การศึกษาเชิงสำรวจปริมาณสาร Aflatoxins ที่ปนเปื้อนในนมพืชทางเลือกที่จำหน่ายในเขตกรุงเทพมหานคร

ดรรชนีพร พฤกษ์วัฒนานนท์

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ปีการศึกษา 2566

AFLATOXINS CONTAMINATION IN PLANT-BASED MILK ALTERNATIVES IN BANGKOK: A CROSS-SECTIONAL QUALITATIVE STUDY

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A Thematic Paper Submitted in Partial Fulfillment of the
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บทคัดย่อ

ในปัจจุบันผู้บริโภคในประเทศไทยนิยมซื้อนมพืชทางเลือกที่ทำจากถั่วมากขึ้นเรื่อยๆเนื่องจากมีคุณค่าทางโภชนาการสูงและราคาย่อมเยาว์ การศึกษานี้มีวัตถุประสงค์เพื่อสำรวจปริมาณสาร Aflatoxins ที่ปนเปื้อนในนมพืชทางเลือกต่างๆ เช่น นมถั่วเหลือง นมอัลมอนด์ นมพิสตาชิโอ นมวอลนัท และนมเฮเซลนัท ผู้วิจัยได้เก็บตัวอย่างนมพืชทางเลือกจำนวน 17 ตัวอย่างจากซุปเปอร์มาร์เก็ต 16 ตัวอย่าง และจากร้านค้าออนไลน์ 1 ตัวอย่าง จำนวนตัวอย่างทั้งหมดได้ผ่านการขึ้นทะเบียนจากสำนักงานคณะกรรมการอาหารและยาแล้วเรียบร้อย และได้ส่งตรวจที่ห้องปฏิบัติกลางประเทศไทยโดยใช้วิธีการตรวจสอบแบบ High Performance Liquid Chromatography เครื่องมือรุ่น Agilent 1100 จากนั้นนำผลที่ได้มาเปรียบเทียบกับค่ามาตราฐานการปนเปื้อนสาร Aflatoxins ในอาหารที่กำหนดจากประกาศกระทรวงสาธารณสุข พ.ศ. 2563 ที่กำหนดว่าการปนเปื้อนของสาร Aflatoxins ทั้งหมดไม่ควรเกิน 20 micrograms/kg ผลการศึกษาพบว่า ทั้ง 17 ตัวอย่างไม่พบการปนเปื้อนสาร Aflatoxins เกินมาตรฐาน ทำให้ ทั้ง 17 ตัวอย่างถือเป็นอาหารที่ปลอดภัยต่อการบริโภค ดังนั้นผู้บริโภคควรพิจารณาการเลือกซื้อนมพืชทางเลือกที่ผ่านการรับรองจากสำนักงานคณะกรรมการอาหารและยาเป็นอันดับแรก จากนั้นควรพิจารณาการเลือกซื้อสินค้าคุณภาพดี เพื่อให้ปลอดภัยต่อการบริโภคและสุขภาพที่ดี

คำสำคัญ: นมพืชทางเลือก, สาร Aflatoxins, ความปลอดภัยของอาหาร

Thematic Paper Title	AFLATOXINS CONTAMINATION IN PLANT-BASE MILK ALTERNATIVES IN BANGKOK: A CROSS-SECTIONAL QUALITATIVE STUDY
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ABSTRACT

In Thailand, the demand for plant-based milk alternatives derived from nuts has been steadily rising among consumers due to their perceived nutritional benefits and cost-effectiveness. This study endeavors to assess the levels of aflatoxin contamination present in a variety of plant-based milk alternatives including soy milk, almond milk, pistachio milk, walnut milk, and hazelnut milk. A total of 17 samples were procured for analysis, comprising 16 samples from local supermarkets and 1 obtained through online marketplace. All samples underwent registration with the Food and Drug Administration and were subjected to testing using the High Performance Liquid Chromatography Agilent 1100 model at the Central Laboratory (Thailand). The research findings were benchmarked against the aflatoxin contamination limits established by the Ministry of Public Health in 2020, stipulating that total aflatoxin levels should not exceed 20 micrograms per kilogram. Notably, none of the 17 samples surpassed this regulatory threshold, indicating compliance with safety standards suitable for consumption. Consequently, it is advisable for consumers to prioritize selecting plant-based milk alternatives endorsed by the Food and Drug Administration and to opt for products of assured high quality, thereby safeguarding food safety and promoting overall health.

Keywords: Plant-based milk alternatives, Aflatoxins, Food Safety.

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Dudchaneeporn Pruckwattananon

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CHAPTER 1
BACKGROUND AND RATIONALE

1.1 Background

In Thailand, the popularity of plant-based milk alternatives, such as soy milk, almond milk, pistachio milk, walnut milk, and hazelnut milk, has surged among health-conscious consumers. This trend is attributed to the high nutritional value and affordability of these options. Additionally, these plant-based milk alternatives are preferred by individuals who follow vegetarian or vegan diets or who have allergies to dairy milk. The primary advantages of plant-based milk alternatives include their rich nutritional content and low-calorie consumption. Health benefits associated with these beverages include lowering blood sugar, blood pressure, and LDL cholesterol levels, thereby reducing the risk of non-communicable diseases such as diabetes, hypertension, atherosclerosis, dementia, and cancer. According to the Nutrition Department of the Faculty of Medicine at Mahidol University[1], certain micronutrients in these alternatives provide antioxidants that support various bodily functions, including those of the eyes, skin, bones, muscles, and brain. Presently, numerous brands of plant-based milk alternatives, both locally produced and imported, are available in Thailand.

According to the World Health Organization, aflatoxin is considered one of the most dangerous carcinogens and mutagens, causing severe health issues such as liver cancer, liver cirrhosis, stunted growth in children, and immunosuppression. Regular consumption of foods contaminated with high levels of aflatoxins can lead to these serious health problems. Aflatoxin contamination is frequently found in agricultural products, including peanuts, corn, grains, and nuts, during on-farm and transit periods. Research on aflatoxin contamination in food crops[2] indicates that certain nuts, such as soybeans, almonds, walnuts, and pistachios, are highly susceptible to aflatoxin contamination. A recent global systematic review[3] also highlighted the widespread contamination of various nuts, including almonds, walnuts, pistachios, and hazelnuts, on an international scale. This issue has become a global concern, impacting agriculture, manufacturing, business, government, healthcare, and household consumption.

Recent research in Spain[4] has identified some levels of aflatoxin contamination in plant-based milk alternatives. Given Thailand's status as both an importer and manufacturer of nuts and plant-based milk alternatives, the country is likely to face similar challenges. To mitigate the risk of consuming aflatoxin-contaminated plant-based milk alternatives, it is imperative for producers to prevent contamination during the manufacturing process, or for consumers to avoid these products. For the benefit of Thai consumers, investigating aflatoxin contamination in plant-based milk alternatives is crucial to assess the potential health risks.

The objective of this study is to provide qualitative food safety data by summarizing findings on aflatoxin contamination in five types of selected plant-based milk alternatives available in Bangkok.

1.2 Research Question

Are there any aflatoxin contaminations in plant-based milk alternatives? If so, what levels of contamination are found in soy milk, almond milk, pistachio milk, walnut milk, and hazelnut milk?

1.3 Research Objective

To assess the level of aflatoxin contamination in plant-based milk alternatives and provide qualitative food safety data for consumers.

1.4 Expected Benefits

1.4.1 To identify which types of plant-based milk alternatives are contaminated with aflatoxins and the levels of contamination.

1.4.2 To provide consumers with qualitative findings regarding aflatoxin contamination in plant-based milk alternatives.

1.5 Scope of the Study

The study will select five types of plant-based milk alternatives from supermarkets in Bangkok: soy milk, almond milk, walnut milk, pistachio milk, and hazelnut milk. Each type will include four samples, with two locally produced and two imported products. In total, 20 plant-based milk alternatives will be analyzed.

1.6 Hypothesis

There are no aflatoxin contaminations in plant-based milk alternatives.

1.7 Terminology

1.7.1 Plant-based milk alternatives: Milk products made from plants, marketed as alternatives to cow's milk, including soybeans, almonds, walnuts, pistachios, and hazelnuts.

1.7.2 Aflatoxins: Mycotoxins produced by molds, specifically ***Aspergillus flavus*** and ***Aspergillus parasiticus***, which can cause health hazards and diseases when consumed in contaminated foods.

CHAPTER 2
CONCEPT, THEORY AND LITERATURE REVIEW

This chapter presents a comprehensive review of aflatoxin contamination in plant-based milk alternatives. The review covers related documents, articles, and research across the following topics:

1. Plant-based milk alternatives
2. Aflatoxins and their impact on human health
3. Aflatoxin testing using the in-house method TE-CH-025 based on AOAC (2023) 991.3 and AOAC (2023) 994.8 with High-Performance Liquid Chromatography (HPLC)
4. Literature review

2.1 Plant-Based Milk Alternatives (PBMA)

2.1.1 Definition by the US FDA

According to the United States Food and Drug Administration (FDA)[5], plant-based milk alternatives are products derived from plants and marketed as substitutes for dairy milk. These alternatives encompass a diverse array of sources, including nuts (such as hazelnuts, walnuts, coconuts, cashews, and almonds), seeds (such as sesame, flax, and hemp), rice, oats, or legumes (such as soy). The composition and nutrient profile of these products can vary significantly based on the plant source, processing methods, and added ingredients.
Plant-based milk alternatives serve as viable options for those seeking to replace dairy milk due to dietary preferences, lactose intolerance, or other health considerations. These products are designed to mimic the texture, flavor, and nutritional content of traditional dairy milk, although variations in nutrient content can occur depending on the type and brand.

2.1.2 Key General Benefits

Plant-based milk alternatives offer numerous benefits compared to traditional dairy milk. The following points, as highlighted in Medical News Today[6], provide an overview of these advantages:

(1) Lactose-Free: Plant-based milk alternatives are inherently free from lactose, making them suitable for individuals who are lactose intolerant or have difficulty digesting

lactose. This characteristic broadens the accessibility of these products to a larger audience who may experience discomfort or digestive issues with dairy milk.

(2) Variety of Options: There is a wide variety of plant-based milk alternatives available, including almond, soy, coconut, oat, rice, hemp, and cashew milk. This variety caters to different tastes and dietary preferences, allowing consumers to select the most suitable option based on their individual needs and flavor preferences.

(3) Nutrient Content: While the nutrient content varies among different types of plant-based milk alternatives, many are fortified with essential vitamins and minerals such as calcium, vitamin D, and vitamin B12. This fortification often makes them nutritionally comparable to dairy milk, providing necessary nutrients that might otherwise be deficient in a plant-based diet.

(4) Lower in Calories: Plant-based milk alternatives tend to be lower in calories than dairy milk. This makes them a suitable option for individuals who are mindful of their calorie intake or those trying to manage their weight. Lower calorie consumption can contribute to better weight management and overall health.

(5) Environmental Sustainability: Producing plant-based milk alternatives generally has a lower environmental impact compared to dairy milk production. Plant-based production requires less water, land, and other resources, thereby contributing to a more sustainable food system and reducing the ecological footprint associated with dairy farming.

(6) Ethical and Animal Welfare: Choosing plant-based milk alternatives supports ethical and animal welfare concerns. By reducing the demand for dairy products, the need for animal exploitation in the dairy industry is diminished, aligning with ethical choices regarding animal rights and humane treatment.

(7) Allergen-Friendly: Plant-based milk alternatives are free from common allergens such as dairy, making them suitable for individuals with dairy allergies or sensitivities. This aspect ensures that individuals with specific dietary restrictions can safely consume these products.

(8) Versatility: Plant-based milk alternatives can be used in various culinary applications, including baking, cooking, and as a substitute for dairy milk in recipes. This versatility provides more choices in the kitchen and allows for creative and diverse culinary experiences.

(9) Longer Shelf Life: Some plant-based milk alternatives have a longer shelf life compared to dairy milk, especially shelf-stable varieties. This extended shelf life reduces

food waste and the need for frequent grocery shopping, contributing to convenience and economic efficiency.

(10) Taste and Texture: Plant-based milk alternatives offer diverse flavors and textures, catering to different preferences. This variety provides a flavorful option to dairy milk, appealing to those who seek different taste experiences or have specific texture preferences.

2.1.3 Key Nutritional and Health Benefits

Based on the article from Food Infotech[7], plant-based milk alternatives contribute multiple key nutrients, including protein, calcium, vitamin A, vitamin D, magnesium, phosphorus, potassium, riboflavin, and vitamin B-12, as well as zinc, choline, and selenium. The health benefits associated with these alternatives are substantial, and they encompass several key aspects:

(1) Growth and Development: Plant-based milk alternatives, particularly those high in protein and calcium, contribute significantly to human growth and development. They support bone and muscle health, immune function, energy metabolism, and overall growth in children and adults. For example, soy milk and almond milk are known to provide high protein and calcium contents similar to cow's milk.

(2) Weight Management: The low-calorie nature of many plant-based milk alternatives aids in weight control and management. This characteristic is beneficial for individuals who are on caloric restriction or those attempting to lose weight. Effective weight management also plays a crucial role in preventing obesity and metabolic syndrome.

(3) Lower Risk of Chronic Diseases: Plant-based milk alternatives are generally cholesterol-free, low in saturated fat, and rich in nutrients and antioxidants. Phytosterols found in these alternatives have been shown to reduce cholesterol levels, prevent cancer, modulate the immune system, and exhibit anti-aging effects on the skin. Consequently, regular consumption of plant-based milk alternatives can lower the risk of chronic diseases such as cardiovascular disease, hypertension, diabetes, dementia, and certain types of cancer.

(4) Support for Multiple Organs: Some plant-based milk alternatives contain specific vitamins, minerals, and antioxidants that support various organs. For instance, these nutrients can enhance the health of the eyes, skin, brain, bones, muscles, and heart. Regular

intake of these nutrients ensures the proper functioning and maintenance of these critical body systems.

(5) Aesthetic Attributes: Beyond health benefits, plant-based milk alternatives can contribute to improved physical appearance. Their lower calorie content and richness in vitamins, minerals, and antioxidants help individuals maintain a healthy, youthful, and radiant look. Additionally, phytosterols in plant-based milk alternatives stimulate collagen production, which can counteract skin aging caused by sun exposure.

2.1.4 Cautions of Plant-Based Milk Alternatives Intake

Despite the numerous benefits, there are some cautions to consider when consuming plant-based milk alternatives, as noted by Nutrition Dynamix[8]:

(1) Nutrient Content: Plant-based milk alternatives may not naturally contain the same nutrient profile as cow's milk. Essential nutrients such as calcium, vitamin D, and vitamin B12 might be lacking unless the products are fortified. Consumers need to be aware of this and select fortified options when necessary.

(2) Allergies and Sensitivities: Certain plant-based milk alternatives, such as almond milk or soy milk, can be allergens for some individuals. It is important for consumers to check the ingredients and be aware of potential allergens before consumption.

(3) Added Sugar: Some plant-based milk alternatives contain added sugars to enhance flavor. Excessive consumption of these added sugars can lead to health issues, including obesity, diabetes, and dental problems. Consumers should check for unsweetened versions to avoid unnecessary sugar intake.

(4) Caloric Content: While many plant-based milk alternatives are low in calories, some may be sweetened or fat-enhanced, resulting in higher calorie content. Consumers aiming for low-calorie options should carefully read labels to ensure they are making the best choice for their dietary needs.

(5) Thickening Agents and Additives: To improve texture and consistency, some plant-based milk alternatives may contain additives, stabilizers, or thickening agents. Some individuals might be sensitive to these substances, leading to potential health concerns such as inflammatory bowel disease. It is advisable to choose products with minimal additives.

(6) Digestive Issues: Certain ingredients used in plant-based milk alternatives, like carrageenan, might cause digestive discomfort in some individuals. Consumers with sensitive digestive systems should look for alternatives that do not contain such ingredients.

2.1.5 Plant-Based Milk Alternatives in Thailand

In Thailand, a variety of plant-based milk alternatives are available, each catering to different dietary preferences and needs. These alternatives are suitable for vegans, lactose-intolerant individuals, or those seeking dairy-free options. Some common plant-based milk alternatives in Thailand include:

(1) Soymilk: Widely popular and readily available at supermarkets and convenience stores. Soymilk is made from soybeans and is a good source of protein and calcium.

(2) Coconut Milk: A staple in Thai cuisine, commonly used for cooking and consumed as a beverage. Coconut milk is made from grated coconut meat and water, offering a rich and creamy texture.

(3) Almond Milk: Increasingly popular, almond milk is available in supermarkets and often fortified with vitamins and minerals. It is made from ground almonds and water.

(4) Rice Milk: This plant-based milk alternative, made from milled rice and water, has a mild, slightly sweet flavor and is available in supermarkets.

(5) Oat Milk: Gaining worldwide popularity, oat milk is starting to appear on shelves in Thailand. It is made from oats and water, providing a creamy texture similar to cow's milk.

(6) In addition to locally made products, imported plant-based milk alternatives, such as walnut milk, hazelnut milk, and pistachio milk, are becoming more popular among health-conscious consumers in Thailand. These imported products are sourced from countries like Australia, the USA, China, and various European nations.

Plant-based milk alternatives in Thailand can be categorized into locally produced and imported products. Locally produced plant-based milk alternatives often use raw materials grown within Thailand, such as rice, coconut, and soybeans. On the other hand, imported products may include nuts like almonds, pistachios, walnuts, and hazelnuts. These imported plant-based milk alternatives cater to the increasing demand for diverse plant-based options and are part of a growing trend among health-conscious consumers.

According to a report by the Food Intelligence Center, National Food Institute[9], the market size of plant-based milk alternatives in Thailand reached 17,960 million Baht in 2022. This sector exhibited a growth rate of 6.6% during the same year. Soy milk accounted for a substantial 93.40% of the total market share, with other plant-based milk alternatives comprising the remaining 6.60%. The primary companies dominating this market included Lactasoy, Vitamilk, V-Soy, and Tofusan. Despite soy milk's longstanding dominance, other plant-based milk alternatives such as oat milk, almond milk, and pistachio milk are gradually gaining acceptance and increasing their consumer base. This shift indicates a diversification in consumer preferences towards a broader range of plant-based milk options.

Figure 2.1 2022 Plant-Based Milk Alternative Market in Thailand[9]

Additionally, an article from The Business Plus[10] projected the market size of plant-based milk alternatives to grow as follows:

(1) 2023: 18,946 million Baht

(2) 2024: 19,826 million Baht

(3) 2025: 20,629 million Baht

(4) 2026: 21,242 million Baht

(5) 2027: 21,852 million Baht

The article also highlighted the top five brands with the highest market shares in 2023: Lactasoy at 38.9%, Vitamilk at 25.3%, DNA at 18.5%, Tofusan at 3.1%, V-Soy at 3%, and other brands at 11.2%.

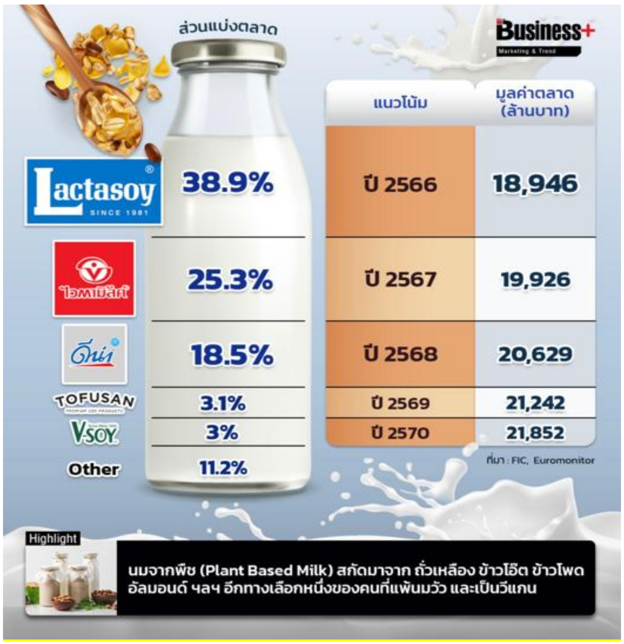

Figure 2.2 Market Growth (2023-2027) and 2023 Market Share of Plant-Based Milk Alternatives in Thailand[10]

The growth of the plant-based milk alternatives market in Thailand is primarily driven by increasing awareness of health and environmental concerns, along with a growing preference for vegan and lactose-intolerant diets. According to an article from Root the Future[11], there are over 100 types of plant-based milk alternatives currently available in Thailand. This diversity in options continues to expand, with new products regularly entering the market, a trend expected to persist in the coming years.

2.1.6 Plant-based milk alternatives in this study

Given the high likelihood of aflatoxin contamination in nuts[2,3], this study focuses on five types of plant-based milk alternatives:

(1) Soy Milk

Based on the article from Health Line[12,], soy milk, derived from soaking and grinding soybeans, is popular among those with lactose intolerance or dairy allergies and those who prefer a vegan lifestyle. It provides high levels of protein, calcium, vitamin D, omega-3 fatty acids, and flavonoids. Notably, it contains isoflavones, beneficial for menopausal women. In Thailand, soy milk constitutes over 90% of the plant-based milk market, with soybeans sourced both locally and internationally.

(2) Almond Milk

Based on the article from Health Line[13], almond milk, made from ground almonds and water, is low in calories and cholesterol-free. It offers a high content of protein, calcium, vitamins D and E, magnesium, zinc, and omega-3 fatty acids. Health benefits include weight loss, reduced blood sugar, and lower risks of heart and brain diseases. Almonds are primarily imported from the USA and Australia for production in Thailand.

(3) Pistachio Milk

Based on the article from Plant Milk Organization[14,], pistachio milk is produced by blending pistachios with water. It is rich in protein, vitamins B and E, magnesium, zinc, omega-3 fatty acids, and antioxidants like lutein and zeaxanthin. These nutrients support eye health and reduce cardiovascular disease risk. Pistachios used in Thailand are mainly imported from the USA, Turkey, and Middle East countries.

(4) Walnut Milk

Based on the article from Plant Milk Organization[15,], walnut milk, made from blending walnuts with water, is rich in omega-3 fatty acids, vitamins, and minerals. It provides significant health benefits, including weight management, lower LDL cholesterol, reduced blood pressure, and decreased diabetes risk. Walnuts are imported primarily from the USA and China.

(4) Hazelnut Milk

Based on the article from Milks and Health[16], hazelnut milk, created by blending hazelnuts with water, is favored by those avoiding dairy. It contains high levels of protein, calcium, vitamins A and E, vitamin B6, folate, zinc, omega-3 fatty acids, and antioxidants like flavonoids and anthocyanins. Health benefits include lower blood sugar, reduced LDL cholesterol, and decreased cardiovascular disease risk. Hazelnuts are imported from Turkey, Italy, and other Mediterranean countries.

2.2 Aflatoxins

According to Wikipedia[17], aflatoxins are a type of mycotoxin produced by certain molds, particularly species of ***Aspergillus***. These molds proliferate in soil, decaying vegetation, hay, and grains, and can contaminate crops such as corn, peanuts, cottonseed, and tree nuts. In essence, these fungi can grow on nearly any crop or food item. When contaminated food is processed or consumed, aflatoxins enter the food supply chain, affecting both human and animal consumption.

Contaminated feed given to agricultural animals can result in the transfer of aflatoxin metabolites into eggs, milk products, and meat. Recognized as potent carcinogens, aflatoxins pose significant health risks, necessitating strict regulation in food and feed products to minimize exposure. The term "**aflatoxins**" is derived from "**A**" for ***Aspergillus*** and "**fla**" from ***flavus*** .

The research on the characteristics, occurrence, detection, and detoxification of aflatoxins in foods and feeds[18] identifies several types of aflatoxins :

2.2.1 Aflatoxins B1 and B2 (AFB)

Aflatoxins B1 and B2 are toxic compounds produced by certain fungi, primarily ***Aspergillus flavus*** and ***Aspergillus parasiticus****.* These fungi commonly contaminate crops such as maize, peanuts, cottonseeds, and tree nuts. Under fluorescent lighting, these toxins exhibit a blue fluorescence. Aflatoxin B1 is the most potent and well-documented carcinogen among aflatoxins, whereas Aflatoxin B2, although less potent, still poses significant health risks. The consumption of food contaminated with these aflatoxins can lead to severe health issues, including liver damage and an increased risk of liver cancer. Consequently, monitoring and controlling aflatoxin contamination in food products is essential.

2.2.2 Aflatoxins G1 and G2 (AFG)

Aflatoxins G1 and G2 are produced by specific strains of ***Aspergillus flavus*** and ***Aspergillus parasiticus***. Classified as Group II carcinogens, they differ from Group I aflatoxins by exhibiting green fluorescence under ultraviolet light. These toxins are frequently found in nuts, grains, and legumes, especially when stored improperly in warm and humid conditions. As recognized carcinogens, aflatoxins G1 and G2 pose significant health risks to both humans and animals.

2.2.3 Aflatoxins M1 (AFM1)

Aflatoxin M1 is a metabolite of Aflatoxin B1 found in the milk of humans and animals. It is formed when dairy cattle consume feed contaminated with Aflatoxin B1, which is then converted into Aflatoxin M1 and excreted in the milk. The presence of Aflatoxin M1 in dairy products poses a health risk to humans upon consumption.

2.2.4 Aflatoxins M2 (AFM2)

Aflatoxin M2 is a metabolite of Aflatoxin B2 found in the milk of cattle fed contaminated food. Similar to Aflatoxin M1, Aflatoxin M2 is derived from Aflatoxin B2 rather than B1. It is found in smaller quantities and has been less extensively studied compared to Aflatoxin M1.

Both Aflatoxins M1 and M2 are considered carcinogenic and can have detrimental effects on human health if ingested in significant amounts over time.

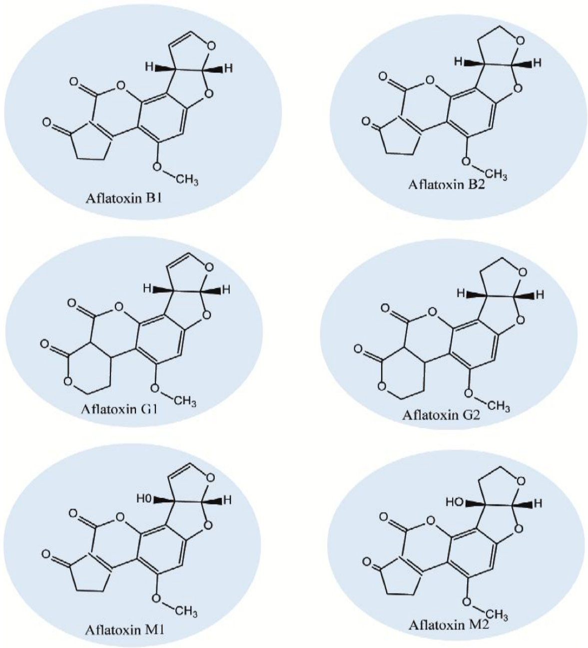

Figure 2.3 Chemical Structure of Each Type of Aflatoxin[18]

2.2.5 Impacts on human's heath

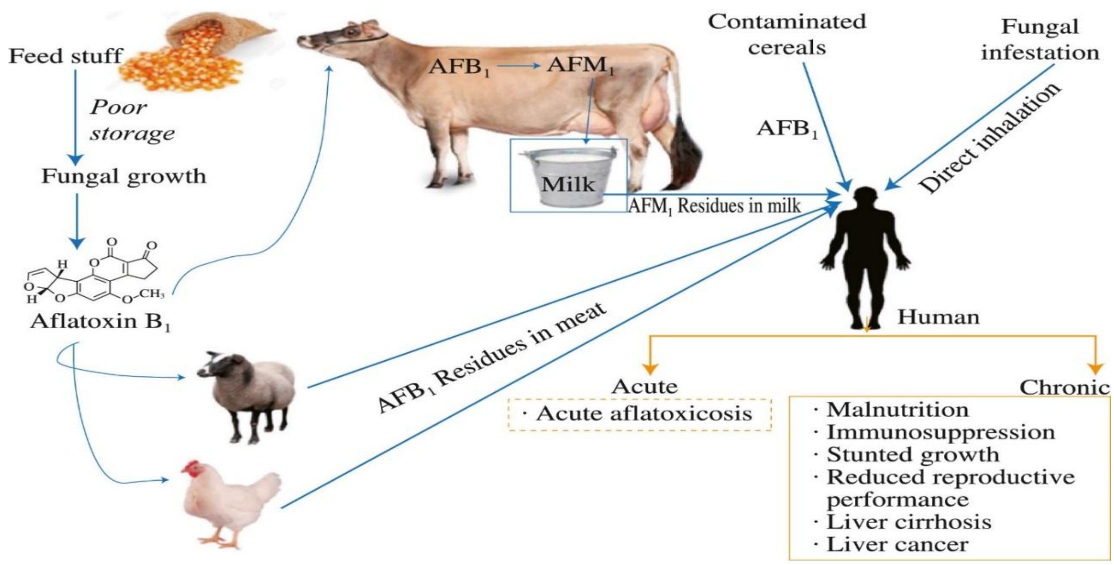

Figure 2.4 Incidence of Acute and Chronic Aflatoxicosis[19]

According to a comprehensive study on major mycotoxins in food products[19], aflatoxin contamination of crops is widespread before harvesting and is often linked to drought stress. More concerning, however, is the contamination that occurs when crops are stored in conditions conducive to mold growth. The most critical variables in storage are the moisture content of the substrate and the relative humidity of the surrounding environment. Increased mortality in agricultural animals has been linked to aflatoxin contamination, significantly decreasing the value of grains as an animal feed and export product.

Figure 2.4 illustrates that aflatoxins can also be found in milk products indirectly. When cows consume aflatoxin-contaminated feed, aflatoxin B1 is bio transformed into aflatoxin M1, a hydroxylated form. In both human and animal populations, aflatoxins have been associated with toxicity and carcinogenicity. Disorders resulting from aflatoxin exposure are termed aflatoxicosis. Acute aflatoxicosis can be fatal, while chronic aflatoxicosis leads to cancer, immunological suppression, and other "slow" pathological conditions.

(1) Acute Aflatoxicosis

Exposure to moderate to large doses of aflatoxins over a relatively short period can result in acute aflatoxicosis. Symptoms of acute intoxication include nausea, jaundice (yellowing of the skin and sclera), hemorrhage, itching, vomiting, abdominal pain, lethargy, edema, acute hepatic damage, convulsions, coma, and potentially death.

(2) Chronic Aflatoxicosis

Chronic aflatoxicosis results from exposure to low to moderate doses of aflatoxins over extended periods. Although the effects are often subclinical and unrecognizable, chronic exposure can lead to numerous health issues, including carcinogenicity, genotoxicity, teratogenic effects, compromised immunity, and reproductive failure. The liver is the primary target organ for chronic aflatoxicosis.

In humans, one of the most serious conditions caused by aflatoxicosis is liver cancer. Consuming aflatoxin-contaminated foods or beverages in high quantities over time can lead to the accumulation and metabolism of aflatoxins in the liver, ultimately resulting in hepatocarcinogenesis and hepatocellular carcinoma (HCC). Aflatoxins are metabolized primarily in the liver, where liver enzymes work to convert aflatoxins into less toxic forms that can be excreted from the body. The primary pathway involves enzymes such as cytochrome P450, which converts aflatoxins into more water-soluble metabolites. These metabolites are then conjugated with molecules like glutathione to facilitate their elimination through bile and urine. However, this metabolic process can also produce reactive intermediates that can bind to cellular macromolecules such as DNA, forming DNA adducts. These adducts can cause mutations and DNA damage, potentially leading to the development of liver cancer. Factors such as genetic variability in enzyme activity, nutritional status, and the level of aflatoxin exposure can influence the efficiency of aflatoxin metabolism and subsequent susceptibility to liver cancer. Aflatoxin B1 is considered the most potent liver carcinogen.

2.2.6 Aflatoxin B1 Metabolism

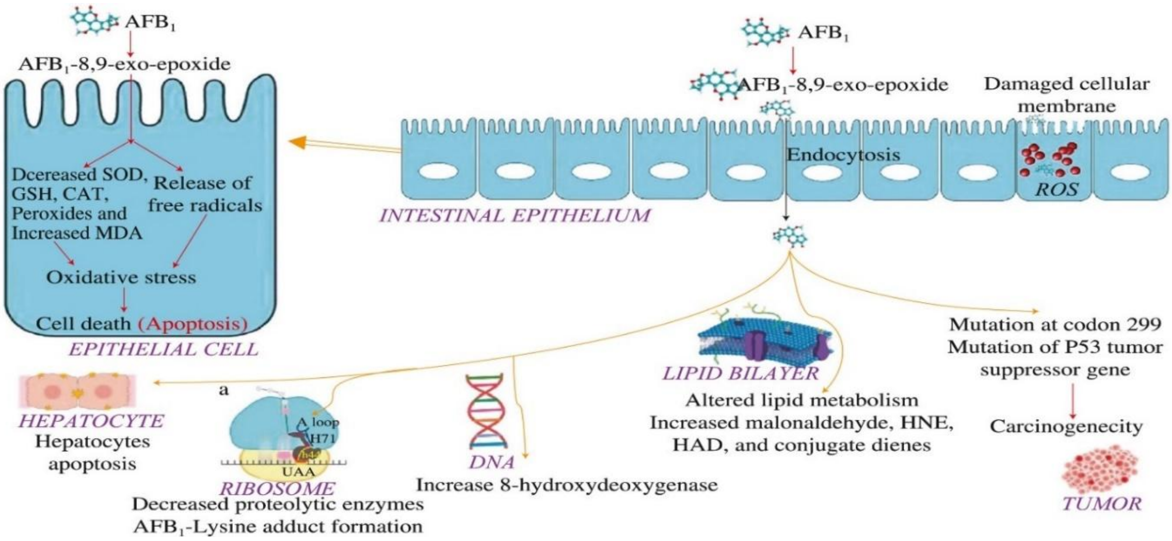

Figure2.5 Aflatoxin B1 Metabolism and Carcinogenicity[19]

According to the study on the major mycotoxins in food products[19] ,the figure 2.5 illustrates that aflatoxins are transformed to the reactive 8,9-epoxide form by cytochrome P450 enzymes, which can bind to DNA and proteins. The reactive aflatoxin epoxide binds to the N7 position of guanines, which is widely understood. Furthermore, GC to TA transversions can be caused by aflatoxin B1-DNA adducts. A reactive glutathione S-transferase system in the cytosol and microsomes catalyzes the conjugation of activated aflatoxins with reduced glutathione, leading to the excretion of aflatoxin. Variations in the glutathione transferase system, as well as the cytochrome P450 system are thought to have a role in aflatoxin sensitivity differences between individuals.

Based on the previous study on aflatoxins contamination in nut products in Thailand[20] , aflatoxins are notorious for their impact on human health due to their ability to enter the body through ingestion and subsequently undergo absorption, distribution, metabolism, and excretion processes. Primarily fat-soluble, aflatoxin B1, a prominent member of the aflatoxin family, is efficiently absorbed during periods of dietary fat consumption. Once absorbed, aflatoxin B1 binds strongly to plasma proteins, facilitating its distribution throughout the bloodstream to hepatocytes and other organs, where it forms covalent bonds with macromolecules.

Metabolism of aflatoxin B1 predominantly occurs in the liver, starting with phase I metabolism mediated by enzymes like CYP3A4 and CYP1A2. During this phase, aflatoxin B1 undergoes oxidation at positions 8 and 9 in the furan ring, resulting in the formation of the highly reactive B1 8,9 epoxide. This epoxide is known to be extremely harmful as it can bind covalently to DNA, RNA, and other cellular proteins within hepatocytes, forming adducts. These adducts disrupt normal DNA function, potentially leading to aberrant cellular processes, including malfunctioning protein synthesis, which can culminate in the accumulation of aflatoxins B1 and subsequent carcinogenesis, particularly hepatocellular carcinoma.

Following phase I metabolism, aflatoxin B1 undergoes phase II metabolism, primarily involving glucuronidation. This process utilizes human glucuronic acid and glutathione, catalyzed by glutathione S-transferase (GSTs), to convert aflatoxin B1 into water-soluble esters. These metabolites are then readily excreted via urine and bile, thereby reducing the body's burden of aflatoxin B1 toxicity. Additionally, hydroxylation by UDP-glucuronyl transferase further aids in reducing the toxicity levels of aflatoxin B1, facilitating its elimination through urine and bile.

Excretion marks the final stage of the process, where aflatoxin B1 and its metabolites are expelled from the body via feces, urine, or even breast milk. The impact of aflatoxin B1, however, extends beyond the liver, affecting other vital organs such as the kidneys, intestines, stomach, heart, and brain. This comprehensive pathway highlights the intricate mechanisms involved in the metabolism and elimination of aflatoxins B1, underscoring the importance of understanding these processes to mitigate their health risks effectively.

Based on National Cancer Institute, U.S. Health Department[21], exposure to aflatoxins is associated with an increased risk of liver cancer. Figure 2.6 illustrates a micrograph of an Aspergillus spore, a type of fungus that produces cancer-causing aflatoxin.

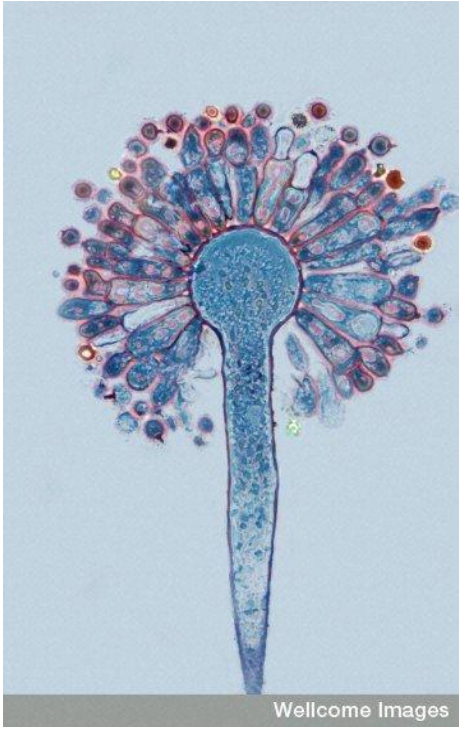

Figure 2.6 Micrograph of cancer-causing aflatoxin[21]

2.2.7 Liver cancer in Thailand

Based on the article from the Faculty of Pharmacy, Chulalongkorn University[22], it indicated that liver cancer is the leading cause of death in Thailand which requires prompt treatment for better chances of survival. While cancer can be detected and treated, early detection is crucial. Therefore, it is suggested to undergo regular physical examinations and monitor the body for any symptoms to ensure a proactive approach for prevention.

According to 2021 statistics, liver cancer claims the lives of over 26,000 Thai individuals annually, accounting for 96.3% of cancer-related deaths. This high mortality rate emphasizes the severity of the issue.

The primary risk factors for liver cancer are a history of hepatitis B or C infection and cirrhosis, which can be caused by alcohol consumption or non-alcohol factors such as fatty liver. Aflatoxin, a toxin produced by fungi commonly found in contaminated dry foods like cereals and nuts, is also strongly associated to liver cancer.

Early-stage liver cancer typically presents no symptoms, making it difficult to detect until it reaches an advanced stage. Symptoms may include gastric-like discomfort, stomach burning, indigestion, distension, rib cage pain on the right side, anorexia, fatigue, weight loss, yellowing of skin and eyes (jaundice), and ascites. By the time liver cancer is diagnosed, it becomes difficult to cure.

As with other cancers, early detection significantly improves treatment efficacy. However, screening recommendations for liver cancer may differ from those for other types. It is advisable that high-risk individuals should undergo liver cancer screening particularly those age over 50 years old. High-risk individuals who should undergo liver cancer screening include those with any causes of cirrhosis, those diagnosed with hepatitis C and significant liver fibrosis, and individuals with a history of hepatitis B infection, particularly if they have a first-degree relative with liver cancer.

To reduce the risk of liver cancer, it is essential to limit alcohol consumption to avoid overworking the liver and potentially developing cirrhosis. Additionally, individual should avoid consuming old food grains and nuts that may be contaminated with aflatoxins. Based on the global systematic review[3] examining aflatoxin contamination in various nuts, including almonds, walnuts, hazelnuts, and pistachios across 14 countries such as the USA, China, Iran, Turkey, and several Mediterranean, Middle East, and South African countries, significant levels of aflatoxin contamination have been observed. This contamination poses concerns ranging from agricultural and economic impacts to food safety and health risks of varying severity.

In Thailand, there is a growing trend in the importation and domestic consumption of these nuts and their derived milk products. This trend raises concerns among consumers regarding potential health risks associated with aflatoxin contamination in these products. Consequently, this study aims to assess the levels of aflatoxin contamination in five selected types of plant-based milk alternatives available in Bangkok supermarkets. The objective is to provide insights into the safety of these products and to address consumer health concerns related to aflatoxin exposure in Thailand's food market.

2.3 Aflatoxins Regulation

Based on the study on aflatoxins in food: prevalence, health effects, and emerging trends in its mitigation[23], different countries have different maximum permitted limits (MPL) for aflatoxins in foods and feeds. The figure 2.7 illustrates the worldwide aflatoxins regulation.

Figure 2.7 Worldwide Aflatoxins Regulation[23]

In Thailand, as stipulated by the Ministry of Public Health[25], the maxim
um permissible limit for total aflatoxins in all food and feed commodities is set at 20 micrograms per kilogram. This regulation serves as a pivotal benchmark against which the findings of this study on aflatoxins contamination in plant-based milk alternatives are evaluated.

2.4 Aflatoxins Elimination Methods

Based on the study of aflatoxin contamination in food crops: causes, detection, and management[2] and the study on aflatoxins in food: Prevalence, health effects, and emerging trends in its mitigation[23], there are numerous methods applicable to eliminate aflatoxins as follows.

2.4.1 UV Radiation.

UV radiation can be used to eliminate aflatoxins through a process called photodegradation. When aflatoxins are exposed to UV radiation, particularly UV-C light in the wavelength range of 200 to 280 nanometers, it causes chemical changes in the molecular structure of the aflatoxins, leading to their decomposition. The mechanism involves the absorption of UV energy by the aflatoxin's molecules, which then undergo various photophysical and photochemical processes, ultimately breaking down to smaller and less harmful compound.

2.4.2 Pulsed Light Treatment.

Pulsed light treatment is another method used for aflatoxins elimination. It involves the application of intense flashes of light in short pulses which are in the ultraviolet (UV) and visible light spectrum to degrade aflatoxins. Like UV radiation, pulsed light treatment causes photodegradation of aflatoxins by breaking down their molecular structure. The intense bursts of light energy led to the formation reactive oxygen species (ROS) such as singlet oxygen and hydroxyl radicals which react with and break down the aflatoxin's molecules.

2.4.3 Ammoniation.

Ammoniation, or the treatment with ammonia, is a method used for elimination or reduction of aflatoxins in agricultural commodities. The process involves exposing the contaminated materials with ammonia gas or ammonia solutions under controlled conditions. Ammoniation works by several mechanisms.

(1) Chemical Reaction. Ammonia reacts with aflatoxins to form stable non-toxic derivatives. This reaction can involve the addition of ammonia to double bond of the lactone ring of aflatoxins, making them less toxic or non-toxic.

(2) pH Adjustment. Ammonia treatment can also alter the pH of the materials, creating an unpleasant environment for the growth of aflatoxin-producing fungi.

(3) Detoxification. Ammonia treatment may detoxify aflatoxins by modifying their chemical structure, making them less harmful to animals upon consumption.

Ammoniation is commonly used as a practical method for aflatoxins mitigation in animal feed. However, it may not be the completed method to eliminate aflatoxins unless it is combined with other methods such as sorting, blending and proper storage.

Additionally, the process needs to be carefully controlled to prevent the negative effect on the nutritional quality of the feed.

2.4.4 Ozonation

Ozonation is another method used for the elimination of aflatoxins in various agricultural commodities. It involves the use of ozone (O3), a powerful oxidizing agent, to degrade and detoxify aflatoxins through oxidation reactions. There are several processes on how ozonation works for aflatoxins elimination.

(1) Oxidation. Ozone reacts with Aflatoxins, breaking down their molecular structure through oxidation reactions. This process results in the formation of less toxic by-products or completed degradation of aflatoxins molecules.

(2) Disruption of Fungal Growth. Ozone treatment can also inhibit the growth of aflatoxin-producing fungi by disrupting their cellular structures and metabolic process.

(3) Surface Decontamination. Ozonation can be used as a surface treatment for food products, where ozone gas is passed over the surface of the products to eliminate aflatoxins and other contaminants.

Ozonation offers several advantages, including its strong oxidizing power, fast reaction kinetics and residue-free nature. It can be applied to a wide range of food products and agricultural commodities without significant alteration to their nutritional composition. However, the effectiveness of ozonation for aflatoxins elimination depends on various factors such as ozone concentration, contact time, temperature, humidity, and the nature of the substance being treated.

2.4.5 Chemical Treatment

Chemical methods offer an alternative approach for aflatoxin elimination, utilizing substances like hydrogen peroxide, sodium hypochlorite, and isopropyl alcohol. Each chemical requires specific concentrations for effective application, such as 1.5% for hydrogen peroxide, 1% for sodium hypochlorite, or 75% for isopropyl alcohol. However, this method entails drawbacks such as high costs and complex equipment requirements. Pilot studies have explored additional chemicals for aflatoxin elimination, including sulfur dioxide, chlorine gas, phosphoric gas, trisodium phosphate, eternal amine, and trimethyl amine. Before employing chemical treatments, several factors warrant consideration:

(1) Low Toxicity Rate for Animals. The safety profile of these chemicals in terms of toxicity to animals is crucially assessed.

(2) Genetic Impact and Carcinogenic Potential. Ensuring that these treatments do not induce genetic alterations that could lead to carcinogenesis is imperative.

(3) Preservation of Nutritional Integrity. Maintaining the nutritional quality of food products during and after treatment is essential.

(4) Residue-Free and Product Safety. It is essential that treated products remain free of chemical residues and that there is no carryover of chemicals into the final food products.

2.5 Aflatoxins Contamination Detection Methods

The detection and quantification of aflatoxins in food products employ various analytical methods, as discussed in several studies[2,19,24] on aflatoxin contamination in food crops, plant-based beverages, and foods and feeds. These methods include thin-layer chromatography (TLC), high-performance liquid chromatography (HPLC), mass spectrometry (MS), enzyme-linked immunosorbent assay (ELISA), and electrochemical immunosensor, each with specific advantages and limitations.

2.5.1 Enzyme-Linked Immunosorbent Assay (ELISA)

ELISA represents a cost-effective and straightforward pre-screening method suitable for assessing total aflatoxin contamination in samples. However, it lacks the capability to differentiate between specific types of aflatoxins, making it more suitable for handling a large number of samples.

2.5.2 Thin Layer Chromatography (TLC) - Densitometry

TLC with densitometry is a straightforward and precise method capable of measuring substance density on TLC plates. It can effectively screen for all four types of aflatoxins.

2.5.3 High Performance Liquid Chromatography (HPLC)

HPLC is widely accepted for screening aflatoxins due to its chromatographic capabilities. It enables the separation, identification, and quantification of aflatoxin components within a sample mixture, making it the most precise analytical technique available. This method involves converting toxins into derivatives and screening them using a fluorescence detector, ensuring accurate identification of both quantity and type of aflatoxins present. In this study, aflatoxin contamination in plant-based milk alternatives was assessed using the In-house method TE-CH-025 based on AOAC (2023) 991.31 and 994.08, employing HPLC at the Central Laboratory (Thailand). A total of 20 samples were analyzed to determine aflatoxin levels in these products.

Based on previous research on aflatoxin contamination in nut products in Thailand[20], the detailed procedures for HPLC are outlined as follows:

(1) Operational Principle

HPLC separates target substances within a sample mixture using a stationary phase (column) and a mobile phase (solvent). Detection occurs via chromatographic peaks that indicate the presence of aflatoxins, with levels evaluated against specific criteria:

(1.1) Limit of Detection (LOD) = 0.25 micrograms per kilogram or liter of edible food

(1.2) Limit of Quantitation (LOQ) = 0.70 micrograms per kilogram or liter of edible food

(2) Components

(1.1) Mobile Phase / Solvent: Solvent used to separate aflatoxins within the mobile phase and transition them to the stationary phase (column).

(1.2) Degasser: Removes bubbles from the sample mixture during the mobile phase to facilitate smooth flow into the column and detector.

(1.3) Pump: Propels the sample mixture through the HPLC system under high pressure, overcoming frictional forces to ensure continuous solvent flow.

(1.4) Injector / Autosampler: Introduces sample components into the HPLC system for analysis.

(1.5) Column: Stationary phase where sample components separate based on their chemical properties, crucial for effective chromatographic separation.

(1.6) Detector: Equipment that identifies and measures aflatoxins within the sample mixture, providing precise analytical data.

Successful screening relies on maintaining the sample mixture as a homogeneous solvent, crucial for achieving accurate separation and detection of aflatoxins through the column length.

2.6 Literature Review

Kumar, Abhishek, et al. articulated that aflatoxins contamination in food crops and related products have become a serious harm to humans and animal’s lives. These contaminated crops are varied from country to country. However, the problem is severe in developing countries. Some legumes and nuts such as soybean, almonds, walnuts, and pistachio were also found in the contamination findings. Aflatoxin contamination has been the causes of serious health problems particularly liver cancer. The aflatoxins-contaminated products are also causing the economic value loss in the global food market. It is advisable that various physical, chemical, biological, and nano-particles based approaches are used for minimizing aflatoxin in food crops. The researchers are in the progress of development for the screening methods through breeding and genetic engineering approaches but their outcome is still questioning. It is thus suggested that a combined approach of using variety of methods along with recommended pre-and post-harvest screening should be followed by farmers and food industries to minimize the aflatoxin contamination in food crops and their related products.[2]

Arezoo Ebrahimi and team members articulated that aflatoxins are the carcinogens derived from the fungi in various Aspergillus species. These fungi can easily contaminate nuts and grains. A global systematic review was done to extract data on the concentration of aflatoxins in different nuts. The databases were searched systematically from 2000 to 2020. Based on the results, aflatoxin B1 (AFB1) had the most frequency in nut samples. The mean concentration of aflatoxin total (AFT) and AFB1 in nuts were as follows: peanut (37.85, 32.82 μg/kg), pistachio (31.42, 39.44 μg/kg), almond (3.54, 3.93 μg/kg), walnut (42.27, 22.23 μg/kg), hazelnut (17.33, 10.54 μg/kg), Brazil nut (4.61, 3.35 μg/kg), and other nuts (26.22, 7.38 μg/kg). According to country the margin of exposure (MOE) ranging from the countries with lowest to highest nuts samples with aflatoxins contamination were Argentina, Congo, India, Bangladesh, Cameroon, Iran, Bahrain, Brazil, Ghana, South Africa, Egypt, USA, China, and Cyprus. The MOE of the consumers in some countries was considerably below the safety margin of 10,000. In conclusion, nuts are highly consumed by different consumers, so it is necessary to emphasize strict control measures to prevent aflatoxin contamination of these foods.[3]

Rodríguez-Cañás, I and team members articulated that a new method based on a QuEChERS extraction procedure followed by UHPLC-MS/MS detection was developed for the simultaneous analysis of 29 mycotoxins in plant-based beverages. The method was validated for the determination of mycotoxins in oat, rice, soy, and almond beverages, and shows good performance characteristics including linearity, repeatability, accuracy, and precision. This study revealed that plant-based beverages are susceptible to mycotoxin contamination, especially beauvericin and enniatins, T-2 and HT-2 were found in oat beverage samples, and aflatoxins in rice and almond. Therefore, further investigation is needed to provide incidence data and evaluate the risk for consumers. Regarding the almond beverage, for the total 7 samples, AFB1 was found in 5 samples, in a concentration lower than 0.04 µg/L and only one sample was contaminated with AFB2 with levels below the LOQ. In this case, there can be a carry-over from raw materials since almonds are usually contaminated with aflatoxins. Also, it is revealed that soy beverage is with the lowest levels of contamination. AFB1 should be monitored in rice and almond beverage to avoid the risks to consumers.[4]

A Nazhand, A Durazzo and team members articulated that aflatoxin contamination continues to be a global food safety concern. The most dangerous toxin is aflatoxins. The carryover of aflatoxins, during food transit or storage, result in the contamination of foods, which can harm the liver, immune system and reproduction system for human beings and animals. There are numerous reports on aflatoxins focusing on achieving appropriate methods for quantification and detection to ensure consumer safety. Aflatoxin contamination of foods and feeds results in economic losses and affects human and animal health. Inadequate knowledge in this area highlighted the necessity of investigations into the chemical properties and biosynthetic processes of aflatoxins and various mechanisms of their detoxification, also considering possible natural agents against the proliferation of field pests for the crops. Numerous studies have been conducted recently to control these toxins. Further research is recommended to focus on field-applicable new technologies for the control of aflatoxin with the aim of protecting human and animal food/feed safety and health.[18]

El-Sayed, R. A and team members articulated that mycotoxins are potentially hazardous secondary metabolites produced by fungi. These small molecular weight compounds are found in nature and are almost unavoidable. They can infiltrate our food chain either directly or indirectly through contaminated plant-based food components or toxigenic fungal development on food. Mycotoxins can build up in corn, cereals, soybeans, sorghum, peanuts, and other food and feed crops in the field and during transportation. Humans and animals can get sick from eating mycotoxin-contaminated food or feed, which can result in acute or chronic poisoning. In addition to worries regarding direct consumption of mycotoxin-contaminated foods and feeds, the public is concerned about the possibility of ingesting mycotoxin residues or metabolites in animal-derived food products such as meat, milk, or eggs. Three fungal genera dominate mycotoxin production: Aspergillus, Fusarium, and Penicillium. Although more than 300 mycotoxins have been found, only six of them (aflatoxins, trichothecenes, zearalenone, fumonisins, ochratoxins, and patulin) are consistently detected in food, posing unpredictability and continuous food safety issues worldwide. This article focused on some of them, which are typically found in foods that have been contaminated by one or more of these mycotoxins.[19]

Balan, B and team members articulated that aflatoxins are carcinogenic and poisonous secondary metabolites produced by *Aspergillus* species. Aflatoxin contamination in food commodities is widespread and unavoidable. Aflatoxin toxicity can occur in both temperate and tropical locations of the world. The situation is particularly serious in developing countries, where, in addition to posing a health risk, aflatoxin-contaminated foodstuffs are losing economic value in the global food market. There is a critical need to enhance public knowledge about the presence of these toxins in food products.

To protect consumers from the health risk caused by the aflatoxin contamination, national governments or regional organizations must continue to support, encourage, and finance initiatives that contribute to reliable exposure risk assessment and aflatoxin risk management in their respective regions. Thus, to effectively manage aflatoxin in the food supply chain, both the public and private sectors need to be involved. Additionally, the country should set explicit aflatoxin maximum limits for all food products. This review was aimed to comprehend the status in the detoxification of food products from aflatoxins, as well as emerging advancing methods. Overall, cutting-edge technology must be adopted and implemented to address existing global food insecurity challenges. GAPs, GMPs, GSPs, HACCP, adequate storage, educated stakeholders, and the ability to predict on-field and in-store contamination of food items could act as the first line of defense against human aflatoxin exposure.

Aflatoxin decontamination techniques for food commodities must be multilevel because there is no single technology that can be used worldwide to address the problem. Long-term agricultural contamination must be reduced, either through the employment of biocontrol techniques or the use of resistant crop cultivars. There is a definite and urgent need to develop techniques that are more quick, accurate, sensitive, and affordable for the testing and evaluation of aflatoxins in foods and feeds. Innovative processing techniques such as microwave heating, UV and pulsed light, electron beam and gamma irradiation, electrolyzed water, and cold plasma showed great potential for future applications. An emerging new area of research is the application of electrochemical biosensors based on nanomaterials for the detection of aflatoxins. Biomarker-based monitoring is suggested to combine with the traditional food analysis approach to evaluate the exposure to aflatoxins and associated health impacts in high-risk population groups. It is crucial to comprehend the underlying processes of aflatoxin detoxification and their impact on the food constituents when using these cutting-edge technologies for aflatoxin decontamination. These techniques must be proven not to alter crop nutrient profiles or sensory qualities, and there should be no residue or production of new contaminants. It is critical to understand the aflatoxin detoxification mechanisms to ensure that no aflatoxin residues are left behind when these approaches are used in food and feed samples. Toxicity testing is also required to guarantee that any secondary degradation products produced are not detrimental to animal or human health. Several strategies for reducing aflatoxin production in the field and during storage have been developed. The collection of data pertaining to epidemiological and toxicological impacts, particularly in humans, also needs to be the focus of future studies. Scientific collaborations and coordinated research initiatives across multiple teams should be promoted to determine the degree of human exposure to aflatoxins. The use of genetic engineering to create new, genetically altered plants that may be resistant to fungal growth may prove to be a wise decision. It may be advantageous for the financial stability of a commodity or an agricultural area to develop new protocols and methods to compare the costs and advantages of various controlling agents against fungal infections and aflatoxin production. Innovative ways are required to address worldwide food security and human safety concerns. Thus, more research should be conducted to better understand the efficacy, safety, and cost-effectiveness of these novel techniques for aflatoxin decontamination.[23]

R. Pavlenko and team members articulated that the analytical methodology based on QuEChERS extraction and HPLC-MS/MS was developed for the analysis of 22 mycotoxins in plant-based milk substitute beverages. The method parameters (correlation coefficient ≥ 0.98, LOQ 0.0078–5.0 $\mu g\ kg^{-1}$, method recovery 79–119% complied with the European Union Commission Regulation No. 401/2006. A total of sixteen mycotoxins were detected in the tested beverages, and 61% of all analyzed beverages contained at least one mycotoxin. The most frequently detected mycotoxins were enniatin B1 in soy drinks, enniatins B and B1, deoxynivalenol, beauvericin, enniatin A, HT-2 and T-2 toxins in oat drinks, aflatoxin B2 in nut drinks (almond drink), deoxynivalenol, enniatins B and B1, aflatoxins B1 and B2 in rice drinks, and enniatin B1 in hemp, millet, buckwheat, and pea beverages.[24]

Hamed Ahmed and team members articulated that after characterization of QuEChERS and DLLME as possible alternative sample treatments, the latter was applied for the quantification of AFB1, AFB2, AFG1, and AFG2 in plant-based beverages and enriched milk. Moreover, the use of photochemical derivatization for enhancing the fluorescence emission coupled to HPLC avoids the use of derivatization reagents and provides an easy and sensitive alternative to these hazardous agents. The proposed method provided good results in terms of precision, recovery, and extract cleanliness, allowing the determination of these mycotoxins at very low concentrations in infrequently analyzed but increasingly consumed vegetable-based milk and milk-based products. Samples of functional vegetable milks and milk-based products were purchased at local stores from Granada, Spain. They comprise four oat milk products (14% oat), five rice milk samples (15% rice), three coconut materials (5.9% coconut), two almond milk products (2% almond), one birdseed milk sample (15% birdseed), and milk-based products: three enriched with oats (0.2%), three with almonds (0.2%), and two with walnuts (0.2%). All the milk samples were stored at 4 C in their original 1 L packaging prior to use. Fortunately, none of the studied aflatoxins were detected at concentration higher than limits of quantification.[27]

Christina Juan and team members articulated that this study was the developed and validated an analytical methodology for the determination of aflatoxins, enniatins, beauvericin, zearalenone, ochratoxin-A, alternariols, HT-2 and T-2 toxin in soy, oat, rice, and almond beverages, based on solid phase extraction columns (SPE) and analyzed by liquid chromatography coupled to mass spectrometry in tandem. The methodology was validated according to Commission Decision 2002/657/EC, with limits of quantification ranging from 0.3 (AFs in oat beverages) to 18 ng/mL (HT-2 in rice beverage). The analysis of 56 beverage samples purchased from Valencia (Spain) showed at least one mycotoxin occurring in 95% of samples, including carcinogenic aflatoxins, and oat beverage was the most contaminated.

This is a newest validated methodology for the quantification of sixty mycotoxins in oat, rice, almond and soy beverages. Based on the results, it was concluded that the validated analytical method is suitable for quantifying 16 mycotoxins in oat, almond, soy, and rice beverages. Analytical data showed that out of total beverage samples, 95% of them presented levels of mycotoxins, and the most detected is ENB (22%). ENB showed a high registered level with 108.9 ng/mL. The co-occurrence of mycotoxins (up to two) was also observed in some positive samples. Risk assessment shows that the intake of mycotoxins through the consumption of these beverages in Valencia does not represent a risk for the population, except for aflatoxins that are classified as carcinogenic compounds by international authorities. More investigations and monitoring studies are recommended to assess the multi-mycotoxin occurrence and the bio accessibility of these compounds in these matrices to assess the potential risk for the consumers.[28]

Salvador, J. P, and team members articulated Aflatoxins B1 is the most potent carcinogenic aflatoxin. It is considered a major concern in food safety due to its high toxicity and possibility contaminations in variety of foods including tree nut. While regular screening and testing for aflatoxins are mainly done in European Union (EU) and United States (US), the problem is still major concern in developing counties where the contamination is relatively high. New technologies are needed to provide more efficient for screening aflatoxins. In this study, coupled with other method, Lateral flow immunoassay (LFIA) is applied to detect almond milk. Almond milk is susceptible of high aflatoxin contamination and thus it was selected for this testing. Optimized LFIA reached a limit of detection (LOD) of 4.80ng/mL in undiluted almond milk. The U.S. Food and Drug Administration (FDA) and the European Commission established an action level of maximum residue level of 20 and 8 ng/mL for almond milk. The developed LFIA has been optimized to distinguish between compliant and noncompliant samples, taking into consideration the signal provided by the control line (CL). The CL signal has been set as a threshold of maximum residue level (MRL) signal (TL). A validation study has been performed and blind samples have been measured successfully.[29]

Ismail, A., Riaz and team members articulated that aflatoxins have become a serious threat for human life especially in the developing countries. Aflatoxins are not only causing toxicity but also producing global food insecurity. More than half of the world’s population is exposed to the threat of aflatoxins. Aflatoxins are reported in many plant-based food commodities; however, some plants are more susceptible than the others. Maize and barley in cereals, nuts in fruits, red chili in spices, and commercially prepared fodder of long storage life need special attention as they are more susceptible to aflatoxins. Resistant crop varieties, proper crop management, controlled storage, and safe transportation are necessary to limit the production of aflatoxins. To ensure aflatoxin-free plant foods, farmers and processors should be properly educated regarding the safe handling of food commodities. Although much research has been done in the field of aflatoxin degradation, further research to find safe and effective strategies for the degradation of aflatoxins is needed.[30]

Miró-Abella, E and team members articulated that this was the first study in which plant-based beverages have been analyzed to determine the presence of several mycotoxins. A sensitive, reliable and multianalyte method were developed for the quantification of eleven mycotoxins using QuEChERS extraction followed by UHPLC-(ESI)MS/MS. The applied QuEChERS approach was suitable for the extraction of the target mycotoxins from this kind of matrices, as shown by the extraction recovery values obtained above 80%, and with ME values comparable to other studies that determine mycotoxins in other matrices. The developed methodology was applied for the analysis in triplicate of three types of plant-based beverages (soy, oat, and rice) from three different commercial brands obtained from local supermarkets. With respect to soy beverages, AFG2, AFG1 and AFB1 were detected in one or two of the soy samples studied, in agreement with the previous literature, which found these aflatoxins in soybean samples and soy derivatives[31].

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Research Methodology

This study employed a cross-sectional qualitative survey to investigate aflatoxin contamination in five selected plant-based milk alternatives: soymilk, almond milk, walnut milk, pistachio milk, and hazelnut milk. Ethical approval for the study was obtained from the Human Research Ethics Review Board of Dhurakit Bundit University.

3.2 Sample Selection

Convenient sampling was utilized based on previous studies[32, 33, 34], which demonstrated its appropriateness for studies with a limited, non-complex sample size. Additionally, considering the methodology described in the determination of mycotoxins in plant-based beverages[31], samples were selected from local supermarkets. In cases where specific plant-based milk alternatives such as pistachio milk, walnut milk, and hazelnut milk were limited in variety, purposive sampling[34] was applied to meet study objectives. In total, 20 samples of plant-based milk alternatives were selected using a combination of convenient and purposive sampling methods.

The 20 samples were equally distributed among the five types, with each type comprising four samples: two from locally produced brands and two from imported brands. The samples, totaling 20 liters in quantity per laboratory requirements, were collected from various supermarkets.

3.3 Inclusion Criteria

Samples were purchased from Tops supermarket, Lotus supermarket, and Villa supermarket in Chatuchak district, Bangkok, based on criteria ensuring their good condition, identical manufacturing lot numbers, and expiration dates not exceeding three months.

3.4 Research Procedures

3.4.1 Literature Review: Relevant studies on aflatoxin contamination in plant-based milk alternatives were reviewed comprehensively.

3.4.2 Sample Selection: A total of 20 plant-based milk alternatives, representing the five types, were selected from supermarkets in Chatuchak district, Bangkok.

3.4.3 Sample Documentation: Detailed information including country of origin, production date, and best before date for the selected 20 samples was compiled.

3.4.4 Sample Delivery: The 20 selected samples were delivered to the designated laboratory.

3.4.5 Laboratory Testing: After a seven-day testing period, conducted exclusively by laboratory specialists, findings for each sample were collected.

3.4.6 Data Analysis: Laboratory results were compared against the initial hypothesis and relevant aflatoxin regulations in food.

3.4.7 Report Compilation: Summary of laboratory findings was compiled into the final research report.

3.5 Aflatoxins Contamination Testing Method

Aflatoxin contamination in the 20 selected samples was tested using the in-house method TE-CH-025, based on AOAC (2023) 991.3 and AOAC (2023) 994.8 standards employing High Performance Liquid Chromatography (HPLC). The laboratory specialists conducted the testing following AOAC (2023) guidelines, which included the following steps:

3.5.1 Weighing a 25-gram test portion into a blending jar.

3.5.2 Adding 5 grams of NaCl and 125 mL of extraction solvent.

3.5.3 Filtering the mixture through prefolded paper.

3.5.4 Pipetting 15 mL of filtrate into a 125 mL glass-stoppered Erlenmeyer flask.

3.5.5 Adding 30 mL of H2O, stoppering, and mixing.

3.5.6 Filtering the diluted extract through glass microfiber paper before affinity column chromatography.

3.5.7 Ensuring clarity of the filtrate; if not clear, refiltering was conducted.

3.5.8 Proceeding immediately with column chromatography.

3.6 Testing Laboratory

Total of 20 plants-based milk alternatives samples are to be delivered to

Central Laboratory (Thailand) Company Limited. (Bangkok Branch)

2179 Phaholyothin Road, Chatuchak, Bangkok 10900

Taxpayer Identification No. 0105546096453

Tel: (66) 2940 5993 / (66) 2940 6881 Fax: (66) 2579 8527 / (66) 2940 5993

3.7 Final Data Analysis

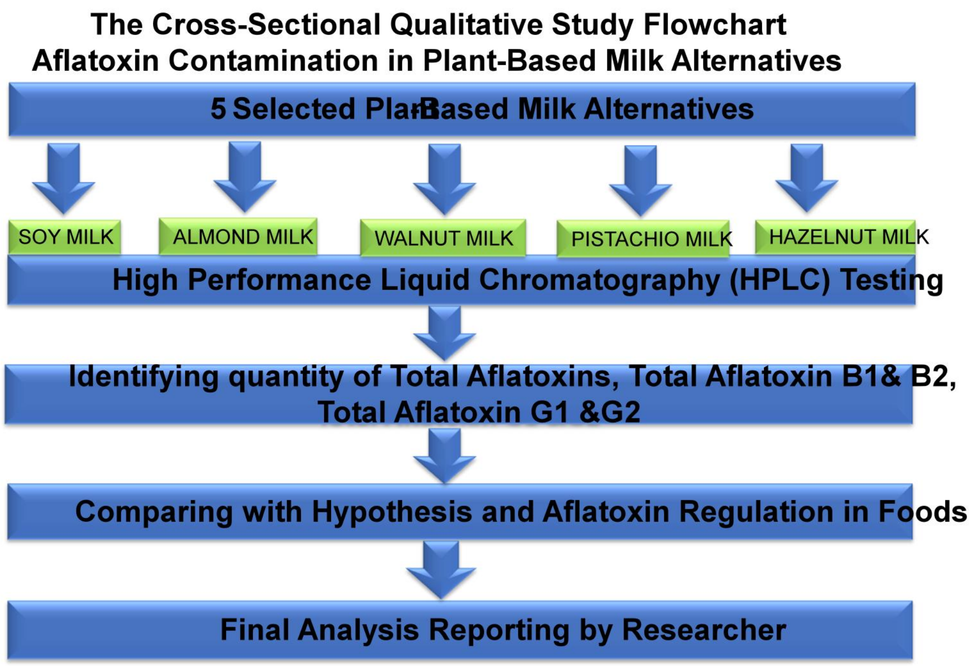

Figure 3.1 Study Flowchart

The final data analysis was conducted by the researcher, comparing the lab reports on aflatoxin contamination levels of each tested sample against the hypothesis. Additionally, the researcher evaluated the food safety of each sample in relation to the aflatoxin contamination limits set by the Ministry of Public Health in Thailand[25]. Currently, the regulation stipulates a maximum total aflatoxin threshold of 20 micrograms per kilogram or liter for all food and feed commodities in Thailand. This comparison was essential to determine compliance with regulatory standards and ensure the safety of the tested plant-based milk alternatives.

Additionally, based on Food and Agriculture Organization guideline [26], these are the following regulations for maximum aflatoxins in foods. (1) All foods ready for human consumption shall not contain more than 10 micrograms per kilogram of aflatoxin, of which aflatoxin B1 shall not be more than 5 micrograms per kilogram.

(2) Notwithstanding the provisions of sub regulation (1), peanuts intended for further processing shall not contain more than 15 micrograms per kilogram of aflatoxin.

(3) Milk shall not contain more than 0.05 micrograms per liter of aflatoxin M1.

CHAPTER 4

RESULTS AND ANALYSIS

A total of 17 samples of plant-based milk alternatives sourced from various supermarkets and online marketplaces were submitted to Central Laboratory (Thailand) Limited for analysis of aflatoxins contamination using the In-house method TE-CH-025, based on AOAC (2023) methods 991.3 and 994.8, employing High Performance Liquid Chromatography (HPLC) with an Agilent 1100 model. The investigation aimed to determine the levels of total aflatoxins, specifically Aflatoxin Type B1 (AFB1), Aflatoxin Type B2 (AFB2), Aflatoxin Type G1 (AFG1), and Aflatoxin Type G2 (AFG2) in each sample.

The researcher assigned identifiers (Brand 1 to 17) to the 17 tested plant-based milk alternatives, with Brands 1-8 representing soymilk, Brands 9-12 for almond milk, Brands 13-15 for pistachio milk, and Brands 16-17 for walnut milk. To differentiate between locally produced and imported products, the researcher annotated (a) for local products and (b) for imported products, as detailed in the table below.

4.1 Baseline characteristics of the 17 tested plant-based milk alternatives samples.

Table 4.1 Baseline characteristics of the 17 tested plant-based milk alternatives samples.

Number	Type	Buying Channel	Thai FDA Approval	Country of Origin	Expiry Date	Price	Quantity (ml)
Brand 1 (a)	Soy Milk	Tops Supermarket	25-2-00136-2-0800	Thailand	14/01/2025	35	1,000
Brand 2 (a)	Soy Milk	Tops Supermarket	13-1-11135-6-0017	Thailand	22/03/2025	36	1,000
Brand 3 (a)	Soy Milk	Tops Supermarket	60-1-05841-6-0018	Thailand	25/03/2025	32	1,000
Brand 4 (a)	Soy Milk	Tops Supermarket	73-1-05246-6-0008	Thailand	04/03/2025	47	1,000
Brand 5 (b)	Soy Milk	Villa Supermarket	10-3-03241-5-0131	Australia	17/01/2025	129	1,000
Brand 6 (b)	Soy Milk	Tops Supermarket	10-3-44357-5-0090	Australia	22/11/2024	79	1,000
Brand 7 (b)	Soy Milk	Villa Supermarket	10-3-10957-5-0799	USA	11/08/2024	235	1,000
Brand 8 (b)	Soy Milk	Tops Supermarket	10-3-11523-5-2030	Japan	17/10/2024	126	1,000
Brand 9 (a)	Almond Milk	Villa Supermarket	13-2-02063-2-0001	Thailand	14/02/2025	99	1,000
Brand 10 (a)	Almond Milk	Villa Supermarket	74-2-01859-2-0006	Thailand	25/01/2025	115	1,000
Brand 11 (a)	Almond Milk	Tops Supermarket	73-1-11224-6-0040	Thailand	02/10/2024	109	1,000
Brand 12 (b)	Almond Milk	Villa Supermarket	10-3-44357-5-0103	Australia	10/09/2024	128	1,000
Brand 13 (a)	Pistachio Milk	Villa Supermarket	13-2-02063-2-0036	Thailand	07/04/2025	99	1,000
Brand 14 (a)	Pistachio Milk	Villa Supermarket	13-2-02063-2-0006	Thailand	04/02/2025	149	1,000
Brand 15 (a)	Pistachio Milk	Tops Supermarket	74-2-01859-2-0013	Thailand	19/02/2025	115	1,000
Brand 16 (a)	Walnut Milk	Tops Supermarket	13-2-02063-2-0004	Thailand	21/01/2025	135	1,000
Brand 17 (a)	Walnut Milk	Lazada	12-1-02261-5-0116	Thailand	16/10/2024	273	1,000

After 7 working days, upon completion of the testing, the researcher retrieved the results and consulted with the lab specialist to verify the findings. In summary, none of the 17 tested samples of plant-based milk alternatives showed detectable levels of aflatoxin AFB1, AFB2, AFG1, and AFG2. The total aflatoxin levels in all samples were below the regulatory limit of 20 micrograms/kg or 20 micrograms/liter (μg/L). Detailed results from the laboratory analysis are presented in the below table.

4.2 Results of aflatoxins contamination in 17 Plant-based milk alternatives samples

Table 4.2 Results of aflatoxins contamination in 17 Plant-based milk alternatives samples

Number	Type	AFB1(μg/L)	AFB2(μg/L)	AFG1(μg/L)	AFG2 (μg/L)	Total Aflatoxins (μg/L)	Aflatoxin Regulation (μg/L)
Brand 1 (a)	Soy Milk	0.00	0.00	0.00	0.00	0.00	20.00
Brand 2 (a)	Soy Milk	0.00	0.00	0.00	0.00	0.00	20.00
Brand 3 (a)	Soy Milk	0.00	0.00	0.00	0.00	0.00	20.00
Brand 4 (a)	Soy Milk	0.00	0.00	0.00	0.00	0.00	20.00
Brand 5 (b)	Soy Milk	0.00	0.00	0.00	0.00	0.00	20.00
Brand 6 (b)	Soy Milk	0.00	0.00	0.00	0.00	0.00	20.00
Brand 7 (b)	Soy Milk	0.00	0.00	0.00	0.00	0.00	20.00
Brand 8 (b)	Soy Milk	0.00	0.00	0.00	0.00	0.00	20.00
Brand 9 (a)	Almond Milk	0.00	0.00	0.00	0.00	0.00	20.00
Brand 10 (a)	Almond Milk	0.00	0.00	0.00	0.00	0.00	20.00
Brand 11 (a)	Almond Milk	0.00	0.00	0.00	0.00	0.00	20.00
Brand 12 (b)	Almond Milk	0.00	0.00	0.00	0.00	0.00	20.00
Brand 13 (a)	Pistachio Milk	0.00	0.00	0.00	0.00	0.00	20.00
Brand 14 (a)	Pistachio Milk	0.00	0.00	0.00	0.00	0.00	20.00
Brand 15 (a)	Pistachio Milk	0.00	0.00	0.00	0.00	0.00	20.00
Brand 16 (a)	Walnut Milk	0.00	0.00	0.00	0.00	0.00	20.00
Brand 17 (a)	Walnut Milk	0.00	0.00	0.00	0.00	0.00	20.00

4.3 Analysis of aflatoxins contamination in 17 tested plant-based milk alternative samples.

Based on the analysis detailed in table 4.2, it is evident that none of the 17 samples of plant-based milk alternatives exhibited detectable levels of total aflatoxins. In compliance with regulatory standards, all samples demonstrated concentrations well below the established limit of 20 micrograms per liter (μg/L) for aflatoxins. This outcome underscores the effectiveness of the testing methodology employed and provides assurance regarding the safety and compliance of the tested plant-based milk alternatives with respect to aflatoxin contamination.

CHAPTER 5

DISCUSSION, CONCLUSION AND SUGGESTION

This cross-sectional qualitative study aimed to investigate aflatoxin contamination in plant-based milk alternatives, focusing on its implications for food safety and consumer health. The key measurement criterion was the regulation stipulating a maximum total aflatoxin content of 20 micrograms per kilogram or 20 micrograms per liter (µg/L) in all food and feed commodities in Thailand.

5.1 Discussion of Results

A total of 17 plant-based milk alternative samples were tested, comprising 8 soy milks, 4 almond milks, 3 pistachio milks, and 2 walnut milks, accounting for 47.06%, 23.53%, 17.65%, and 11.76% respectively. Unfortunately, hazelnut milk, specifically the imported brand from Italy, was discontinued in all supermarkets and online marketplaces, resulting in the absence of imported hazelnut milk. There were no local brands of hazelnut milk available in Thailand. The sample size for soy milk was doubled due to its predominant market share among plant-based milk alternatives in Thailand. Among the 17 samples, there were 12 local brands and 5 imported brands originating from Australia, USA, and Japan. Samples were collected from top supermarkets (9 samples), Villa Supermarket (7 samples), and Lazada (1 sample).

The primary objective was to assess aflatoxin contamination and ensure the safety of plant-based milk alternatives derived from nuts. Fortunately, all 17 tested samples were found to be "Not Detected" for AFB1, AFB2, AFG1, and AFG2, with total aflatoxin levels below 20 micrograms per liter (µg/L), compliant with the Ministry of Public Health's aflatoxin regulation. This finding supports the hypothesis that plant-based milk alternatives are free from aflatoxin contamination.

5.2 Conclusion

In conclusion, all 17 tested plant-based milk alternatives, including soy milks, almond milks, pistachio milks, and walnut milks, were deemed safe for consumption, with total aflatoxin levels below 20 micrograms per liter (µg/L), consistent with regulatory standards set by the Ministry of Public Health. Food safety certificates were issued by Central Laboratory (Thailand) Limited for all tested samples.

5.3 Recommendations

5.3.1 Consumers

To mitigate health risks associated with aflatoxin-contaminated plant-based milk alternatives, consumers are advised to prioritize products with FDA approvals. Regular monitoring of aflatoxin contamination news and updates in plant-based milk alternatives is recommended. Optimal health practices include consuming antioxidants to reduce oxidative stress, supporting liver detoxification with relevant antioxidants and vitamins, and adopting a healthy lifestyle involving exercise, balanced diet, sufficient sleep, regular detoxification, and stress reduction.

5.3.2 Manufacturers

Manufacturers of plant-based milk alternatives should prioritize food safety and consumer health by adhering to Good Manufacturing Practices (GMP) throughout production. This includes sourcing fresh, clean, and uncontaminated raw materials and implementing rigorous quality control measures to ensure compliance with aflatoxin regulations.

5.3.3 Government

Government agencies should conduct regular random checks on raw materials such as soybeans, almonds, pistachios, walnuts, and other nuts to verify low aflatoxin contamination levels aligned with regulations. They should also raise public awareness about the health risks associated with aflatoxin-contaminated foods and provide regular updates on relevant information.

5.3.4 Researchers in Future Studies

Future research should expand the variety of plant-based milk alternatives tested for aflatoxin contamination and consider increasing sample sizes to enhance study robustness.

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APPENDIX

Appendix A

Data Record Form

Plant-based milk alternatives	Total Aflatoxins (µg/L)	Aflatoxins Regulation (µg/L)
Soy Milk 1		
Soy Milk 2		
Soy Milk 3		
Soy Milk 4		
Almond Milk 1		
Almond Milk 2		
Almond Milk 3		
Almond Milk 4		
Walnut Milk 1		
Walnut Milk 2		
Walnut Milk 3		
Walnut Milk 4		
Pistachio Milk 1		
Pistachio Milk 2		
Pistachio Milk 3		
Pistachio Milk 4		
Hazelnut Milk 1		
Hazelnut Milk 2		
Hazelnut Milk 3		
Hazelnut Milk 4		

Appendix B

Memorandum from Human Research Ethics Review Board Committee

DPU DHURAKIJ PUNDIT UNIVERSITY มหาวิทยาลัยธุรกิจบัณฑิตย์

บันทึก
Memorandum

ที่ DPUHREC 0305/2566 วันที่ 3 พฤษภาคม 2567

จาก สำนักงานคณะกรรมการจริยธรรมการวิจัยในมนุษย์ มหาวิทยาลัยธุรกิจบัณฑิตย์

เรียน คุณดรรชนีพร พฤกษ์วัฒนานนท์

เรื่อง แจ้งผลการประเมินตนเองเกี่ยวกับจริยธรรมการวิจัยในมนุษย์

ตามที่ วิทยาลัยการแพทย์และบูรณาการ มหาวิทยาลัยธุรกิจบัณฑิตย์ ได้ขอความอนุเคราะห์ให้ทางสำนักงานคณะกรรมการจริยธรรมการวิจัยในมนุษย์ฯ พิจารณาผลการประเมินตนเองเกี่ยวกับจริยธรรมการวิจัยในมนุษย์ ของ คุณดรรชนีพร พฤกษ์วัฒนานนท์ วิทยาลัยการแพทย์และบูรณาการ มหาวิทยาลัยธุรกิจบัณฑิตย์ โครงการวิจัย เรื่อง "การศึกษาเชิงสำรวจปริมาณสาร Aflatoxins ที่ปนเปื้อนในนมพืชทางเลือกที่จำหน่ายในเขตกรุงเทพมหานคร (AFLATOXINS CONTAMINATION IN PLANT-BASED MILK ALTERNATIVES IN BANGKOK: A CROSS-SECTIONAL QUALITATIVE SURVEY.)"

จากการตรวจสอบเบื้องต้นโดยพิจารณาจาก แบบตรวจสอบ IRB Checklist DPUHRECs และโครงร่างการวิจัย ทางคณะกรรมการจริยธรรมการวิจัยในมนุษย์ฯ ได้พิจารณาแล้วเห็นว่า การดำเนินงานวิจัยของโครงการวิจัยดังกล่าว ไม่เข้าข่ายจริยธรรมการวิจัยในมนุษย์

ทั้งนี้ผลการพิจารณาเอกสารดังกล่าวข้างต้น ไม่ถือเป็นการรับรองจริยธรรมการวิจัยในมนุษย์

จึงเรียนมาเพื่อโปรดทราบ

(ดร.เภสัชกรหญิง วรอนงค์ พฤกษากิจ)
ประธานคณะอนุกรรมการจริยธรรมการวิจัยในมนุษย์
ด้านวิทยาศาสตร์

มหาวิทยาลัยธุรกิจบัณฑิตย์

โทร. 128, 632
สำนักงานคณะกรรมการจริยธรรมการวิจัยในมนุษย์ มหาวิทยาลัยธุรกิจบัณฑิตย์ (DPUHREC)

Appendix C

Laboratory Test Report

บริษัท ห้องปฏิบัติการกลาง (ประเทศไทย) จำกัด
Central Laboratory (Thailand) Co.,Ltd.
สาขากรุงเทพ: 2179 ถนนพหลโยธิน แขวงลาดยาว เขตจตุจักร กรุงเทพมหานคร 10900
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Tel: (662) 940 6881-3 Ext. 164, 202, 204, 218 Fax: (662) 579 4890
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TEST REPORT

Date of Issue May 13, 2024
Report No. TRBK67/23047
Page (s) 01/01

Customer Name & Address (provided by customer)	DUDCHANEEPORN PRUCKWATTANANON 71/61 Baan Tharinee, Soi Pravit and Friends, Ladyao, Chatuchak, Bangkok 10900
Sample Description (provided by customer)	Lactasoy
Sample Code	BK67/09163-016
Sample Condition	Sample Type: Soy Milk Packaging : UHT box Quantity : 6 boxes, Weight/Volume : 360 mL/box. Temperature : room temperature, in good condition when received
Date of sample received	May 07, 2024
Date of analysis	May 07, 2024 - May 13, 2024

RESULT (S)

Test item	Result	Standard	Unit	LOD	Reference Method
Aflatoxins					
Aflatoxin B_1	Not Detected	-	µg/kg	0.25	In-house method TE-CH-025 based on AOAC (2023) 991.31 and 994.08.
Aflatoxin B_2	Not Detected	-	µg/kg	0.25	
Aflatoxin G_1	Not Detected	-	µg/kg	0.25	
Aflatoxin G_2	Not Detected	-	µg/kg	0.25	
Total Aflatoxin	Not Detected	≤20	µg/kg	-	

Note: Standard : Notification of the Ministry of Public Health No. 414/2020
: The laboratory has been accepted as an accredited laboratory complying with the ISO/IEC 17025.

~End of Report~

(M[illegible]s. Wanisa M[illegible]charoen)
Appr[illegible]ory
Central Laboratory (Thailand) Co., Ltd. Bangkok Branch
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The results apply to the sample as received.
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Central Laboratory (Thailand) Co.,Ltd.
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TEST REPORT

Date of Issue May 13, 2024
Report No. TRBK67/23049
Page (s) 01/01

Customer Name & Address (provided by customer): DUDCHANEEPORN PRUCKWATTANANON
71/61 Baan Tharinee, Soi Pravit and Friends, Ladyao, Chatuchak, Bangkok 10900

Sample Description (provided by customer): Vitamilk Low Sugar

Sample Code: BK67/09163-018

Sample Condition: Sample Type: Soy Milk
Packaging : UHT box
Quantity : 6 boxes, Weight/Volume : 250 mL/box.
Temperature : room temperature, in good condition when received

Date of sample received: May 07, 2024

Date of analysis: May 07, 2024 - May 13, 2024

RESULT (S)

Test item	Result	Standard	Unit	LOD	Reference Method
Aflatoxins					
Aflatoxin B_1	Not Detected	-	µg/kg	0.25	In-house method TE-CH-025 based on AOAC (2023) 991.31 and 994.08.
Aflatoxin B_2	Not Detected	-	µg/kg	0.25	
Aflatoxin G_1	Not Detected	-	µg/kg	0.25	
Aflatoxin G_2	Not Detected	-	µg/kg	0.25	
Total Aflatoxin	Not Detected	≤20	µg/kg	-	

Note: Standard : Notification of the Ministry of Public Health No. 414/2020
: The laboratory has been accepted as an accredited laboratory complying with the ISO/IEC 17025.

~End of Report~

(Mrs. Wanisa Meecharoen)
Approved Signatory
Central Laboratory (Thailand) Co., Ltd. Bangkok Branch

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TEST REPORT

Date of Issue May 13, 2024
Report No. TRBK67/23048
Page (s) 01/01

Customer Name & Address (provided by customer): DUDCHANEEPORN PRUCKWATTANANON
71/61 Baan Tharinee, Soi Pravit and Friends, Ladyao, Chatuchak, Bangkok 10900

Sample Description (provided by customer): Dna Original

Sample Code: BK67/09163-017

Sample Condition: Sample Type: Soy Milk
Packaging : UHT box
Quantity : 6 boxes, Weight/Volume : 250 mL/box.
Temperature : room temperature, in good condition when received

Date of sample received: May 07, 2024

Date of analysis: May 07, 2024 - May 13, 2024

RESULT (S)

Test item	Result	Standard	Unit	LOD	Reference Method
Aflatoxins					
Aflatoxin B_1	Not Detected	-	µg/kg	0.25	In-house method TE-CH-025 based on AOAC (2023) 991.31 and 994.08.
Aflatoxin B_2	Not Detected	-	µg/kg	0.25	
Aflatoxin G_1	Not Detected	-	µg/kg	0.25	
Aflatoxin G_2	Not Detected	-	µg/kg	0.25	
Total Aflatoxin	Not Detected	≤20	µg/kg	-	

Note: Standard : Notification of the Ministry of Public Health No. 414/2020
: The laboratory has been accepted as an accredited laboratory complying with the ISO/IEC 17025.

~End of Report~

(Mrs. Wanisa Meecharoen)
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TEST REPORT

Date of Issue May 13, 2024
Report No. TRBK67/23045
Page (s) 01/01

Customer Name & Address (provided by customer)	DUDCHANEEPORN PRUCKWATTANANON 71/61 Baan Tharinee, Soi Pravit and Friends, Ladyao, Chatuchak, Bangkok 10900
Sample Description (provided by customer)	Home Soy
Sample Code	BK67/09163-014
Sample Condition	Sample Type: Soy Milk Packaging : UHT box Quantity : 1 box, Weight/Volume : 1000 mL. Temperature : room temperature, in good condition when received
Date of sample received	May 07, 2024
Date of analysis	May 07, 2024 - May 13, 2024

RESULT (S)

Test item	Result	Standard	Unit	LOD	Reference Method
Aflatoxins					
Aflatoxin B_1	Not Detected	-	µg/kg	0.25	In-house method TE-CH-025 based on AOAC (2023) 991.31 and 994.08.
Aflatoxin B_2	Not Detected	-	µg/kg	0.25	
Aflatoxin G_1	Not Detected	-	µg/kg	0.25	
Aflatoxin G_2	Not Detected	-	µg/kg	0.25	
Total Aflatoxin	Not Detected	≤20	µg/kg	-	

Note: Standard : Notification of the Ministry of Public Health No. 414/2020
: The laboratory has been accepted as an accredited laboratory complying with the ISO/IEC 17025.

~End of Report~

(Mrs. Wanisa Meecharoen)
Approved Signatory
Central Laboratory (Thailand) Co., Ltd. Bangkok Branch
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TEST REPORT

Date of Issue May 13, 2024
Report No. TRBK67/23043
Page (s) 01/01

Customer Name & Address (provided by customer): DUDCHANEEPORN PRUCKWATTANANON
71/61 Baan Tharinee, Soi Pravit and Friends, Ladyao, Chatuchak, Bangkok 10900

Sample Description (provided by customer): Pure Harvest Organic Soy Milk

Sample Code: BK67/09163-012

Sample Condition: Sample Type: Organic Soy Milk
Packaging : UHT box
Quantity : 1 box, Weight/Volume : 1000 mL.
Temperature : room temperature, in good condition when received

Date of sample received: May 07, 2024

Date of analysis: May 07, 2024 - May 13, 2024

RESULT (S)

Test item	Result	Standard	Unit	LOD	Reference Method
Aflatoxins					
Aflatoxin B_1	Not Detected	-	µg/kg	0.25	In-house method TE-CH-025 based on AOAC (2023) 991.31 and 994.08.
Aflatoxin B_2	Not Detected	-	µg/kg	0.25	
Aflatoxin G_1	Not Detected	-	µg/kg	0.25	
Aflatoxin G_2	Not Detected	-	µg/kg	0.25	
Total Aflatoxin	Not Detected	≤20	µg/kg	-	

Note: Standard : Notification of the Ministry of Public Health No. 414/2020
: The laboratory has been accepted as an accredited laboratory complying with the ISO/IEC 17025.

~End of Report~

(Mrs. Wanisa Meecharoen)
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TEST REPORT

Date of Issue May 13, 2024
Report No. TRBK67/23044
Page (s) 01/01

Customer Name & Address (provided by customer): DUDCHANEEPORN PRUCKWATTANANON
71/61 Baan Tharinee, Soi Pravit and Friends, Ladyao, Chatuchak, Bangkok 10900

Sample Description (provided by customer): Sogood Soy Regular

Sample Code: BK67/09163-013

Sample Condition: Sample Type: Soy Milk
Packaging : UHT box
Quantity : 1 box, Weight/Volume : 1000 mL.
Temperature : room temperature, in good condition when received

Date of sample received: May 07, 2024

Date of analysis: May 07, 2024 - May 13, 2024

RESULT (S)

Test item	Result	Standard	Unit	LOD	Reference Method
Aflatoxins					
Aflatoxin B_1	Not Detected	-	µg/kg	0.25	In-house method TE-CH-025 based on AOAC (2023) 991.31 and 994.08.
Aflatoxin B_2	Not Detected	-	µg/kg	0.25	
Aflatoxin G_1	Not Detected	-	µg/kg	0.25	
Aflatoxin G_2	Not Detected	-	µg/kg	0.25	
Total Aflatoxin	Not Detected	≤20	µg/kg	-	

Note: Standard : Notification of the Ministry of Public Health No. 414/2020
: The laboratory has been accepted as an accredited laboratory complying with the ISO/IEC 17025.

~End of Report~

(Mrs. Wanisa Meecharoen)
Approved Signatory
Central Laboratory (Thailand) Co., Ltd. Bangkok Branch
CERTIFIED

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TEST REPORT

Date of Issue May 13, 2024
Report No. TRBK67/23042
Page (s) 01/01

Customer Name & Address (provided by customer)	DUDCHANEEPORN PRUCKWATTANANON 71/61 Baan Tharinee, Soi Pravit and Friends, Ladyao, Chatuchak, Bangkok 10900
Sample Description (provided by customer)	Silk Organic Soymilk
Sample Code	BK67/09163-011
Sample Condition	Sample Type: Soy Milk Packaging : UHT box Quantity : 2 boxes, Weight/Volume : 946 mL/box. Temperature : room temperature, in good condition when received
Date of sample received	May 07, 2024
Date of analysis	May 07, 2024 - May 13, 2024

RESULT (S)

Test item	Result	Standard	Unit	LOD	Reference Method
Aflatoxins					
Aflatoxin B_1	Not Detected	-	µg/kg	0.25	In-house method TE-CH-025 based on AOAC (2023) 991.31 and 994.08.
Aflatoxin B_2	Not Detected	-	µg/kg	0.25	
Aflatoxin G_1	Not Detected	-	µg/kg	0.25	
Aflatoxin G_2	Not Detected	-	µg/kg	0.25	
Total Aflatoxin	Not Detected	≤20	µg/kg	-	

Note: Standard : Notification of the Ministry of Public Health No. 414/2020
: The laboratory has been accepted as an accredited laboratory complying with the ISO/IEC 17025.

~End of Report~

(Mrs. Wanisa Meecharoen)
Approved Signatory
Central Laboratory (Thailand) Co., Ltd. Bangkok Branch

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Central Lab

TEST REPORT

Date of Issue May 13, 2024
Report No. TRBK67/23046
Page (s) 01/01

Customer Name & Address (provided by customer)	DUDCHANEEPORN PRUCKWATTANANON 71/61 Baan Tharinee, Soi Pravit and Friends, Ladyao, Chatuchak, Bangkok 10900
Sample Description (provided by customer)	Kikkoman Soymilk
Sample Code	BK67/09163-015
Sample Condition	Sample Type: Soy Milk Packaging : UHT box Quantity : 6 boxes, Weight/Volume : 200 mL/box. Temperature : room temperature, in good condition when received
Date of sample received	May 07, 2024
Date of analysis	May 07, 2024 - May 13, 2024

RESULT (S)

Test item	Result	Standard	Unit	LOD	Reference Method
Aflatoxins					
Aflatoxin B_1	Not Detected	-	µg/kg	0.25	In-house method TE-CH-025 based on AOAC (2023) 991.31 and 994.08.
Aflatoxin B_2	Not Detected	-	µg/kg	0.25	
Aflatoxin G_1	Not Detected	-	µg/kg	0.25	
Aflatoxin G_2	Not Detected	-	µg/kg	0.25	
Total Aflatoxin	Not Detected	≤20	µg/kg	-	

Note: Standard : Notification of the Ministry of Public Health No. 414/2020
: The laboratory has been accepted as an accredited laboratory complying with the ISO/IEC 17025.

~End of Report~

(Mrs. Wanisa Mancharoen)
Approved Signatory
Central Laboratory (Thailand) Co., Ltd. Bangkok Branch

CERTIFIED

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ilac-MRA DMSc Accreditation No. 1051/47

Central Lab One Stop & Fast Services

TEST REPORT

Date of Issue May 13, 2024
Report No. TRBK67/23037
Page (s) 01/01

Customer Name & Address (provided by customer): DUDCHANEEPORN PRUCKWATTANANON
71/61 Baan Tharinee, Soi Pravit and Friends, Ladyao, Chatuchak, Bangkok 10900

Sample Description (provided by customer): 137 Almond Milk

Sample Code: BK67/09163-006

Sample Condition: Sample Type: Almond Milk
Packaging : UHT box
Quantity : 1 box, Weight/Volume : 1000 mL.
Temperature : room temperature, in good condition when received

Date of sample received: May 07, 2024

Date of analysis: May 07, 2024 - May 13, 2024

RESULT (S)

Test item	Result	Standard	Unit	LOD	Reference Method
Aflatoxins					
Aflatoxin B_1	Not Detected	-	µg/kg	0.25	In-house method TE-CH-025 based on AOAC (2023) 991.31 and 994.08.
Aflatoxin B_2	Not Detected	-	µg/kg	0.25	
Aflatoxin G_1	Not Detected	-	µg/kg	0.25	
Aflatoxin G_2	Not Detected	-	µg/kg	0.25	
Total Aflatoxin	Not Detected	≤20	µg/kg	-	

Note: Standard : Notification of the Ministry of Public Health No. 414/2020
: The laboratory has been accepted as an accredited laboratory complying with the ISO/IEC 17025.

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(Mrs. Wanisa Meecharoen)
Approved Signatory
Central Laboratory (Thailand) Co., Ltd. Bangkok Branch
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Central Lab
One Stop & Fast Services

TEST REPORT

Date of Issue May 13, 2024
Report No. TRBK67/23038
Page (s) 01/01

Customer Name & Address (provided by customer): DUDCHANEEPORN PRUCKWATTANANON
71/61 Baan Tharinee, Soi Pravit and Friends, Ladyao, Chatuchak, Bangkok 10900

Sample Description (provided by customer): Almond Breeze

Sample Code: BK67/09163-007

Sample Condition: Sample Type: Almond Milk
Packaging : UHT box
Quantity : 2 boxes, Weight/Volume : 946 mL/box.
Temperature : room temperature, in good condition when received

Date of sample received: May 07, 2024

Date of analysis: May 07, 2024 - May 13, 2024

RESULT (S)

Test item	Result	Standard	Unit	LOD	Reference Method
Aflatoxins					
Aflatoxin B_1	Not Detected	-	µg/kg	0.25	In-house method TE-CH-025 based on AOAC (2023) 99131 and 994.08.
Aflatoxin B_2	Not Detected	-	µg/kg	0.25	
Aflatoxin G_1	Not Detected	-	µg/kg	0.25	
Aflatoxin G_2	Not Detected	-	µg/kg	0.25	
Total Aflatoxin	Not Detected	≤20	µg/kg	-	

Note: Standard : Notification of the Ministry of Public Health No. 414/2020
: The laboratory has been accepted as an accredited laboratory complying with the ISO/IEC 17025.

~End of Report~

(Mrs. Wanisa M[illegible]charoen)
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TEST REPORT

Date of Issue May 13, 2024
Report No. TRBK67/23036
Page (s) 01/01

Customer Name & Address (provided by customer): DUDCHANEEPORN PRUCKWATTANANON
71/61 Baan Tharinee, Soi Pravit and Friends, Ladyao, Chatuchak, Bangkok 10900

Sample Description (provided by customer): Glico Almond KOKA

Sample Code: BK67/09163-005

Sample Condition: Sample Type: Almond Milk
Packaging : UHT box
Quantity : 1 box, Weight/Volume : 1000 mL.
Temperature : room temperature, in good condition when received

Date of sample received: May 07, 2024

Date of analysis: May 07, 2024 - May 13, 2024

RESULT (S)

Test item	Result	Standard	Unit	LOD	Reference Method
Aflatoxins					
Aflatoxin B_1	Not Detected	-	µg/kg	0.25	In-house method TE-CH-025 based on AOAC (2023) 991.31 and 994.08.
Aflatoxin B_2	Not Detected	-	µg/kg	0.25	
Aflatoxin G_1	Not Detected	-	µg/kg	0.25	
Aflatoxin G_2	Not Detected	-	µg/kg	0.25	
Total Aflatoxin	Not Detected	≤20	µg/kg	-	

Note: Standard : Notification of the Ministry of Public Health No. 414/2020
: The laboratory has been accepted as an accredited laboratory complying with the ISO/IEC 17025.

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TEST REPORT

Date of Issue May 13, 2024
Report No. TRBK67/23035
Page (s) 01/01

Customer Name & Address (provided by customer): DUDCHANEEPORN PRUCKWATTANANON
71/61 Baan Tharinee, Soi Pravit and Friends, Ladyao, Chatuchak, Bangkok 10900

Sample Description (provided by customer): Sogood Almond Milk

Sample Code: BK67/09163-004

Sample Condition: Sample Type: Almond Milk
Packaging : UHT box
Quantity : 1 box, Weight/Volume : 1000 mL.
Temperature : room temperature, in good condition when received

Date of sample received: May 07, 2024

Date of analysis: May 07, 2024 - May 13, 2024

RESULT (S)

Test item	Result	Standard	Unit	LOD	Reference Method
Aflatoxins					
Aflatoxin B_1	Not Detected	-	µg/kg	0.25	In-house method TE-CH-025 based on AOAC (2023) 991.31 and 994.08.
Aflatoxin B_2	Not Detected	-	µg/kg	0.25	
Aflatoxin G_1	Not Detected	-	µg/kg	0.25	
Aflatoxin G_2	Not Detected	-	µg/kg	0.25	
Total Aflatoxin	Not Detected	≤20	µg/kg	-	

Note: Standard : Notification of the Ministry of Public Health No. 414/2020
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TEST REPORT

Date of Issue May 13, 2024
Report No. TRBK67/23032
Page (s) 01/01

Customer Name & Address (provided by customer)
DUDCHANEEPORN PRUCKWATTANANON
71/61 Baan Tharinee, Soi Pravit and Friends, Ladyao, Chatuchak, Bangkok 10900

Sample Description (provided by customer)
137 Pistachio Milk

Sample Code BK67/09163-001

Sample Condition
Sample Type: Pistachio Milk
Packaging : UHT box
Quantity : 1 box, Weight/Volume : 1000 mL.
Temperature : room temperature, in good condition when received

Date of sample received May 07, 2024

Date of analysis May 07, 2024 - May 13, 2024

RESULT (S)

Test item	Result	Standard	Unit	LOD	Reference Method
Aflatoxins					
Aflatoxin B_1	Not Detected	-	µg/kg	0.25	In-house method TE-CH-025 based on AOAC (2023) 991.31 and 994.08.
Aflatoxin B_2	Not Detected	-	µg/kg	0.25	
Aflatoxin G_1	Not Detected	-	µg/kg	0.25	
Aflatoxin G_2	Not Detected	-	µg/kg	0.25	
Total Aflatoxin	Not Detected	≤20	µg/kg	-	

Note: Standard : Notification of the Ministry of Public Health No. 414/2020
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TEST REPORT

Date of Issue May 13, 2024
Report No. TRBK67/23033
Page (s) 01/01

Customer Name & Address (provided by customer)	DUDCHANEEPORN PRUCKWATTANANON 71/61 Baan Tharinee, Soi Pravit and Friends, Ladyao, Chatuchak, Bangkok 10900
Sample Description (provided by customer)	Sunkist Pistachio Milk
Sample Code	BK67/09163-002
Sample Condition	Sample Type: Pistachio Milk Packaging : UHT box Quantity : 2 boxes, Weight/Volume : 946 mL/box. Temperature : room temperature, in good condition when received
Date of sample received	May 07, 2024
Date of analysis	May 07, 2024 - May 13, 2024

RESULT (S)

Test item	Result	Standard	Unit	LOD	Reference Method
Aflatoxins					
Aflatoxin B_1	Not Detected	-	µg/kg	0.25	In-house method TE-CH-025 based on AOAC (2023) 991.31 and 994.08.
Aflatoxin B_2	Not Detected	-	µg/kg	0.25	
Aflatoxin G_1	Not Detected	-	µg/kg	0.25	
Aflatoxin G_2	Not Detected	-	µg/kg	0.25	
Total Aflatoxin	Not Detected	≤20	µg/kg	-	

Note: Standard : Notification of the Ministry of Public Health No. 414/2020
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Central Lab

TEST REPORT

Date of Issue May 13, 2024
Report No. TRBK67/23034
Page (s) 01/01

Customer Name & Address (provided by customer): DUDCHANEEPORN PRUCKWATTANANON, 71/61 Baan Tharinee, Soi Pravit and Friends, Ladyao, Chatuchak, Bangkok 10900

Sample Description (provided by customer): Wholly Nuts Pistachio Milk

Sample Code: BK67/09163-003

Sample Condition: Sample Type: Pistachio Milk
Packaging : UHT box
Quantity : 1 box, Weight/Volume : 1000 mL.
Temperature : room temperature, in good condition when received

Date of sample received: May 07, 2024

Date of analysis: May 07, 2024 - May 13, 2024

RESULT (S)

Test item	Result	Standard	Unit	LOD	Reference Method
Aflatoxins					
Aflatoxin B1	Not Detected	-	µg/kg	0.25	In-house method TE-CH-025 based on AOAC (2023) 991.31 and 994.08.
Aflatoxin B2	Not Detected	-	µg/kg	0.25	
Aflatoxin G1	Not Detected	-	µg/kg	0.25	
Aflatoxin G2	Not Detected	-	µg/kg	0.25	
Total Aflatoxin	Not Detected	≤20	µg/kg	-	

Note: Standard : Notification of the Ministry of Public Health No. 414/2020
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TEST REPORT

Date of Issue May 13, 2024
Report No. TRBK67/23039
Page (s) 01/01

Customer Name & Address (provided by customer): DUDCHANEEPORN PRUCKWATTANANON
71/61 Baan Tharinee, Soi Pravit and Friends, Ladyao, Chatuchak, Bangkok 10900

Sample Description (provided by customer): 137 Walnut Milk

Sample Code: BK67/09163-008

Sample Condition: Sample Type: Walnut Milk
Packaging : UHT box
Quantity : 1 box, Weight/Volume : 1000 mL.
Temperature : room temperature, in good condition when received

Date of sample received: May 07, 2024

Date of analysis: May 07, 2024 - May 13, 2024

RESULT (S)

Test item	Result	Standard	Unit	LOD	Reference Method
Aflatoxins					
Aflatoxin B_1	Not Detected	-	µg/kg	0.25	In-house method TE-CH-025 based on AOAC (2023) 991.31 and 994.08.
Aflatoxin B_2	Not Detected	-	µg/kg	0.25	
Aflatoxin G_1	Not Detected	-	µg/kg	0.25	
Aflatoxin G_2	Not Detected	-	µg/kg	0.25	
Total Aflatoxin	Not Detected	≤20	µg/kg	-	

Note: Standard : Notification of the Ministry of Public Health No. 414/2020
: The laboratory has been accepted as an accredited laboratory complying with the ISO/IEC 17025.

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Central Lab One Stop & Fast Services

TEST REPORT

Date of Issue May 13, 2024
Report No. TRBK67/23041
Page (s) 01/01

Customer Name & Address (provided by customer)	DUDCHANEEPORN PRUCKWATTANANON 71/61 Baan Tharinee, Soi Pravit and Friends, Ladyao, Chatuchak, Bangkok 10900
Sample Description (provided by customer)	Handy Herb Walnut Milk
Sample Code	BK67/09163-010
Sample Condition	Sample Type: Walnut Milk Packaging : easily opened glass bottle Quantity : 12 bottles, Weight/Volume : 115 mL/bottle. Temperature : room temperature, in good condition when received
Date of sample received	May 07, 2024
Date of analysis	May 07, 2024 - May 13, 2024

RESULT (S)

Test item	Result	Standard	Unit	LOD	Reference Method
Aflatoxins					
Aflatoxin B_1	Not Detected	-	µg/kg	0.25	In-house method TE-CH-025 based on AOAC (2023) 991.31 and 994.08.
Aflatoxin B_2	Not Detected	-	µg/kg	0.25	
Aflatoxin G_1	Not Detected	-	µg/kg	0.25	
Aflatoxin G_2	Not Detected	-	µg/kg	0.25	
Total Aflatoxin	Not Detected	≤20	µg/kg	-	

Note: Standard : Notification of the Ministry of Public Health No. 414/2020
: The laboratory has been accepted as an accredited laboratory complying with the ISO/IEC 17025.

~End of Report~

(Ms. Wanisa Meecharoen)
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BIOGRAPHY

NAME		Dudchaneeporn Pruckwattananon

EDUCATION

1993	-	Master Degree in Business Administration. Assumption University
1988	-	Bachelor Degree in Business Administration. Major in Finance. Faculty of Commerce and Accountancy. Thammasat University

WORK EXPERIENCE

2004-2016	-	Marketing Director. Intel (Microelectronics) Thailand Limited.