Chapter 1

Introduction

1.1 Background

Nutmeg (*Myristica fragrans*) is one of the valuable spices indigenous to Indonesia and plays an important role in the nation's agro-economy. According to the data from FAOSTAT (2023), Indonesia is the largest nutmeg producer in the world reaching production of 44,597 tons of nutmeg with Guatemala and India on the second and third rank. As the world's largest producer, Indonesia dominates 47.2% of global nutmeg exports, reaching USD 112 million primarily to China, Vietnam, Netherlands, United States, and Germany. Furthermore, an annual report by Intelligence (2024), shows that the nutmeg market was valued around USD 2.4 billion in 2022 and increased in growth with compound annual growth rate (CAGR) reaching 5.4%, and projected to reach USD 3.6 billion by 2030. Increasing the demand for nutmeg globally is mainly driven by the rising popularity of ethnic cuisines such as Indian and Thai food and also due to the functional nature of the nutmeg which has anti-inflammatory, antioxidant, and aiding digestive system (Antani & Mahapatra, 2022; Arimah et al., 2022).

Despite high production and demand worldwide, as Indonesia is located along the equatorial line, the temperature is relatively warm and humid (Susanto et al., 2020). This condition makes Indonesia's nutmeg production and cultivation still face food safety and quality challenges particularly due to the contamination of toxic fungal and mold. *Aspergillus flavus* is one of the fungi that can contaminate nutmeg during drying processing. This fungus can produce carcinogenic and genotoxic compounds namely aflatoxin B1 (AFB1) that can increase the risk of liver cancer and impair children's development (Jallow et al., 2021; Umar et al., 2023). The International Agency for Research on Cancer (IARC) classified AFB1 as a group 1 carcinogen which means it directly causes liver cancer in humans (Aiyama et al., 2018).

Although regulatory bodies have set strict management and preventive action for many toxicants, AFB1 contamination in spices is undeniable as full removal of AFB1 is considered costly and needs enormous effort (Wagacha & Muthomi, 2008). This is due to the fact that from 2020-2024, the European Union (EU) reported 27 cases related to AFB1 contamination from Indonesian nutmeg with some findings exceeding 100 ppb of AFB1 (RASFF, 2024; Wahidin & Purnhagen, 2018). Moreover, referring to Sembiring et al. (2020), there were also 53 out of 80 rejections of Indonesian nutmeg exported to EU due to AFB1 contamination level exceeding the maximum limit. However, previous studies did not specify the origin, grade, or health risks associated with AFB1-contaminated nutmeg, particularly for the Indonesian population. Therefore, this study aims to evaluate AFB1 contamination in nutmeg from various regions in Indonesia and assess the associated health risks to Indonesian consumers. In addition, the physicochemical properties of the nutmeg samples will be analyzed to support the findings on AFB1 contamination levels.

1.2 Objective

The objective of this study is to assess the AFB1 contamination level in nutmeg from several origins in Indonesia including Papua, Sulawesi, Kalimantan, and Maluku Island by utilizing a Liquid Chromatography tandem Mass Spectrophotometer (LC-MS). Furthermore, all of the data obtained from the evaluation will be used to conduct a risk assessment of AFB1 contamination in nutmeg by using the Margin of Exposure (MOE) approach proposed by the EFSA and quantitative liver cancer risk approach proposed by Joint FAO/WHO Expert Committee on Food Additives (JECFA). Additionally, physicochemical analyses such as moisture content (MC), water activity (Aw), and ash content will also be evaluated.

1.3 Hypothesis

1.3.1 AFB1 Contamination Levels

- H_0: The AFB1 contamination level is above the maximum limit from BPOM regulation

- H_1: The AFB1 contamination level is below the maximum limit from Indonesian BPOM regulation

1.3.2 Margin of Exposure (MOE) levels

- H_0: The margin of exposure levels of nutmeg consumption in Indonesia is of concern (<10,000)
- H_1: The margin of exposure levels of nutmeg consumption in Indonesia is of no concern (>10,000)

1.3.3 Quantitative Liver Cancer Risk levels

- H_0: The quantitative liver cancer risk level is of concern (>0.1 liver cancer cases/100,000 individuals in 75 years.
- H_1: The quantitative liver cancer risk level is of no concern (<0.1 liver cancer cases/100,000 individuals in 75 years.

1.3.4 Physicochemical Properties

1.3.4.1 Moisture Content

- H_o: There is no significant difference in the moisture content among nutmeg samples.
- H_1: There is a significant difference in the moisture content among nutmeg samples.

1.3.4.2 Water Activity

- H_0: There is no significant difference in the water activity among nutmeg samples.
- H_1: There is a significant difference in the water activity among nutmeg samples.

1.3.4.3 Ash Content

- H_0: There is no significant difference in the ash content among nutmeg samples.
- H_1: There is a significant difference in the ash content among nutmeg samples.