

**UNIVERSITI TEKNOLOGI MARA**

**SIX GRADES AGARWOOD OIL  
QUALITY CLASSIFICATION USING  
K – NEAREST NEIGHBOUR MODEL  
OF SIGNIFICANT CHEMICAL  
COMPOUNDS**

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## ABSTRACT

Agarwood is a valuable plant species known as *Aquilaria*, belonging to the Thymelaeaceae family. Agarwood oil is a concentrated volatile aromatic chemical that is extracted from the stem of the agarwood plant. Agarwood oil is widely used in perfumes, incense, and traditional medicine products. On the other hand, agarwood oil has a very good commercial value, and the price is determined based on the oil quality grade. Currently, the process of agarwood oil grading is based on human sensory. Besides, without an established grading method being approved, most countries have used their own way of grading agarwood oil. Thus, this study proposes a novel classification technique for the agarwood oil quality grade using K-Nearest Neighbour (KNN) algorithm applied to selected chemical compound of the agarwood oil. In order to group the data into more parsimonious and possible clusters and reduce the amount of data, Principal Component Analysis (PCA) was employed during data pre-processing. Then, statistical analysis was performed by using boxplot to explore the behaviour or characteristics of a high-quality agarwood oil sample; the result of which will improve the grading from the recently published four grades to a new six grades classification. Eleven most significant chemical compounds of the agarwood oil were used as input in the KNN classification model, and the grades were the output of the model. Eighty percent of the data samples are used for the model training, and twenty percent of the data samples are used for the model testing. The validation for the KNN classification model was conducted using performance measures including accuracy, sensitivity, specificity, and precision. All the grades (four, five, and six) have 100% accuracy, sensitivity, specificity, and precision, which means the classification model passed the performance measure criteria standard. Results of the proposed research show that the agarwood oil can be accurately classified into six grades. The outcomes of this research would be beneficial to the research and development (R&D) of agarwood oil areas in the long term in the future, including the grading classification method.

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# CHAPTER ONE

## INTRODUCTION

### 1.1 Research Background

Agarwood is known by different names in different countries [1]. For example, in Malaysia, agarwood is known as "Gaharu". However, in China, it is called "Chexiang". As written in previous researchers [1]-[8], agarwood is also known by the names "Kalambak", "Kanankoh", "Agalloch", "Jinkoh", "Eaglewood", and "Aloeswood". Agarwood, a non-timber forest product, has a high demand and is extremely valuable due to its use as a key ingredient in herbal and medication production, as well as in the production of fragrant products. It is also an essential material used in various religious and cultural ceremonies and festivals [1], [2], [4]-[7], [9], [10], [12], [13].

Agarwood oil, also referred to as "Black Gold" [13] or "Wood of God" [14], is an essential oil that is naturally produced through a series of processes in the forest. It is obtained from a type of tree known as the "Aquilaria," which belongs to the "Thymelaeaceae" family [8], [15]. According to records, there are approximately twenty-eight to thirty-one different species of "Aquilaria" that have been discovered worldwide, including in Southeast Asia. Previous research studies have documented that the highest concentration of each of these species is found in southern and eastern Asian countries [2], [5]-[7], [16], [17].

Agarwood oil is graded based on various factors, resulting in different grading standards in different countries [6], [18]. For instance, in Malaysia, Japan, and India, agarwood oil is classified into two or more categories or classes. Malaysian researchers use "Gaharu" and "Kalambak" as standard names for low and high quality, respectively. In Japan, "Kanankoh" and "Jinkoh" are generally used to denote high and low quality, while in India, alphabetical labels (A, B, C, and D) or numbers (1, 2, 3, and 4) are used to indicate the brightness and concentration level of the oil [6], [18], [19].

Next, the price of agarwood oil in the market is determined based on the quality of the agarwood oil itself. Like other products sold on the market, their prices also depend on their quality [20]-[22]. The same goes for agarwood oil. The higher the quality of agarwood oil, the higher the price of agarwood oil [6], [23], [24]. As