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Quality Assessment of Green Coffee Beans in Cavite Based on the Philippine National Standard

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Abstract

Aim: This study aimed to evaluate the quality of green coffee beans (GCB) in Cavite, specifically focusing on moisture content, GCB grade, and defects profile, while also examining compliance with Good Manufacturing Practices (GMP) audits in primary production, in-process activities, and post-production processes of coffee producers and processors in Cavite.

Methodology: Using the principles of a true experiment, specifically the repeated measures design, this study evaluated the quality of green coffee beans (GCB) in Cavite in compliance with the Philippine National Standards-Bureau of Agriculture and Fisheries Standards (PNS/BAFPS) 01:2012 in terms of moisture content, GCB grade, and defects profile, as well as investigated the compliance of coffee producers and processors in Cavite with Good Manufacturing Practices (GMP) in primary production, in-process, and post-production.

Results: The results show that three out of five coffee producers in Cavite failed moisture content analysis, with specific four out of ten green coffee bean (GCB) samples failing. The GCB grade analysis suggested geographical influences on variations while emphasizing overall compliance with the Philippine National Standard, with primary non-conformance related to black and partly black beans. Audit data showcased an impressive 96.8% average compliance rate, pinpointing areas for improvement in Surroundings and Condition of Equipment categories, notably debris in production areas and the importance of effective clean-up processes.

Conclusion: These findings emphasize the intricacies of factors influencing Cavite's GCB quality, urging specific attention to sustained improvement in the local coffee industry.

Keywords: green coffee beans, Cavite, GMP audit, quality assessment

INTRODUCTION

Coffee is a globally popular beverage, with consumption reaching approximately 166.63 million bags (60 kg per bag) in 2020 and 2021, showing a slight increase from 2019's 164 million bags. The Philippines, due to its favorable climate and land conditions, has achieved a production volume of locally grown coffee averaging around 68,823 metric tons, with a supply utilization of approximately 60,426 metric tons in 2016. Green coffee beans (GCB), also referred to as raw coffee beans, are the trading and purchasing material for coffee. The composition profile of these raw beans can serve as an indicator of the sensory quality of brewed coffee, which is crucial information for producers and the industry (MacDonnell, 2022). Currently, coffee is sold by farmers to small processors, large corporations, and specialty coffee shops. These buyers transform coffee into a variety of forms, including GCB, roasted, ground, and instant. The continuous drop in production was caused by a number of factors, including an increase in the number of coffee growers shifting to other crops, the old age of trees with limited or no rejuvenation, poor farm practices (farmers with limited knowledge of appropriate coffee technology, aged farmers), limited access to certified planting materials, and limited access to credit (Hasibuan, Ferry & Wulandari, 2022).

GCB trace their origins to the *Coffea* plant species, which predominantly grow in equatorial regions. The cultivation process involves meticulous attention to environmental factors such as altitude, temperature, rainfall, and

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soil composition. The coffee cherries are handpicked when they reach their optimal ripeness, and the beans are extracted and processed to preserve their natural state.

GCB possess a complex composition that underlies their unique properties. They contain a variety of bioactive compounds, including caffeine, chlorogenic acids, trigonelline, and diterpenes. These compounds contribute to the distinct flavor profile and potential health benefits associated with green coffee consumption.

Roasting is a critical step in coffee production that transforms GCB into the familiar brown beans used for brewing. During this process, the chemical composition of the beans undergoes significant changes, leading to the development of various flavors and aromas. However, it also results in the loss of certain bioactive compounds present in their raw form.

GCB have garnered attention for their potential health benefits. Chlorogenic acids, abundant in unroasted beans, have been associated with antioxidant and anti-inflammatory effects, as well as potential benefits for weight management. However, further research is needed to fully elucidate the extent and mechanisms of these health effects. Beyond their role in coffee production, GCB have found applications in other domains. Extracts derived from GCB are utilized in dietary supplements, skincare products, and food additives, capitalizing on their potential health properties and antioxidant content. As the demand for sustainable and health-conscious products increases, GCB hold promise as an alternative to traditional coffee. However, challenges such as climate change, disease susceptibility, and market dynamics present hurdles to their widespread adoption. Continued research and innovation are necessary to address these challenges and fully unlock the potential of GCB.

GCB possess a wide range of chemical compounds, including acids, sugars, and aromatic oils. During the roasting process, these compounds undergo complex chemical reactions that result in the development of flavors and aromas characteristic of coffee. The specific composition and quality of GCB greatly influence the final taste profile of the brewed coffee. Coffee producers and roasters carefully select GCB based on factors such as origin, variety, altitude, and processing methods. These variables contribute to the unique flavor profiles found in different types of coffee. By selecting high-quality GCB, coffee professionals can ensure a more desirable taste in the final cup. The GCB act as the starting point for the roasting process. Roasters have the flexibility to control various parameters, such as temperature and duration, to achieve the desired roast level. GCB with specific characteristics, such as higher acidity or unique flavors, provide roasters with more options for creating diverse coffee profiles. GCB contain a higher concentration of antioxidants compared to roasted coffee beans. Antioxidants are known for their potential health benefits, including protecting the body against oxidative stress. Some studies suggest that consuming GCB or extracts may have positive effects on certain health markers, although more research is needed to fully understand their impact. GCB are a key component of the specialty coffee market, which focuses on high-quality coffee with unique flavors and characteristics. Specialty coffee enthusiasts and professionals place great importance on sourcing and roasting exceptional green coffee beans to produce outstanding coffee experiences. The GCB industry has embraced sustainability initiatives, including certifications like Fair Trade, Rainforest Alliance, and organic production. By supporting environmentally friendly practices and fair trade principles, the coffee industry aims to minimize its impact on the environment and support the well-being of coffee farmers and their communities.

Arabica beans are by far the most popular type of coffee bean, accounting for roughly 60% of the world's coffee production. Originating many centuries ago in Ethiopia's highlands, it is revered as the first coffee bean ever consumed. *Coffea Arabica* got its name around the 7th century, when the bean crossed the Red Sea from Ethiopia to present-day Yemen and lower Arabia, hence the term "*arabica*."

Robusta is the second-most popular type of coffee bean. This bean was developed in Sub-Saharan Africa and is now primarily grown in Africa and Indonesia. It's also very popular in Vietnam, where it's frequently mixed into coffee blends. It is a less expensive variety, making it an excellent choice for roasters on a budget.

Coffea liberica is prized for its piquant floral aroma and bold, smoky flavor profile. It is native to central and western Africa, specifically Liberia, hence its name. This hardy species is frequently mixed with other varieties to add body and complexity, but it rarely gets credit for it.

Liberica gained a foothold with Southeast Asian coffee producers after a fungal disease ("coffee rust") wiped out much of the region's *Arabica* crops, which was unheard of in Western civilization prior to the late 1800s. *Excelsa* is the fourth major type of coffee bean. Though it was previously thought to be a distinct coffee species, scientists recently reclassified it as a *Liberica* variant. *Excelsa* beans are almost entirely grown in Southeast Asia and are shaped similarly to *Liberica* beans—elongated ovals. At medium altitudes, these beans grow on large 20- to 30-foot coffee plants.

The Philippines has a long history of coffee cultivation, and green coffee bean production continues to be an important aspect of the country's agricultural industry. The Philippines boasts an ideal environment for cultivating

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four coffee varieties: *Robusta, Arabica, Excelsa*, and *Liberica. Robusta* (Noemi, 2018), the most prevalent variety, contributes to 69 percent of the total production in the country, primarily used for producing instant coffee. *Arabica,* comprising 24 percent of the production, is grown at higher elevations and commands a premium price, commonly used in brewing or blending. *Excelsa* and *Liberica*, known as "*kapeng barako*", make up the remaining varieties. In Mindanao, small farmers are the country's primary coffee producers. *Robusta*, which accounts for 69 percent of production, *Robusta* (24 percent), *Excelsa* (6 percent), and *Liberica* are the four varieties grown (1 percent). However, the country's coffee supply is insufficient. Coffee production in 2015 was only 36,171 MT of GCB. Farm yields were only 0.30 tons per hectare on average (Andoko, 2020).

Some of the major coffee-growing areas include the Cordillera Administrative Region (CAR), particularly the provinces of Benguet, Kalinga, and Ifugao, which are known for *Robusta* coffee. The provinces of Cavite, Batangas, and Quezon in the CALABARZON region are known for both *Robusta* and *Robusta* production. Other coffee-growing regions include Mindanao, particularly the provinces of Sultan Kudarat, Bukidnon, and Davao (Noemi, 2018).

Presently, Cavite is widely recognized as the Coffee Capital of the Philippines, with Amadeo alone cultivating 4,790 hectares of coffee (Bolido, 2019). Additionally, numerous hectares in neighboring upland municipalities of Cavite contribute to 67% of the coffee production in CALABARZON (Region IV-A). However, the quality of GCB from Cavite is uncertain because of a scarcity of studies that identify it. Hence, this study aims to evaluate the quality profile of GCB in Cavite in accordance with the Philippine National Standard for Green Coffee Beans (PNS/BAFPS 01:2012), providing accurate and valuable information.

Objectives

In general, the study aimed to assess the quality profile of green coffee beans from different coffee processors in Cavite.

Specifically, the study aimed to:

1. assess the quality of green coffee beans in Cavite in compliance with the Philippine National Standards-Bureau of Agriculture and Fisheries Product Standards (PNS/BAFPS) 01:2012 in terms of moisture content, GCB grade, and defects profile; and
2. investigate compliance of coffee producers and processors in Cavite with Good Manufacturing Practices (GMP) in primary production, in-process, and post-production, focusing on their specific elements such as surrounding, equipment, water supply, waste management, fermentation shed, drying and conditioning facilities, building facilities, sorting and bagging, storage, conveyances, and transport.

The study is limited to the quality comparison of GCB in Cavite based on PNS/BAFPS 01:201, which includes the following: the moisture content of GCB shall be 9.0% and not exceed 12%; GCB shall be free from musty, moldy, and other foreign odors and tastes; GCB shall be of homogeneous species; and GCB shall be free from insects and other foreign matters; excluding clause 5.3, where "Green coffee beans shall be fairly uniform in size and not more than 10% shall pass through sieve no. 13 round with apertures having a nominal diameter of 5 mm as described in PNS/ISO 4150".

The study does not include the shelf-life determination and microbiological analysis of GCB.

METHODS

Experimental Design

Repeated Measures Design was used in the study wherein the samples were subjected to same conditions and were evaluated based on the given standard.

Procurement of Materials

The GCB were obtained from six (6) coffee processors around Cavite: Amadeo, Bailen, Indang, Magallanes, and Silang from May 2022 to January 2023, stored in a cool, dry place away from direct sunlight and heat.

Green Coffee Beans Evaluation

GCB were evaluated for its grade through defects percentage, maximum defects compliance, and moisture content. The evaluation sheet includes parameters and specifications based on the Philippine National Standard (PNS/BAFPS 01:2012).

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Moisture Content Analysis

Moisture content shall be tested in accordance with ISO 6673 or with the use of moisture tester calibrated by any authorized government agency. Oven drying was used to measure moisture content of GCB. One-hundred grams of GCB were placed in a petri dish and dried in an oven for three hours at 105oC. It was then cooled in the desiccator and weighed. The same procedure was done in triplicate. Weight loss after drying was recorded and percent moisture was computed. A moisture content analysis sheet was used in the study. Moisture content of GCB shall be 9.0% and not to exceed 12%. Percent moisture content was computed using the formula:

$$\% \text{ Moisture Content} = \frac{\text{initial weight of sample} - \text{final weight of sample}}{\text{initial weight of sample}} \text{ x } 100$$

Grading by Defects

The GCB were evaluated for its defects (% total defects of 300 g sample) sectioned as follows:

1. Defects associated with foreign matter
2. Defects associated with non-bean matter coming from the coffee fruit
3. Defects associated with irregular beans
4. Defects associated with visual appearance
5. Defects mostly evident in cupping.

Table 1. Total defects of 300 – g sample % by mass, max.

GCB Variant	Grade 1	Grade 2	Grade 3	Grade 4
Arabica	7%	15%	20%	>20%
Robusta	8%	15%	17%	>17%
Excelsa	10%	15%	25%	>25%
Liberica	10%	15%	25%	>25%

GMP Audit Compliance

The GMP audit aims to assess the production and processing practices of Cavite coffee producers and processors. The questionnaire was adapted from the "Development of Good Manufacturing Practice (GMP) in the Form of a Practical-Oriented Application for Household Coffee Processing Guidelines (Pranadikusumah et al., 2021) with modifications. The survey questionnaire covered the following parameters:

Surrounding Check

This checking includes checking the perimeter for the presence of rubbish, weeds, brush, standing water on the grounds, and other plant conditions to be investigated.

Condition of Equipment Check

The condition of equipment checking includes cleaning of in-contact surfaces of the equipment, suitability of design (construction material, areas of production build-up, evidence of seepage of cleaning solvents or lubricants, difficulty of machine disassembly, and other equipment cleaning and maintenance issues that should be covered.

Water Supply / Waste Management Check

Suitability of water quality, regular removal of pulp from processing area, garbage removal, pulp handling, wastewater treatment, handling of other waste material, and other water/ waste management issues requiring attention.

Fermentation Shed Check

The fermentation shed checking includes cleaning activities and its frequency, cleaning efficiency, pest control, and roofing condition.

Drying and Conditioning Facilities Check

This checking includes parchment quantity during peak season, drying area condition, drying yard size, capacity of conditioning bins, safety drying practices, and assessment of other sources of possible contamination.

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Building Facilities Check

The questions for building facilities check involves pest control, infrastructure condition, availability of handwashing and restrooms, and nature of construction.

Sorting and Bagging Check

The sorting and bagging check includes adequacy of the light source, availability of moisture measuring equipment, regular cleaning, usage of appropriate packaging materials, and condition of packaging storage.

Storage Check

The storage check involves checking of high moisture indicators, presence of leakage in roof area, condensation, good ventilation, adequate lighting, storage area conditions, coffee stacking, stock rotation, and cross-contamination probability.

Conveyances and Transport Check

This sector assesses if transport is carried out hygienically, religious cleaning and disinfecting of conveyance for transport before and after loading, and protective measures against re-wetting during transport.

Assessment of the level of suitability (%) of each respondent in handling coffee is calculated using the following formula:

$$\frac{Number\ of\ compatible\ answer}{Total\ of\ questions}\ x\ 100\ \% = GMP\ Conformity\ (\%)$$

where the Number of compatible answers simply refers to the affirmative answers of each respondent in every indicator under this sector or the Compliance Score. Needs Attention or Non-compliance Score shall be answered if the indicator is not met or does not comply with the given audit criteria. Non-applicable answers, or N/A, shall be answered if the process or parameter does not apply to the auditee and shall be considered non-auditable hence compliant. The results of the audit and grading of coffee processors by defects will be subjected to statistical analysis

Statistical Analysis

The results of coffee processors audit and grading by defects were analyzed by frequency. T-tests, One Way Analysis of Variance (ANOVA), Post Hoc Tests, and Homogenous Subsets were used to determine the significant difference in the moisture content.

RESULTS and DISCUSSION

Quality of Green Coffee Beans in Cavite

The findings of this study underscore the importance of evaluating the quality of green coffee beans (GCB) in Cavite, a region known for its significant contribution to the Philippines' coffee industry. The quality assessment focused on key parameters such as moisture content, GCB grade, and defects profile, all of which play a crucial role in determining the sensory attributes of the brewed coffee. These were analyzed and evaluated to determine and support the assessment of green coffee bean compliance based on the Philippine National Standard for Green Coffee Bean Specifications (PNS/BAFPS 01:2012).

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Moisture Content Analysis

Table 2. Moisture content analysis results of GCB, based on the PNS/BAFPS 01:2012 passing %MC range

Coffee Producers	Variant	Mean Initial Weight	Mean Final Weight	% MC	Disposition
Gourmet Farms, Silang	*Arabica*	100	90.57	9	Passed
	Robusta	100	87.57	12	Passed
	Liberica	99.33	87.6	12	Passed
The Coffee Estate, Amadeo	*Arabica*	99.17	86.97	12	Passed
	Robusta	98.83	86.7	12	Passed
	Liberica	99	87.2	12	Passed
Tua Coffee Growers Association, Magallanes	*Robusta*	100	86.1	14	Failed
Bailen Coffee Growers Association, Bailen	*Robusta*	100	84.17	16	Failed
Café Amadeo, Amadeo	*Robusta*	100	82.87	17	Failed
	Excelsa	100	86.8	13	Failed

Table 2 shows that 3 out of 5 coffee producers and processors failed moisture content analysis, making 4 out of 10 GCB samples fail. Specifically, the Bailen Coffee Growers Association, Café Amadeo, and Tua Coffee Growers Association failed the moisture content analysis. The specific GCB samples that failed the moisture analysis include *Robusta* from Bailen Coffee Growers Association, *Robusta* and *Excelsa* from Café Amadeo, and *Robusta* from Tua Coffee Growers Association. The moisture content of GCB influences the sensory attributes and cup quality of the brewed coffee. Optimal moisture content within a specific range contributes to the desirable flavor, aroma, acidity, and body of the resulting coffee beverage. Higher moisture content can lead to issues such as mold growth, off-flavors, and reduced cup quality, while excessively low moisture content can result in flavor loss and a decrease in aromatic compounds (Boot, 2021).

Moisture Content and Its Implications

The observed variations in moisture content among different coffee producers in Cavite align with previous research on the impact of moisture content on coffee quality (Boot, 2021). Optimal moisture levels within a specific range contribute to desirable flavor, aroma, acidity, and body in the resulting coffee beverage. The failures in moisture content analysis, particularly by Bailen Coffee Growers Association, Café Amadeo, and Tua Coffee Growers Association, highlight potential challenges in maintaining ideal moisture levels during processing and storage.

Previous studies (Boot, 2021) have emphasized the significance of controlling moisture content to prevent issues such as mold growth, off-flavors, and reduced cup quality. The presence of moldy beans in some samples may

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be attributed to inadequate storage practices and the absence of proper monitoring tools, aligning with the audit results that identified deficiencies in moisture control mechanisms.

Grading by Defect

Table 3. GCB grading by defects

Producers	*Robusta*		*Excelsa*		*Arabica*		*Liberica*	
	% Defects	Grade	% Defects	Grade	% Defects	Grade	% Defects	Grade
Bailen Coffee Growers Association	45	4						
Cafe Amadeo	22.53	4	20	3				
Gourmet Farms	16.67	3			19	3	8.37	1
Coffee Estate Amadeo	15	2	15	2	19	3		
Tua Coffee Growers Association	14	2						

Table 3 provides an overview of the grades obtained for Cavite GCB, as determined by the maximum total defects per 300g sample. The data underscores the presence of various grades for the GCB, and it is plausible to consider that geographical factors such as altitude and soil may contribute to this variation.

One significant factor that could impact the grade variation is how the beans are stored. Inadequate storage practices, as identified during the GMP audit, have led to the development of a fermented odor in the beans. Moreover, the absence of moisture monitoring tools has resulted in the occurrence of moldy beans, while over-fermentation has led to the presence of black beans. These quality issues may be attributed to the lack of proper control over moisture levels during storage.

Another factor influencing the observed grade variation is the inefficiency in the sorting process. Inadequate sorting procedures have facilitated the presence of insects that further damage the beans, negatively impacting their overall quality. Additionally, the practice of drying the beans on the ground has introduced foreign matter, which adds to the defects observed in the GCB.

The identified factors, such as improper storage practices, absence of moisture monitoring tools, inefficient sorting procedures, and the presence of foreign matter, have contributed to the variation in the overall quality of the GCB. Given that some coffee beans traded in the region may not have originated in Cavite but are integrated into the local market, there arises the potential for preliminary sorting before these beans undergo the roasting process. Specifically, the inclusion of *Arabica*, a coffee variety not cultivated in Cavite, underscores the diverse sourcing practices within the local coffee industry. These non-local beans may be strategically blended with Cavite-produced beans, a common practice aimed at achieving a desired flavor profile. The intentional blending of coffee varieties not native to Cavite with locally cultivated beans suggests a nuanced approach to coffee production, where regional distinctions are blurred to create unique and marketable flavor combinations. This blending strategy raises intriguing questions about the impact on overall coffee quality and consumer preferences, warranting further investigation into the dynamics of bean sourcing and mixing practices within the broader context of Cavite's coffee production and trade.

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Table 4. Compliance overview of 10 GCB samples

DEFECTS	ARABICA		ROBUSTA					EXCELSA		LIBERICA
PARAMETERS	THE COFFEE ESTATE	GOURMET FARM	THE COFFEE ESTATE	GOURMET FARM	CAFÉ AMADEO	MAGALLANES	BAILEN	THE COFFEE ESTATE	CAFÉ AMADEO	GOURMET FARM
1. Defects associated with foreign matter										
1.1 Stone	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
1.2 Sticks	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
1.3 Soil agglomerate	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
1.4 Metallic Matter	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
1.5 Foreign matter other than described	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
2. Defects associated with non-bean matter coming from the coffee fruit										
2.1 Bean in parchment (pergamino)	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
2.2 Piece of parchment (pergamino)	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
2.3 Dried cherry (pod)	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
2.4 Husk fragment	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
3. Defects associated with irregular beans										
3.1 Malformed bean, shell and ear	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
3.2 Bean fragment	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
3.3 Broken bean	Compliant	Compliant	NC	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
3.4 Insect damaged bean	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
3.5 Insect-infested bean	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
3.6 Pulper-nipped bean; Pulper-cut bean	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
4. Defects associated with visual appearance										
4.1 Black bean and partly black bean	Compliant	Compliant	Compliant	Compliant	Compliant	NC	NC	NC	NC	Compliant
4.2 Black-green bean	Compliant	NC	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
4.3 Brown bean ("ardido")	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
4.4 Amber bean	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
4.5 Immature bean; 'quaker' bean	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
4.6 Waxy bean	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
4.7 Blotchy bean; spotted bean	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
4.8 Withered bean	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
4.9 Spongy bean	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
4.10 White bean	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
5. Defects mostly evident in cupping:										
5.1 Bean producing stinker or fermented flavors	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
5.2 Bean producing other current off flavor	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
MOISTURE CONTENT	Compliant	Compliant	Compliant	Compliant	NC	NC	NC	Compliant	NC	Compliant
GREEN COFFEE GRADE	**Grade 3**	**Grade 3**	**Grade 2**	**Grade 3**	**Grade 4**	**Grade 2**	**Grade 4**	**Grade 2**	**Grade 3**	**Grade 1**

*NC = Non-compliant

Table 4 shows the summary of compliance with parameters in PNS/BAFPS 01:2012. The primary non-conformance is observed in black bean and partly black bean, followed by black-green bean and broken bean. The table suggests that the Cavite GCB is generally compliant with all other parameters regarding the presence of defects based on the standard. This means that Cavite green coffee beans are generally compliant to the Philippine National Standard.

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Table 4.a. Café Amadeo *Excelsa* Grade 3 in comparison with standard

Parameters	PNS/BAFPS 01:2012	Café Amadeo *Excelsa* Grade 3	Remarks
	Max. % Defect for Grade 3	Actual % Defect	
1. Defects associated with foreign matter			
1.1 Stone	1	0	Compliant
1.2 Sticks	1	0	Compliant
1.3 Soil agglomerate	1	0	Compliant
1.4 Metallic Matter	1	0	Compliant
1.5 Foreign matter other than described	1	0	Compliant
2. Defects associated with non-bean matter coming from the coffee fruit			
2.1 Bean in parchment (pergamino)	2	0.5	Compliant
2.2 Piece of parchment (pergamino)	2	0	Compliant
2.3 Dried cherry (pod)	2	0	Compliant
2.4 Husk fragment	2	0	Compliant
3. Defects associated with irregular beans			
3.1 Malformed bean, shell and ear	7	2.9	Compliant
3.2 Bean fragment	7	1.5	Compliant
3.3 Broken bean	7	2.2	Compliant
3.4 Insect damaged bean	7	1.1	Compliant
3.5 Insect-infested bean	7	0.3	Compliant
3.6 Pulper-nipped bean; Pulper-cut bean		1.5	Compliant
4. Defects associated with visual appearance			
4.1 Black bean and partly black bean	9	8.0	NC
4.2 Black-green bean	9	0.4	Compliant
4.3 Brown bean (“ardido”)		0.0	Compliant
4.4 Amber bean		6.5	Compliant
4.5 Immature bean; ‘quaker’ bean	5	1.5	Compliant
4.6 Waxy bean		0.0	Compliant
4.7 Blotchy bean; spotted bean		0.0	Compliant
4.8 Withered bean	5	0.0	Compliant
4.9 Spongy bean	5	0.0	Compliant
4.10 White bean	5	1.3	Compliant
5. Defects mostly evident in cupping:			
5.1 Bean producing stinker or fermented flavors	2		Compliant
5.2 Bean producing other current offflavor			Compliant

**NC- non-compliant*

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Table 4.b. Gourmet Farm *Arabica* Grade 3 in comparison with standard

Parameters	PNS/BAFPS 01:2012	Gourmet Farm Arabica Grade 3	Remarks
	Max. % Defect for Grade 3	Actual % Defect	
1. Defects associated with foreign matter			
1.1 Stone	1	0.0	Compliant
1.2 Sticks	1	0.0	Compliant
1.3 Soil agglomerate	1	0.0	Compliant
1.4 Metallic Matter	1	0.0	Compliant
1.5 Foreign matter other than described	1	0.0	Compliant
2. Defects associated with non-bean matter coming from the coffee fruit			
2.1 Bean in parchment (pergamino)	2	0.0	Compliant
2.2 Piece of parchment (pergamino)	2	0.0	Compliant
2.3 Dried cherry (pod)	2	0.0	Compliant
2.4 Husk fragment	2	0.0	Compliant
3. Defects associated with irregular beans			
3.1 Malformed bean, shell and ear	7	4.2	Compliant
3.2 Bean fragment	7	0.8	Compliant
3.3 Broken bean	7	1.8	Compliant
3.4 Insect damaged bean	7	1.7	Compliant
3.5 Insect-infested bean	7	0.0	Compliant
3.6 Pulper-nipped bean; Pulper-cut bean		4.3	Compliant
4. Defects associated with visual appearance			
4.1 Black bean and partly black bean	9	1.0	Compliant
4.2 Black-green bean	9	7.2	NC
4.3 Brown bean (“ardido”)		0.0	Compliant
4.4 Amber bean		4.2	Compliant
4.5 Immature bean; ‘quaker’ bean	5	1.8	Compliant
4.6 Waxy bean		0.0	Compliant
4.7 Blotchy bean; spotted bean		0.0	Compliant
4.8 Withered bean	5	0.0	Compliant
4.9 Spongy bean	5	0.0	Compliant
4.10 White bean	5	0.0	Compliant
5. Defects mostly evident in cupping:			
5.1 Bean producing stinker or fermented flavors	2	0.0	Compliant
5.2 Bean producing other current offflavor		0.0	Compliant

**NC- non-compliant*

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Table 4.c. The Coffee Estate *Robusta* Grade 2 in comparison with standard

Parameters	PNS/BAFPS 01:2012	The Coffee Estate *Robusta* Grade 2	Remarks
	Max. % Defect for Grade 2	Actual % Defect	
1. Defects associated with foreign matter			
1.1 Stone	1	0	Compliant
1.2 Sticks	1	0	Compliant
1.3 Soil agglomerate	1	0	Compliant
1.4 Metallic Matter	1	0	Compliant
1.5 Foreign matter other than described	1	0	Compliant
2. Defects associated with non-bean matter coming from the coffee fruit			
2.1 Bean in parchment (pergamino)	1.5	0.2	Compliant
2.2 Piece of parchment (pergamino)	1.5	0	Compliant
2.3 Dried cherry (pod)	1.5	0	Compliant
2.4 Husk fragment	1.5	0	Compliant
3. Defects associated with irregular beans			
3.1 Malformed bean, shell and ear	5	2.1	Compliant
3.2 Bean fragment	5	0.0	Compliant
3.3 Broken bean	5	5.5	NC
3.4 Insect damaged bean	5	2.8	Compliant
3.5 Insect-infested bean	5	0.0	Compliant
3.6 Pulper-nipped bean; Pulper-cut bean		2.0	Compliant
4. Defects associated with visual appearance			
4.1 Black bean and partly black bean	6	2.1	Compliant
4.2 Black-green bean	6	0.0	Compliant
4.3 Brown bean (“ardido”)		0.0	Compliant
4.4 Amber bean		4.5	Compliant
4.5 Immature bean; ‘quaker’ bean	3	1.0	Compliant
4.6 Waxy bean		0.3	Compliant
4.7 Blotchy bean; spotted bean		0.0	Compliant
4.8 Withered bean	3	0.0	Compliant
4.9 Spongy bean	3	0.0	Compliant
4.10 White bean	3	1.5	Compliant
5. Defects mostly evident in cupping:			
5.1 Bean producing stinker or fermented flavors	1.5		Compliant
5.2 Bean producing other current offflavor			Compliant

**NC- non-compliant*

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Table 4.d. Gourmet Farm *Liberica* Grade 1 in comparison with standard

Parameters	PNS/BAFPS 01:2012	Gourmet Farm *Liberica* Grade 1	Remarks
	Max. % Defect for Grade 1	Actual % Defect	
1. Defects associated with foreign matter			
1.1 Stone	1	0.0	Compliant
1.2 Sticks	1	0.0	Compliant
1.3 Soil agglomerate	1	0.0	Compliant
1.4 Metallic Matter	1	0.0	Compliant
1.5 Foreign matter other than described	1	0.0	Compliant
2. Defects associated with non-bean matter coming from the coffee fruit			
2.1 Bean in parchment (pergamino)	1	0.3	Compliant
2.2 Piece of parchment (pergamino)	1	0.2	Compliant
2.3 Dried cherry (pod)	1	0.1	Compliant
2.4 Husk fragment	1	0.2	Compliant
3. Defects associated with irregular beans			
3.1 Malformed bean, shell and ear	3	0.7	Compliant
3.2 Bean fragment	3	2.6	Compliant
3.3 Broken bean	3	0.3	Compliant
3.4 Insect damaged bean	4	0.9	Compliant
3.5 Insect-infested bean	4	0.7	Compliant
3.6 Pulper-nipped bean; Pulper-cut bean		2.7	Compliant
4. Defects associated with visual appearance			
4.1 Black bean and partly black bean	4	0.3	Compliant
4.2 Black-green bean	4	1.2	Compliant
4.3 Brown bean (“ardido”)		0.0	Compliant
4.4 Amber bean		14.7	Compliant
4.5 Immature bean; ‘quaker’ bean	2	0.0	Compliant
4.6 Waxy bean		0.0	Compliant
4.7 Blotchy bean; spotted bean		0.0	Compliant
4.8 Withered bean	2	0.0	Compliant
4.9 Spongy bean	2	0.0	Compliant
4.10 White bean	2	0.9	Compliant
5. Defects mostly evident in cupping:			
5.1 Bean producing stinker or fermented flavors	1	0.0	Compliant
5.2 Bean producing other current offflavor			Compliant

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The following are the most notable results during the sorting of GCB per defect variation.

Figure 1. Representation of defects in GCB.
(A) Beetles and larvae; (B) Black beans; (C) Malformed beans; (D) Broken bean; (E) cherry (pod) and husk fragment; (F) Insect-damaged; (G) Stones as foreign matter

GCB Grading and Geographical Influences

The GCB grading results revealed geographical influences on variations, particularly in terms of defects associated with visual appearance and irregular beans. These findings resonate with studies by MacDonnell (2022), which suggest that factors such as altitude, soil composition, and environmental conditions contribute to the unique flavor profiles of coffee beans. Inadequate sorting practices, as identified in the study, may have led to the presence of insects, foreign matter, and defects that impact overall bean quality.

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GMP Audit Results

Table 5. Overall GMP compliance scores

GMP Parameter	Compliance Score	Non-Compliance Score	REMARKS
Surroundings	91.50	8.50	One (1) coffee processor area is not clear of rubbish and weeds
Condition of Equipment	91.50	8.50	One (1) coffee processor area has seepage of cleaning solvents; one (1) equipment is hard to disassemble for cleaning
Water Supply / Waste Management	100.00	-	Complied
Fermentation Shed	100.00	-	Complied
Drying / Conditioning Facilities	97.17	2.83	One (1) coffee processor is practicing drying on the ground
Building Facilities	100.00	-	Complied
Sorting and Bagging	95.29	4.71	Two (2) coffee processors don't have moisture measuring instrument
Storage	95.75	4.25	One (1) storage area is not well-ventilated, not stored on pallets and does not conform to least 40cm away from the walls
Conveyances and Transport	100.00	-	Complied

In Table 5, the data reveals the overall average compliance rate of 96.8%. Notably, the categories of Surroundings and Condition of Equipment emerged as areas requiring attention, while Building Facilities demonstrated a perfect compliance rate of 100% during the audit. The primary factor contributing to the lower compliance scores in the Surroundings category was the presence of debris in the production area. Regarding the Condition of Equipment, it was observed that effective clean-up and disassembly processes played a significant role.

Furthermore, the audit findings identified malpractices in the production and processing premises. Processors practiced drying in direct contact with the ground and the use of jute sacks as storage packaging material in the drying/conditioning facilities could lead to the contamination of CBG with foreign matter. Moreover, a number of processors neglected the monitoring of moisture content and lack the necessary tools, such as a relative humidity

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thermostat. The assessment of storage areas highlighted a prevailing lack of proper ventilation in some processors' facilities, which could potentially result in a fermented smell emanating from the beans. Lastly, some processors did not adhere to the recommended pallet distance of 40cm away from the wall.

GMP Compliance and Areas for Improvement

The Good Manufacturing Practices (GMP) audit revealed an impressive overall compliance rate of 96.8% among coffee processors in Cavite. However, specific areas, such as Surroundings and Condition of Equipment, emerged as needing attention. These findings are consistent with the study (Pranadikusumah et al., 2021), which emphasizes the importance of effective clean-up processes, infrastructure conditions, and pest control in coffee processing facilities.

Debris in production areas and the lack of proper clean-up and disassembly processes, as identified in the audit, may contribute to non-compliance in these categories. The audit results also highlighted the significance of adherence to recommended practices, such as maintaining proper pallet distances and using suitable storage packaging materials, to prevent contamination and ensure the overall hygiene of coffee processing facilities.

Implications for the Local Coffee Industry

The results of this study have important implications for the local coffee industry in Cavite. The identification of areas for improvement in moisture control, sorting practices, and adherence to GMP guidelines provides valuable insights for coffee producers and processors. Implementing automated sorting mechanisms, as recommended by previous studies (Boot, 2021), could address primary non-conformances in the bean processing industry and enhance overall quality control practices.

Additionally, the study's emphasis on geographical influences on GCB quality calls for a deeper understanding of regional variations in coffee production. Further research into the sourcing and blending practices of coffee varieties in Cavite could contribute to the development of strategies for achieving consistent and high-quality coffee products. The study's findings serve as a benchmark for both producers and consumers, guiding them in making informed decisions regarding the sourcing and selection of green coffee beans.

Summary

The research revealed variations in grade among the four (4) coffee variants originating from a single province. Significant contributors to these differences were the disparities in "defects associated with visual appearance" and "defects associated with irregular beans." Some coffee beans, including Arabica not harvested in Cavite, undergo preliminary sorting before roasting. This practice aims to enhance taste when mixed with Cavite-produced beans.

The moisture content analysis results indicated that 3 out of 5 coffee producers failed to meet the recommended range, highlighting challenges in maintaining ideal levels during processing and storage. Variations in moisture content underscored the need for improved control mechanisms to prevent issues like mold growth and off-flavors. The presence of insects in beans suggested inadequate storage and stacking practices. Monitoring favorable moisture levels is crucial for achieving high cupping scores, balanced acidities, and a great aroma.

Meanwhile, the audit reported 96.8% compliance with the checklist, conducted in both self-administered and researcher-administered manner.

Conclusions

This study aimed to evaluate the quality profile of green coffee beans (GCB) in Cavite, Philippines. It focused on key parameters: moisture content, GCB grade, and defects profile, while assessing compliance with Good Manufacturing Practices (GMP) by coffee producers and processors. Grading by defects revealed geographical influences on GCB variations, with altitude, soil composition, and environmental conditions contributing to distinct flavor profiles.

Inadequate sorting practices and intentional blending of non-local varieties complicated the grading process, emphasizing the need to investigate sourcing and mixing practices. The GMP audit showed 96.8% overall compliance, with attention areas identified as Surroundings and Condition of Equipment. Cavite GCB generally meets quality standards, though improvements for some producers are recommended to prevent foreign matter, posing a risk to food safety. While hygienic processing facilities are evident, external party audits are recommended.

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Recommendations

Implications for the local coffee industry in Cavite are significant. Areas for improvement in moisture control, sorting practices, and GMP adherence offer insights for producers and processors. Implementing automated sorting mechanisms, addressing primary non-conformances, and understanding regional variations can contribute to consistent, high-quality coffee. The study serves as a benchmark for decision-making in sourcing and selecting green coffee beans.

Future research may explore innovative technologies for moisture control and sorting processes, alongside an in-depth investigation into the impact of blending practices on coffee quality. The potential of automated sorting mechanisms to address non-conformances is highlighted. Exploring emerging technologies' efficiency, accuracy, and cost-effectiveness can enhance quality control and operational efficiency. Collaborative efforts among local coffee producers, regulatory bodies, and researchers can develop industry best practices, ensuring Cavite's continued growth as the Coffee Capital of the Philippines.

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