dan 1:7 (37.5:262.5). Makanan tambahan yang dirumuskan telah dianalisis untuk komposisi pemakanan, sifat fizikal, kapasiti anti-oksidatif, dan penilaian deria dalam kalangan pelajar ijazah sarjana muda di Kampus Kesihatan Universiti Sains Malaysia yang tidak mempunyai masalah kesihatan. Analisis pemakanan mendapati bahawa kandungan lemak dalam formulasi meningkat dengan jumlah EVOO yang lebih

banyak digunakan dalam formula. Analisis fizikal tertumpu pada warna, mendapati bahawa warna kuning nisbah 1:3 adalah yang paling cerah dan terang ($p<0.05$). Sifat anti-oksidatif produk ini dinilai menggunakan ujian DPPH dan FRAP esei untuk menangkap aktiviti penghapusannya dan mengurangkan kuasa. Kedua-dua ujian mendedahkan bahawa aktiviti anti-oksidatif meningkat dengan ketara dengan tahap EVOO yang lebih tinggi. Penilaian deria menggunakan skala Hedonik 7 mata menunjukkan keutamaan yang kuat untuk nisbah 1:3. Oleh itu, campuran minyak zaitun-fig ini berpotensi untuk digunakan sebagai makanan tambahan dalam pasaran makanan semasa kerana sifat nutrisinya, anti-oksidatif dan kebolehterimaannya untuk menggalakkan kesihatan.

NUTRITIONAL, PHYSICAL, AND ANTI-OXIDATIVE PROPERTIES OF OLIVE OIL-FIG BLEND SUPPLEMENTARY FOOD

ABSTRACT

Extra virgin olive oil (EVOO) and figs are widely known as superfoods due to their nutrient-rich properties with extensive health benefits, such as anti-inflammatory and cardioprotective effects. This study investigates olive oil-fig blends as a novel formulation. This study aims to analyze the synergistic effect of olive oil and dried fig in terms of the nutrient composition, physical properties, and anti-oxidative activity of EVOO and dried fig when blended and formulated as a supplementary food. Four ratios of olive oil-fig blends were formulated with varying levels of EVOO, with different ratios of dried fig to extra virgin olive oil: 1:1 (150:150), 1:3 (75:225), 1:5 (50:250), and 1:7 (37.5:262.5). The formulated supplementary food were analysed for nutrients composition, physical properties, anti-oxidative capacity, and sensory evaluation among healthy undergraduate university students in Universiti Sains Malaysia Health Campus. Nutritional analysis revealed the fat content of formulations increased with higher EVOO levels used in the formula. Physical analysis focused on colour, revealing that the 1:3 ratio is the lightest and most intense in yellow ($p<0.05$). The anti-oxidative properties of this product were assessed using DPPH and FRAP assays to capture its scavenging activity and reducing power. Both assays revealed that the anti-oxidative

activity increased significantly with the higher EVOO levels. Sensory evaluation using a 7-point Hedonic scale indicated a strong preference for the 1:3 ratio. Thus, this olive oil-fig blend has potential to be used as supplementary food in the current food market due to its nutrient composition, anti-oxidative properties and acceptability to promote health.

CHAPTER 1: INTRODUCTION

1.1 Background of Study

Olive (*Olea europaea L.*) belongs to the family of Oleaceae. The family of Oleaceae can be divided into several groups, which are Fontanesieae, Forsythieae, Jasmineae, Myxopyreae, and Oleeae (Bartolini, G., & Petruccelli, R., 2002). The genus *Olea* consists of 30 species, but *Olea europaea L.* is the most popular among all (Bracci et al., 2011). By the fifth millennium BCE, olive cultivation had become widespread across the region (Zohary et al., 2012), significantly transforming the agricultural landscape of the southern Levant, which includes modern-day Syria, Lebanon, Israel, the Palestinian territories, and western Jordan (Barazani et al., 2023). The olive tree is mentioned numerous times in religious texts such as the holy Quran, the Hebrew Bible, and the Christian Bible, emphasizing its historical and spiritual significance to humans (Kaniewski et al., 2012). Olive oil is a staple of the Mediterranean diet, is particularly noted for its cardiovascular benefits, largely due to its high antioxidant content.

Fig (*Ficus carica L.*), a native fruit in the Mediterranean, Middle East, and Southwest Asia (Mawa et al., 2012), is a fruit that belongs to the mulberry family (*Moraceae*). It has a unique structure because it blooms from the inside, unlike other flowers. It is also called 'syconium' due to its fleshy, hollow structure. Fig is one of the oldest cultivated fruit species in the Mediterranean (Veberic et al., 2015), and the benefits are also discussed in the chapter At-Tin of the holy Quran. Aside from dates, figs are also known as sunnah food, traditionally consumed by the Prophet Muhammad SAW.

Unlike figs, olive is not usually consumed as a natural fruit due to their bitter taste, but rather as an oil (American Chemical Society, n.d.). Olive oil has been widely used in traditional medicine for its therapeutic properties, including the management of diabetes, hypertension, inflammation, diarrhea, respiratory and urinary tract infections, stomach and intestinal diseases, asthma, hemorrhoids, rheumatism, laxative, mouth cleanser, and as a vasodilator (Hashmi et al., 2015). Figs, on the other hand, are rich in both macro- and micronutrients, including carbohydrate, vitamins, organic acid, minerals, dietary fibre (Badgujar et al., 2014), protein, and fat (Sandhu et al., 2023). They also contain a wide variety of bioactive compounds, such as flavonoids, phenolic acids, carotenoids, and tocopherols, which have long been utilized in traditional medicine for their beneficial effects on gastrointestinal, respiratory, inflammatory, metabolic, and cardiovascular health (Sandhu et al., 2023).

Although existing studies have highlighted numerous clinical effects of using fig and olive oil, research exploring their combined nutritional and anti-oxidative effects on cardiovascular health remains limited. Given the benefits of each ingredient, it is important to investigate the underlying mechanism of their potential synergy. This study aims to analyze the combined effect of olive oil and fig in terms of the nutritional composition, physical properties, and antioxidative activity of olive oil and fig blending, formulated as a supplementary food.

1.2 Problem Statement

Despite their potent anti-oxidative properties and well-documented health benefits of olive oil and fig, research on their combined effects, particularly on cardiovascular health, is limited. While both ingredients have been extensively studied for their nutritional and therapeutic properties, there remains a gap in understanding how their synergistic interaction influences antioxidative and nutritional factors. This study aims to address the knowledge gap by evaluating the physical and biochemical characteristics of a fig and olive oil blend formulated as a supplementary food, thereby providing valuable insights into its potential health benefits.

1.3 Study Objectives

I. General Objective:

To evaluate the nutritional, physical, and anti-oxidative properties of olive oil-fig blend supplementary food at four different ratios of fig to olive oil (1:1, 1:3, 1:5, 1:7)**.** By investigating the synergistic effect of these ingredients, this study aims to contribute to a deeper understanding of their potential health benefits, particularly in terms of cardiovascular well-being.

II. Specific Objective:

1. To analyze the nutritional composition (moisture, protein, fat, ash) of the olive oil-fig blend supplementary food.
2. To evaluate the physical properties of the olive oil-fig blend supplementary food using colour analysis.
3. To determine the *in vitro* anti-oxidative properties of olive oil-fig blend supplementary food.
4. To compare and identify the most preferred formulation among the four variations of the olive oil-fig blend supplementary food, each developed with distinct ingredient ratios, through a sensory evaluation session.

1.4 Study Hypothesis

I. Null Hypothesis

There are no significant differences in nutritional, physical, anti-oxidative, and sensory properties of various formulations of supplementary food.

II. Alternative Hypothesis

There are significant differences in nutritional, physical, anti-oxidative, and sensory properties of various formulations of supplementary food.

1.5 Research Questions

1. What is the nutritional composition of the olive oil-fig blend supplementary food at different ratios of fig to olive oil (1:1, 1:3, 1:5, 1:7)?
2. How do the physical properties (colour) of the olive oil-fig blend supplementary food vary across the different ratios?
3. What is the antioxidative potential of each formulation that influences one's cardiovascular health, and which ratio exhibits the most nutritional and bioactive properties in enhancing cardiac function?
4. Which ratio of the olive oil-fig blend supplementary food is the most acceptable for consumption?

1.6 Significance of the Study

This study is significant as it contributes to the growing body of research on functional foods, focusing specifically on the combined health benefits of fig and olive oil. Both ingredients have long been recognized for their therapeutic properties, yet their synergistic effects, especially concerning cardiovascular health, remain largely unexplored. By analyzing the nutritional, physical, and antioxidative properties of olive oil-fig blend supplementary food, this research provides valuable insights into their potential role in preventing and managing cardiovascular diseases.

The findings from this study may serve as a foundation for future product development in the functional food industry, helping manufacturers formulate innovative, health-promoting food products based on traditional medicinal ingredients. The results could also be beneficial in guiding nutritional recommendations, supporting consumers in making more informed dietary choices for disease prevention.

Additionally, there are populations or groups of people who prefer natural remedies rather than synthetic medicines, who are still seeking natural-based foods for the prevention of cardiovascular disease. This belief is driven by the thought that traditional medicines are safer alternatives to modern drugs when used appropriately (Geethangili et al., 2018). This study may potentially help provide them with a deeper, scientifically based understanding of the olive oil and fig's capabilities in reducing the risk of cardiovascular disease.

From a cultural and religious perspective, this study highlights the historical significance of figs and olives, which are deeply rooted in sacred texts such as the Quran, the Hebrew Bible, and the Christian Bible. By scientifically examining their health benefits, this research supports traditional beliefs and reinforces the importance of these fruits in modern nutrition and wellness practices. Ultimately, this study aims to bridge the gap between traditional knowledge and scientific evidence, providing both health professionals and consumers with a deeper understanding of the potential benefits of fig and olive oil when consumed together in a supplementary food form.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

2.1.1 Overview of Cardiovascular Disease and Its Global Health Impact

Cardiovascular disease (CVD) is a major global health concern, particularly in low and middle-income countries like Malaysia. In 2019, an estimated 17.9 million deaths worldwide, making up 32% of global fatalities, heart attacks and strokes accounted for 85% of these deaths. Meanwhile, in Malaysia, cardiovascular disease (ischemic heart disease) is one of the top causes of death. In 2023, 15.1% of deaths in Malaysia were caused by ischemic heart disease (Department of Statistics Malaysia, 2024).

Cardiovascular disease is a group of disorders of the heart and blood vessels, including coronary heart disease, cerebrovascular disease, rheumatic heart disease, peripheral heart disease, congenital heart disease, and deep vein thrombosis and pulmonary embolism (WHO, 2021). According to the World Health Organization (2021), cardiovascular disease and stroke are largely influenced by lifestyle choices. Key risk factors include poor diet, lack of physical activity, smoking, and excessive alcohol consumption. Environmental factors, such as air pollution, also play a significant role. These risks often lead to hypertension, diabetes mellitus, hyperlipidemia, and obesity, which favour the conditions that increase the likelihood of serious complications like heart attacks and strokes.

The general symptoms of CVD are shortness of breath, severe constricting chest pain, irregular heartbeat (sometimes missed heartbeat), numbness of the face, arm, or leg, especially on one side of the body, and difficulty seeing with one or both eyes. CVD can lead to or worsen other health conditions, such as stroke, because CVD increases the risk of blood clots and arterial blockage (Shahjehan et al., 2024). Other than that, CVD can lead to kidney disease due to poor circulation and high blood pressure that can damage kidney tissues (Vaidya et al., 2024), and heart failure because long-term strain on the heart from CVD can weaken its ability to pump blood effectively (Golla et al., 2024).

The global impact of CVD is disproportionately high in low- and middle-income countries, where over three-quarters of CVD-related deaths occur (WHO, 2021). Additionally, 38% of premature deaths (under age 70) from noncommunicable diseases in 2019 were caused by CVDs (WHO, 2021). Beyond mortality, CVDs contribute to long-term disability, reduced quality of life, and economic strain on healthcare systems. The World Heart Report (2023) highlights that more than half a billion people worldwide are affected by CVDs, and while mortality rates have declined in recent decades, progress is stalling. Without stronger interventions, this trend may reverse, increasing the global burden.

Preventive measures, including healthy diets, physical activity, tobacco cessation, and improved air quality, are essential to reducing CVD risks. However, access to diagnostic tools, treatments, and preventive care remains unequal, particularly in lower-income regions.

2.1.2 Importance of Diet and Functional Foods in CVD Management

Nowadays, eating habits have undergone significant changes worldwide, with dietary shifts accelerating, particularly in low- and middle-income countries. Snacking habits have grown in frequency, and the variety of snacks available has increased significantly (Adair et. al., 2025). More people are incorporating snacks into their daily routines, whether as quick energy boosts or convenience foods.

Changes in the global food system and dietary behavior have led to changes in food supply and, importantly, dietary implications. Shift of complex carbohydrate to refined carbohydrate (refined grains and refined sugar) is one of the major changes that can be seen. Consumption of refined carbohydrate-based foods like white bread was once rare in Latin America, but now it is common due to the high yield of wheat varieties (Anand et. al., 2015). In Asia, on the other hand, white rice is dominant compared to legumes and coarse grains as the primary staple, while instant noodles have recently gained popularity as a widely consumed staple food (Reddy et al., 2002). The increasing trend of consumption of sugar has also been associated with increasing CVD risk. High sugar consumption can trigger low-grade chronic inflammation in the body, including the heart and blood vessels (Ma et. al., 2022). It can weaken arterial walls, making them more prone to damage and increasing the likelihood of hypertension, heart attacks, and strokes. Long-term exposure to elevated sugar levels can lead to diabetes also impair endothelial function, reducing the ability of blood vessels to dilate properly (Petrie et. al., 2018). As high blood sugar can damage blood vessels over time, leading to atherosclerosis, hypertension accelerates this process by putting extra strains on the heart and arteries, increasing the risk of heart attack, stroke, and heart failure. Other than that, high consumption of trans-fat, excessive salt intake, low intake of fibre, and high consumption of highly processed food are also among the dietary factors that may lead to CVD.

Consumption of fruits and vegetables can help reduce CVD risk. Fruits and vegetables are the source of antioxidants such as vitamin C, polyphenols, and carotenoids. By high consumption of these foods, high concentration of antioxidant nutrients such as vitamin C, vitamin E, polyphenols, and carotenoids can lower the risk of CVD (Liu et al., 2000; Rissanen et al., 2003). Polyphenols have also been found useful in enhancing endothelial function, preventing abnormal platelet aggregation, reducing inflammation, and improving plasma lipid profile, all of which benefit cardiovascular health (Iqbal et al., 2023). Other than that, consumption of mono and polyunsaturated fatty acids is proven to reduce the risk of CHD. Additionally, sources of n-3 polyunsaturated fat, such as ALA found in rapeseed and canola oil, offer cardioprotective benefits (Anand et al., 2015), aside to monounsaturated fat that can be found in olive oil, which can lower LDL cholesterol.

2.1.3 Research Gaps and Justification for Studying Olive Oil-fig Blends

Both olive oil and fig are known for their benefits and nutritional content separately; however, limited research has been conducted to study the synergistic effect and health benefits of olive oil and fig. The potential synergistic antioxidant and anti-inflammatory interactions between these two components remain understudied, creating a significant research gap in nutritional science. While olive oil is well-documented for its cardioprotective properties, including its role in reducing inflammation and improving lipid profiles, studies examining its interaction with fig, a fruit rich in antioxidants, fibre, and bioactive compounds, are limited. The sensory acceptability of olive oil-fig blend is also understudied, with no comprehensive studies conducted to evaluate texture properties such as grittiness, cohesiveness, and adhesiveness, which may influence consumer preference. Addressing these gaps will help provide valuable insights into the optimization of the formulation, cardiovascular health benefits, and consumer acceptability. This study also provides a scientific understanding and practical dietary interventions for CVD prevention, which can be very helpful to those who seek a natural remedies approach in preventing the disease.

2.2 Nutritional and Bioactive Properties of Olive Oil and Figs in CVD Prevention

2.2.1 Lipid Profile Modulation of Olive Oil

In this study, the type of olive oil that will be used is extra virgin olive oil (EVOO). Regarding lipid profile, the major component of olive oil is fatty acids (98-99%), mostly are MUFA which are (55.3–86.5%; oleic acid and palmitoleic acid), followed by PUFA which are (3.5–21%; linoleic and linolenic acids), and SFA (8–25.1%; myristic, palmitic and stearic acids). The other 1-2% of olive oil components are sterols and terpenoids and aliphatic alcohols, pigments, squalene, tocopherols (vitamin E), and polar phenolic compounds (Daniel et al., 2023). The chemical composition of olive oil depends on the extraction technology and process applied to obtain the oil. Among pomace olive oil, refined olive oil, and common olive oil, EVOO has the highest polyphenol content, which is around 150-400mg/kg (Gorzynik-Debicka et al., 2018). Olive oil is the primary source of omega-9 fatty acids, particularly oleic acid. Omega-9 can offer several health benefits, particularly related to the heart, such as improving heart health, reducing inflammation, and regulating cholesterol levels.

2.2.2 Antioxidant Mechanisms in Reducing Oxidative Stress and Inflammation

2.2.2.1 Extra Virgin Olive Oil (EVOO)

Antioxidant phenolic compounds from EVOO, such as oleocanthal, oleuropein, hydroxytyrosol, flavonoids, and vitamin E (Xia et al., 2022) can mediate cardiovascular-protective effects by neutralizing free radicals and preventing oxidative damage to blood vessels. This can also help protect from atherosclerosis, which is the major contributor to CVD. A study conducted by Hernáez Á et. al (2017) found that a combination of VOO and Mediterranean diet can improve endothelial function by increasing LDL resistance against oxidation, LDL particle size and composition (cholesterol-rich), and decreasing LDL oxidative modifications and particles cytotoxicity bioavailability by promoting vasodilation and preventing arterial stiffness.

Chronic inflammation is the main factor leading to CVD; polyphenols present in EVOO possess cardiometabolic protective effects via the well-known anti-inflammatory, antioxidant, and anti-thrombotic functions (Carluccio et al., 2007). This can reduce the excretion of C-reactive protein (CRP) markers. The consumption of olive oil has shown antithrombotic properties, and the intake of EVOO and refined olive oil (ROO) has shown improvement of several CVD risk markers, such as lower blood cell count, decreased erythrocyte sedimentation rate (ESR), and increased mean platelet volume in patients with fibromyalgia (Rus et al., 2020). Research also found that one year of oral supplementation of EVOO enriched with vitamins, such as vitamin K1, D3, and B6, could prevent ischemic stroke, which is the second leading cause of death in Malaysia, as it is able to reduce platelet aggregation among post-menopausal women (Vignini et al., 2017). The European Food Safety Authority (EFSA) (2010) has issued a health claim regarding the protective role of olive oil polyphenols (OOPs) in preventing LDL oxidation in vivo, stating that consuming 20 g of olive oil per day, containing at least 5 mg of hydroxytyrosol and its derivatives (such as oleuropein and tyrosol), delivers the anticipated health benefits. Another study conducted by Guasch-Ferré et al., (2020) found that people with higher olive oil intake (>0.5 tablespoon/day or >7 g/day), together with adjusting their major diet and lifestyle factors, had 14% lower risk of CVD and 18% lower risk of CHD.

2.2.2.2 Figs

Figs are a fruit that is rich in antioxidants, primarily in polyphenols and carotenoids. The major types of polyphenols in fig are phenolic acids, flavonnes, flavonones, flavonols, anthocyanins, and proanthocyanidins. Fig is included in dark varieties of fig, and it is known to have higher polyphenol content (TPC, TAC, and TFC) and antioxidant capacity compared to lighter varieties (Veberic et al., 2016). Some studies compare peels and pulps of fig and found that peels have higher concentrations of phenolic compounds and antioxidant capacity compared to pulp, regardless of the colour intensity (Maghsoudlou et al., 2017; Luziana et al., 2015; Solomon et al., 2006; Palmeira et al., 2019; Mahmoudi et al., 2018; Hssaini et al., 2021). Figs are rich in micro and macronutrients such as carbohydrates, dietary fibre, vitamins, minerals, and organic acids (Badgujar et al., 2014). Organic acids are essential for preserving the nutritional value and enhancing the sensory qualities of foods. They also provide various health benefits, including reducing inflammation, regulating the immune system, promoting calcium absorption, and preventing blood clots (Shi et al., 2021). Figs are also high in potassium, which can counteract the effects of salt, which regulates blood pressure, promoting vasodilation and reducing strain on blood vessels, which can protect the cardiovascular system (Aaron et al., 2013). After considering the high antioxidant content of fig, it can be said that figs have the potential to reduce the reactive oxygen stress (ROS) that may attack the heart and blood vessels, and potentially may prevent the progression to CVD.

2.2.3 Role of Dietary Fibre and Micronutrients in Cardiovascular Health

Dietary fibre present in figs may help prevent and resolve CVD. This is because dietary fibre can bind to cholesterol in the digestive tract, which can reduce LDL-c levels. Dietary fibre can also regulate blood pressure by slowing down carbohydrate digestion and glucose absorption in the blood vessels, which also improves insulin sensitivity and glycemic control by preventing blood glucose spikes. This can prevent extra exertion on blood vessels, which can reduce the risk of endothelial dysfunction that may lead to CVD. Regular intake of dietary fibre will not only slow down gastric emptying (which can ensure prolonged satiety), but also help in weight loss by reducing total calorie intake. Certain types of fibres contained in fig are fermentable fibres, which can be broken down into SCFAs and help reduce inflammation and potentially reduce the risk of CHD (Liew, 2020).

Micronutrients available in both olive oil and fig, such as potassium, can reduce the risk of CVD by lowering blood pressure, which can minimize the risk of CVD. According to the United States Department of Agriculture (2004), 2 servings of dried figs contain 298mg of potassium.

Flavonoids are high in both olive oil and fig, possess function as antioxidant, which can act in reducing oxidative stress, reducing inflammation, improving lipid metabolism (Kozłowska et al., 2022), enhancing vascular function (Liu et al., 2024), and reducing platelet activation as too much platelets activation can lead to blood clot and other vascular problems (Ciumărnean et al., 2020).

2.3 Physical Properties of the Formulation

2.3.1 Stability and Emulsification in Blended Supplementary Foods

The development of blended supplementary food requires careful evaluation of its morphological and physical properties, as these factors can directly impact stability and emulsification. The interaction between hydrophilic (fig) and lipophilic (olive oil) components plays an important role in determining the texture, nutrient absorption, and consumer acceptability.

EVOO has high stability and is highly resistant to oxidation due to its fatty acid composition which is characterized by a high monounsaturated-to-polyunsaturated fatty acid ratio, and it also contains a diverse range of minor compounds of potent antioxidant activities, with polyphenols standing out (Kiritsakis, 1990). Polyphenols have been the major contributors to the stability of olive oil for many years (Velasco et al., 2002). Polyphenols and tocopherols are the two main components of phenolic compounds in EVOO, and they act as antioxidants to inhibit oxidation in EVOO. They mainly act as chainbreakers by donating a radical hydrogen to alkylperoxyl radicals formed during the propagation step of lipid oxidation and subsequently forming a stable radical (A•) through the well-known reaction:

$$ROO\bullet + AH \rightarrow ROOH + A$$

Olive oil is a stable ingredient on its own; however, to create an olive oil-fig supplementary food, some changes need to be made to ensure the chemical stability after mixing olive oil and dried fig. Mixing EVOO and dried fig will create a water-in-oil emulsion. Over time, EVOO will separate from the dried fig puree. To prevent this separation, an emulsifier like lecithin may be added to the mixture to ensure uniform dispersion of the lipophilic compound. Proper homogenization technique, such as grinding the mixture at a consistent speed and duration for each ratio, also helps to create a stable and smoother product.

2.3.2 Impact of Processing Methods on Bioavailability of Key Compounds

Processing of olive oil and figs may influence the bioavailability of key compounds significantly, particularly polyphenols, flavonoids, and antioxidants. To prevent the decrease of these compounds, some methods can be practiced in this research, such as controlled thermal processing and the micro-encapsulation method.

Controlled thermal processing, such as controlled heating, can change the bioavailability of nutrients by breaking down complex molecular structures, facilitating absorption when consumed. However, excessive heat can degrade the polyphenols, so optimized processing conditions are required. Micro-encapsulation method is a process in which tiny particles or droplets are surrounded by a coating wall or embedded in a homogeneous or heterogeneous matrix, to give small capsules (Calvo et al., 2010; Gharsallaoui et al., 2007) which can build a barrier between the olive oil in the capsule and the environment, to protect the antioxidant compounds. If either of these methods is done, the bioavailability of the compound in the mixture can be guaranteed.

2.4 Antioxidative Properties and Cardiovascular Benefits

2.4.1 Synergistic Antioxidant Effects of Olive Oil and fig

Antioxidants from olive oil and figs are both powerful, and the synergistic effects can be beneficial in preventing CVD. Olive oil is high in polyphenols, and it has also been demonstrated to exhibit antioxidant, anti-inflammatory, cardioprotective, neuroprotective, antimicrobial, and various other beneficial properties (Rigacci et al., 2016). Hydroxytyrosol (HT) is a phenol compound present in EVOO that exhibits potent antioxidant properties by donating hydrogen atoms, and it can enhance radical stability (Bilal et al., 2021). Other than that, olive oil also contains other major phenolic compounds such as oleuropein and tyrosol. According to Rigacci et al. (2016), most of these attributes are primarily linked to the key secoiridoid derivatives, including oleuropein (Ole), oleocanthal (Oc), and oleacein, as well as the simple phenols hydroxytyrosol (HTyr) and tyrosol (Tyr). Lipophilic antioxidant from olive oil and hydrophilic antioxidant from fig ensure antioxidant balance. Lipophilic antioxidants contained in olive oil can protect cell membranes and lipid structures from oxidation (Liu et al., 2024). Hydrophilic antioxidants contained in fig target aqueous environments in the body.

Fig, on the other hand, have high antioxidant properties due to the presence of phenolic compounds, flavonoids, and tannins (Benmaghnia et al., 2019). Figs are a rich source of bioactive compounds, including vitamins, minerals, organic acids, amino acids, dietary fibre, and a variety of phytochemicals such as carotenoids and polyphenols (Sandhu et al., 2023; Subramanian et al., 2024). A study conducted by Hussain et al (2021) found that daily consumption of figs can provide almost 20% of the recommended dietary fibre per serving, while also assisting in regulating blood pressure and cholesterol due to its potassium, omega-6, and omega-3 fatty acid content. Fig contains dietary carbohydrates that can postpone digestion; meanwhile, anthocyanins can control hyperglycemia (Adisakwattana et al., 2011). Consumption of dried fig can boost humans' plasma antioxidant capability. The number of polyphenols and anthocyanins in fresh fig depends on their overall antioxidant capacity (Yang et al., 2009). The water-soluble vitamin C found in figs is a great natural antioxidant and aids in reducing the non-enzymatic oxidation of vegetables and fruits. It is also used in industry to replace artificial antioxidants (Fasakin et al., 2011).

The growing demand for fig by-products (such as peel, leaves, and oil) and fig-based products is driven by their of bioactive compounds, which are beneficial for heart health (Aziz et al., 2023). The dietary fibre in figs can also help lower triglyceride levels in human, thereby supporting heart health (Aziz et al., 2023). Blood fat molecules known as triglycerides are a major contributor to heart disease. Study conducted by Soni et al. (2014) found the antioxidants in figs help to neutralize free radicals from the body, which contribute to coronary arteries blockage and lead to cardiovascular disease.

In short, by combining EVOO and fig, the polyphenols that are rich in EVOO, rich flavonoids and fibre coming from fig can act as a powerful free radical scavenger, which can help in protecting blood vessels and reducing lipid peroxidation. High MUFAs from EVOO and soluble fibre from fig can help in reducing LDL cholesterol and improve cholesterol balance. MUFAs are also able to increase HDL cholesterol levels, which helps in removing LDL-c from the bloodstream and reducing the risk of atherosclerosis that may cause CVD. MUFAs can also help lower elevated triglycerides, especially in individuals with insulin resistance or type 2 diabetes. Chronic inflammation is the root cause of CVD.

Both EVOO and fig can independently reduce inflammation, and when combined, they may have an amplified effect in reducing inflammation. Figs are rich in potassium, which can help regulate blood pressure by counteracting the effects of sodium and supporting proper kidney function (Yang et al., 2009). EVOO contains polyphenols that promote vasodilation by relaxing and widening blood vessels. This process can enhance circulation and contribute to lower blood pressure (Fito et al., 2005). When consumed together, the potassium in figs and the vasodilatory properties of EVOO may act synergistically to support healthy blood pressure regulation and reduce the risk of hypertension. Lastly, olive oil improves endothelial function, and fig's antioxidant content helps prevent endothelial dysfunction, which is a precursor to atherosclerosis

2.5 Total Phenolic Content (TPC)

Phenolic compounds are the phytochemicals that can be found in plants. Phenolic compounds that are present in fig include flavonoids, phenolic acids, carotenoids, and tocopherols; meanwhile, phenolic compounds from EVOO include oleocanthal, oleuropein, hydroxytyrosol, flavonoids, and vitamin E (Xia et al., 2022). These bioactive components have been widely used in traditional medicine for centuries for addressing inflammation, metabolic, and cardiovascular issues (Sandhu et al., 2023).