I. Introduction

Coffee is recognized as the second largest major commodity in global trade after crude oil and has a positive economic impact on developing exporting countries, such as Brazil, Vietnam, Colombia, Indonesia, and Ethiopia [1], [2]. Coffee has become part of our daily routine as a beverage that boosts energy and reduces drowsiness. Consuming a cup of coffee every day has made it a part of many people's lifestyles. As such, there is a huge business opportunity in the coffee industry [2].

One of the important factors in the coffee industry in general is the quality of green coffee beans, which is a reference in determining the flavor and aroma of brewed coffee [3]. If green coffee beans display defects, cracks, physical imperfections or alterations in color, these problems can significantly impact the quality of the end product [4]. A decline in the quality of green coffee beans results in dissatisfied customers and can cause financial setbacks for coffee producers, roasters, and farmers.

In recent times, the selection of defects in green coffee beans continues to rely on manual labor. Although this human effort is employed to sort the beans, the process lacks standardization and is quite time-intensive [5]. To address the challenges in selecting green coffee beans, advancements in computer vision and machine learning offer promising solutions to ensure that the beans meet the quality standards set by the Specialty Coffee Association of America (SCAA) [4], [6].

This research focuses on the classification process of 17 classes, covering 16 types of defects outlined by the SCAA standard and 1 normal class with a Specialty grade [6]. Previous studies have successfully classified defects in green coffee beans in accordance with the SCAA standard, but generally only cover a small subset of defect categories [4], [7]-[11]. Similarly, studies that do not apply the SCAA standard also show good results but are limited to a few types of defects [2], [5], [12]-[19]. Furthermore, studies related to green coffee bean defects applied to

object detection shows good performance and still uses several types of green coffee bean defects [1], [3], [20].

Although the related studies showed good performance (41% to 96% accuracy) in classification [4], [7]-[11], it was only conducted on one lighting condition for the images. Whereas different lighting levels can have a significant influence on the classification results [21]. To address this issue, this research integrates image capture under different lighting level conditions, namely low, medium, and high, to evaluate their impact on classification performance.

This research proposes a new 17-class classification system (16 defects and 1 normal) for green coffee beans using MobileNetV3. The proposed system classifies 16 defect classes in green coffee beans based on SCAA standards, including Full Black, Full Sour, Dried Cherry/Pod, Fungus Damage, Foreign Matter, Severe Insect Damage, Partial Black, Partial Sour, Parchment/Pergamino, Floater, Immature/Unripe, Withered, Shell, Broken/Chipped/Cut, Hull/Husk, and Slight Insect Damage, as well as 1 normal class for Specialty grade. The main contributions of this research are as follows: (i) the design of a comprehensive 17 class classification using MobileNetV3 designed to classify defects in green coffee beans; and (ii) the inclusion of classification performed under different lighting level conditions, namely low, medium, and high.

The content of this research is divided into several parts. Section II covers previous related studies on defect classification in green coffee beans. Defect classification using MobileNetV3 under different lighting conditions in Section III. Section IV presents the experimental setup, results, and analysis of the classification performance under different lighting conditions. Finally, Section V concludes with a summary of the results and recommendations for future research.