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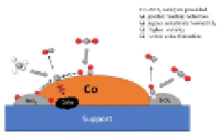

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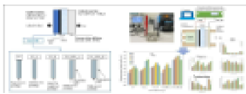

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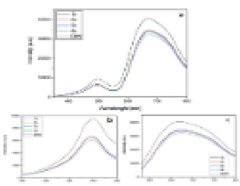

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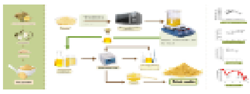

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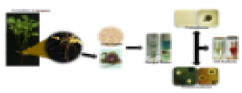

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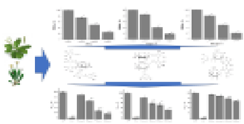

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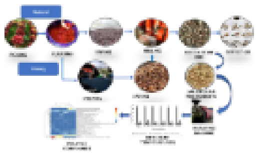

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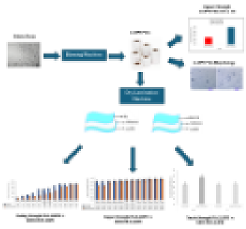

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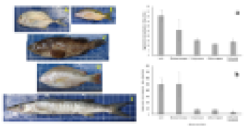

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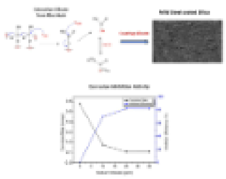

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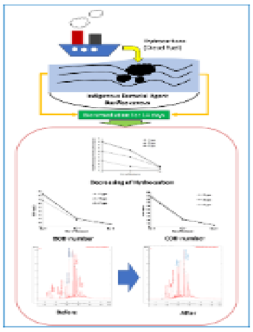

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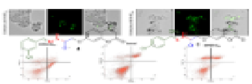

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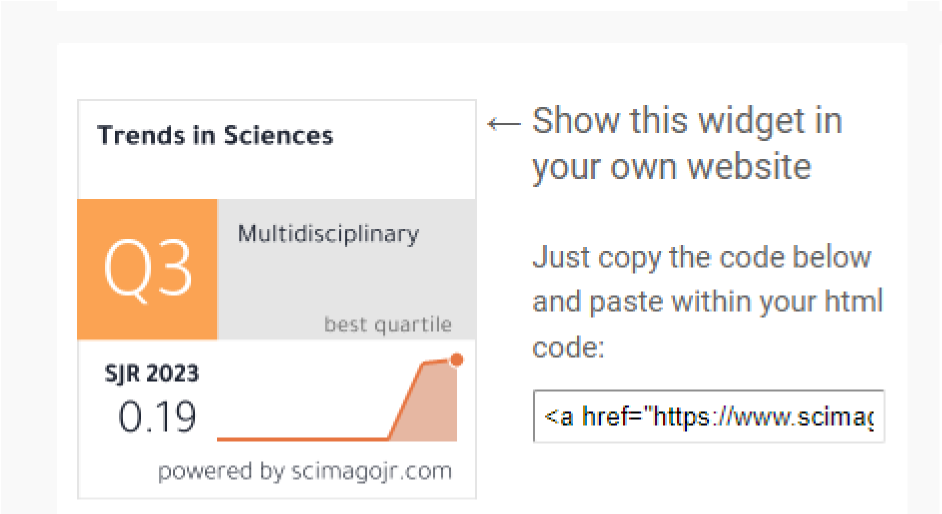
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Defects of Coffee Beans with Different Postharvest Processes and Roasting Temperatures on Volatile Compounds of Coffee Beans from Coffee Small-Scale Industries of West Lampung Indonesia

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Abstract

Specialty coffee is processed by performing high standards nationally (SNI) and internationally (SCAA). Good handling in the small coffee industry is essential to producing coffee raw materials as a refreshing drink. The aroma released from the best coffee beans gives an emotional flavor to the drinker - the aroma produced from the best coffee beans with different post-harvest methods. This study analyzed the physical quality of moisture content, coffee bean defects from dry processing post-harvest handling (natural and honey), and different roasting temperature differences to produce volatile compound profiles from three small-scale coffee industries. Six samples of raw materials from 3 small-scale coffee industries were selected by purposive sampling with the criteria that the processing farmer had performed SNI standards. Six coffee samples from the September harvest in 2022. Observations were made in the laboratory for analysis of moisture content and quality defects of coffee beans, then roasted by the industry and analyzed descriptively and multivariate analysis for volatile compounds. The moisture content of coffee beans from all coffee industries has met the requirements following SNI 01-2907-2008, that the moisture content is not more than 12.5 %. All coffee beans produced have 50 % potential as fine robusta coffee beans because they have no primary defects. Increasing the roasting temperature on all coffee beans increases volatile compounds. Coffee beans processed with honey produced more volatile compounds than the natural post-harvest method. The caffeine content in all post-harvest processing processes in the three industries has a difference in concentration due to differences in roasting temperature and time. The study that in the three-ground coffee small-scale industries processed by the natural post-harvest method, carbamic acid compounds were suspected to be from carbamate class insect pesticides (carbofuran) and the fungicide pyraclostrobin. Considering that pesticide residues harm human health, it is essential to implement measures to educate farmers to use organic fertilizers and ensure consumer safety.

Keywords: Coffee, Defect coffee, Fine robusta, Post-harvest, Roasting, Volatile

Introduction

Coffee is a refreshing drink that is currently in demand by most people of all ages, and every year new innovations are always found to create trends in coffee beverage consumption. The majority of Indonesian consumers (63 %) prefer to buy coffee at coffee shops every week [1]. This makes it a concern for industries engaged in the coffee beverage business in café shops to pay attention to the quality of their coffee. Seninde and Iv [2] stated that coffee flavor is the driving force for sustainable growth in the coffee business today. Volatile and non-volatile compounds and sensory aspects make coffee different from one another. Good quality coffee beans give the aroma of volatile and non-volatile compounds that consumers very well receive.

Quality coffee is very important to drive coffee demand for the world's coffee industry. Coffee quality is influenced by many factors, including coffee plant growth conditions [3], post-harvest processing [4], preparation variables (roasting time and temperature) [5], coffee bean defects [6,7] and moisture content [8].

Small-scale industries in West Lampung, Indonesia, have a role to play in providing raw materials for coffee shops. Coffee with a flavors advantage makes a niche market where consumers consider sensory attributes such as aroma, taste, body, and bitterness distinctive product attributes [9]. Small-scale industries perform post-harvest processing with dry processes, namely natural and honey (natural pulp). The post-harvest process of coffee is closely related to physical properties and chemical modifications that can affect the sensory quality of coffee and become a determining factor in achieving the desired quality standards

[10]. Small-scale industrial activities in rural areas are a form of small-scale participation in the coffee market that contributes to the sustainability of the coffee supply chain. The involvement of small-scale industries in this niche market provides desirable socio-economic, technological, and environmental benefits to coffee producers and improves the economy in communities [11-14] stated that post-harvest is a crucial factor in determining beverage quality, with an emphasis on harvesting red-picked fruits and drying methods of coffee beans. [15] added that the roasting process is essential for the coffee industry to perform correctly because many biochemical reactions occur in this process that are responsible for producing the flavor and aroma that characterizes the beverage from the industry.

In addition to the post-harvest process and the process of roasting coffee beans, other factors can affect the taste and aroma of coffee, namely the moisture content of coffee beans and coffee bean defects. The moisture content of coffee beans is used as a quality parameter in the coffee trading industry. The moisture content of coffee ranges from 8.0 - 12.5 %. A more than 12.5 % moisture content should not be traded because it can accelerate microbial growth during storage, causing bad taste and health risks. If the moisture content is below 8.0 %, shrinkage of coffee beans occurs, and the physical appearance is undesirable [16]. The physical appearance of good coffee beans and the absence of defects can produce high-quality drinks. The occurrence of coffee bean defects is an essential factor as a marker of coffee bean quality, as a high or low quality of the taste of the coffee produced [17]. The selection of coffee beans without major defects (black beans, brown beans, logs, mouldy beans, beans with many holes, and other materials) in this study, by SCAA standards [18] aims to obtain fine robusta coffee quality from the small coffee industry.

The coffee industry that pays attention to the quality of coffee beans aims to maintain the quality of coffee and the aroma produced. Coffee aroma is essential to consumers' emotional response when drinking coffee [19]. The selection of raw materials with different post-harvest processes gives different characteristics of volatile compounds. Handling of coffee bean raw materials to improve the physical quality of coffee beans such as moisture content, selection of coffee beans from inferior coffee, and selection of roasting temperatures to obtain volatile compounds that affect the level of consumer loyalty to consumers of coffee products [20,21]. The composition of volatile compounds from different post-harvest processing, storage is often used as the quality of coffee flavor.

Many studies have examined the volatile compounds produced from coffee beans based on differences in variety, roasting intensity of post-harvest differences [22,23]. However, there are still few studies on the physical parameters of moisture content, types of quality defects, differences in post-harvest dry processing methods (natural and honey), and differences in roasting temperatures and volatile compounds produced by small-scale coffee powder industries. This study analyzed the physical quality of moisture content, coffee bean defects from post-harvest handling of dry processing (natural and honey) and differences in roasting temperature to produce a profile of volatile compounds from three small ground coffee industries.

Materials and methods

The sample determination in the study was purposive sampling, the selection of samples on purpose. The selected sample is a small coffee industry that has been carrying out standard post-harvest processing since 2017. Green bean robusta coffee samples picked red from 3 small industries in Kebun Tebu District, West Lampung, Indonesia. Coffee bean samples consisted of 2 types of post-harvest methods, namely natural and honey from three small coffee industries, namely (1) Raosan_natural (R_N), (2) Raosan_honey (R_H), (3) Rope_natural (Ro_N), (4) Rope_honey (Ro_H), (5) TM_natural (T_N), and (6) TM_honey (T_H). Each coffee bean sample with post-harvest method treatment was 3 kg, so each small industries prepared 6 kg of coffee bean samples from the 2022 harvest season. Location of cultivation Coffee plants have an altitude of 900 m above sea level and are located in the Kebun Tebu sub-district of West Lampung. The planting location is in the HGU mountain Barisan forest area of West Lampung, with granular soil texture, soil acidity (pH) 4, and annual rainfall of 2000 mm/t. The planting location has an ambient temperature of 23 - 26 °C, with several types of shade trees, namely lirisidi trees, gamal trees, and green dadap trees.

Figure 1 shows that Coffee fruits from each coffee farm are processed with 2 post-harvest methods, natural and honey. The stages of the natural process are picking 25 kg of the red coffee fruit, floating the freshly picked coffee fruit with water aims to separate the nutritious coffee fruit from the inferior coffee fruit, Drying for ± 25 days, Peeling the coffee fruit skin with a huller machine (hulling), Selection of coffee beans, Fine robusta coffee (Sorting aims to separate good quality coffee beans with defective beans), Roasting coffee beans (adjusted to the small-scale coffee industry) with different temperatures, and Observation of volatile compounds in roasted coffee beans.

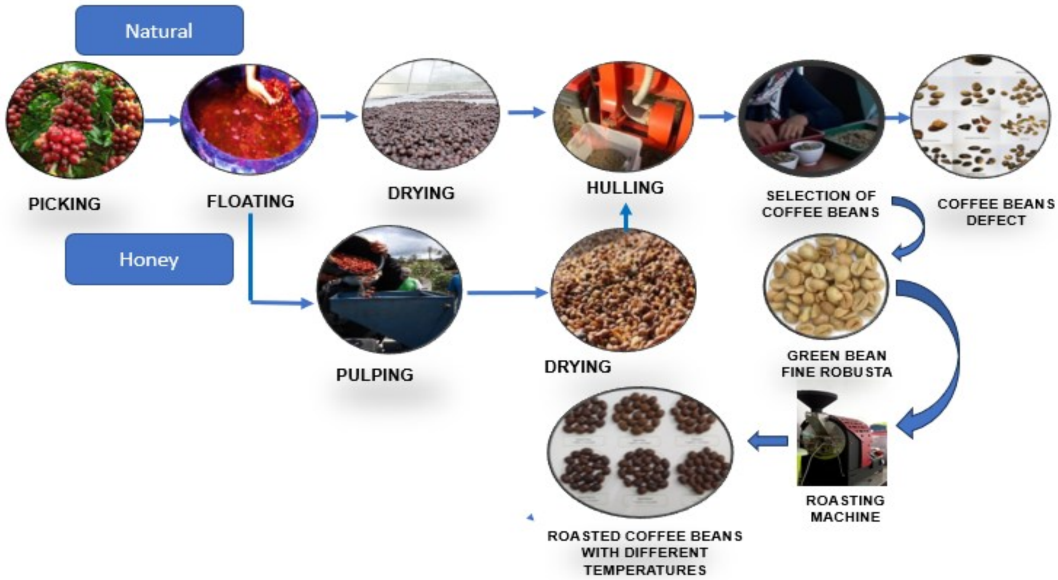

Figure 1 Postharvest methods with dry processing Natural and Honey from three small-scale ground coffee industries (Raosan, Rope, and TM).

The stages of the honey process are: picking red coffee fruit of as much as 25 kg, floating the freshly picked coffee fruit with water aims to separate the nutritious coffee fruit from inferior coffee fruit, Peeling the fruit skin with a pulper machine (pulping); Drying for ± 15 days until the moisture content is 12 - 13 %; Hulling (Peeling the coffee fruit skin with a huller machine); Selection of coffee beans; Fine robusta coffee (Sorting aims to separate good quality coffee beans from defective beans using the SCAA method): Roasting coffee beans (adjusted to small-scale coffee industries), and Observation of volatile compounds in roasted coffee beans.

Green coffee beans of each sample consisting of 6 samples were analyzed in preparation of raw materials for the roasting process. The first preparation is the preliminary treatment to analyze the moisture content of coffee beans by gravimetric analysis [24] and the second preparation is sorting coffee beans from inferior coffee beans. The Sorting of coffee bean defects aims to separate coffee beans with the main type of coffee defects (primary) (**Table 1**) and secondary defects (**Table 2**) and determine the quality classification based on **Table 3** by calculating using the form in **Table 4** according to Specialty Coffee Association of America (SCAA) standards [18]. The procedure for determining the number of coffee bean defects is as follows: As many as 350 g of green bean coffee samples are weighed and then selected and separated from the defective beans and impurities in the coffee samples that have been weighed. Then, the sample is placed separately in each cup. Furthermore, the defect value is calculated by summing the type of coffee defect with the defect value according to the form for determining the number of defects (**Table 4**). The final stage determines the quality grade criteria for coffee beans in the specialty/fine coffee and premium positions (**Table 3**).

Click or tap here to enter text. Furthermore, the roasting process was carried out with a temperature of 220 °C (Raosan natural), 226 °C (Raosan honey), 223 °C (Rope natural), 223 °C (Rope natural), 215 °C (TM natural), and 220 °C (TM honey). The temperature determination is based on the roasting process carried out by each small coffee industry.

The data collection stage of moisture content and the number of defect values were analyzed by variance (ANOVA). If the treatment is significantly different in the variance analysis, it is continued with the LSD test at the 5 % level. Meanwhile, the determination of fine/premium coffee grade was analyzed descriptively. Industry players conduct roasting, and during the data collection phase, GCMS tools are utilized to categorize volatile and non-volatile compounds in each sample. Volatile compounds obtained were analyzed descriptively and grouped based on the Hierarchical Critical Analytical (HCA) chart.

Table 1 Types and Values of Major Coffee Bean Defects (Primary).

No	Type of defect	Defect value
1	1 Full Black	1
2	1 Full Sour	1
3	1 Dried Cherry/Pad	1
4	1 Fungus Damaged	1
5	1 Severe Insect Damage	5

Source: Kosalos *et al.* [18]

Table 2 Types and Values of secondary defect.

No	Type of defect	Defect value
1	1 Partially black seed	1/3
2	1 partially brown bean	1/3
3	1 Horn-shelled seed	1/5
4	1 white seed	1/5
5	1 young seed	1/5
6	1 wrinkled seed	1/5
7	1 seed pod	1/5
8	1 broken seed	1/5
9	1 Hull/husk skin	1/10

Source: Kosalos *et al.* [18]

Table 3 Quality classification based on SCAA system.

No	Grade	Quality Requirements
1	Specialty/Fine grade	• Maximum number of defect values 5 • Free of major defect values • There are no young beans visible in the roast coffee beans (Quaker) • Cup Evaluation min 80
2	Premium grade	• Maximum number of defect values 8 • May have a major defect value • Maximum of 3 young (quaker) beans visible in roast beans • Cup Evaluation 79

Source: Kosalos *et al.* [18]

Results and discussion

The small-scale coffee industry in West Lampung has the potential to produce robusta coffee that has a high standard of quality (fine robusta coffee). In general, there are three scales of the coffee industry in Indonesia: Small-scale processed coffee, medium-scale processed coffee, and large-scale processed coffee [25,26]. Coffee that applies high standards has implemented post-harvest methods in accordance with the international standards of the Specialty Coffee Association of America. The first thing that must be considered is the physical quality, especially water content to maintain the quality so that the coffee beans are not attacked by mold during the storage process. The treatment of coffee bean separation based on quality defects is in accordance with SCAA standards [17].

The moisture content of coffee bean raw materials of three small-scale coffee industries

The small-scale coffee industry's coffee bean raw materials were observed for moisture content to determine the moisture content range to be processed into ground coffee. The gravimetric method was used to determine the moisture content of coffee beans in this study. Kyaw *et al.* [27] state that the gravimetric method is widely accepted as a reference for determining moisture content in all coffee trading countries. The moisture content produced by small coffee industries ranged from 8.68 - 11.63 % (**Figure 2**). The moisture content of industrial coffee raw materials is by SNI 01-2097-2008. Rodriguez *et al.* [8] and Adnan *et al.* [16] stated that the moisture content of coffee beans ranging from 10 - 12 % could prevent the occurrence of over-fermented processes that can affect the taste and cause lousy taste.

Figure 2 shows moisture content. The moisture content produced from small-scale coffee industries ranged from 8.68 - 11.63 %. The moisture content of industrial coffee raw materials is in accordance with SNI 01-2097-2008 [8].

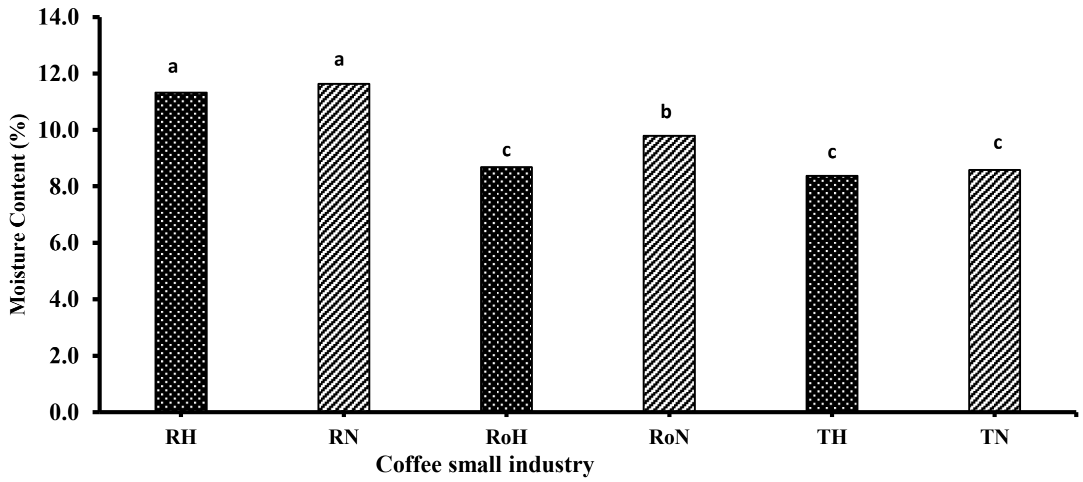

Figure 2 Moisture content in the raw materials of three small industries (R = Raosan, Ro = Rope, T = TM) with 2 postharvest methods (Honey and Natural).
Notes: 1) Each data analysis is the mean of 3 replicates ± standard deviation.
2) Numbers accompanied by different notations indicate significant differences (α = 0.05)

The moisture content in the Raosan (R) small-scale coffee industry with post-harvest methods (Honey/Natural) shows differences in the Rope (Ro) small-scale coffee industry with the Natural (N) post-harvest method, but for the Rope (R) industry the Honey (H) post-harvest method, the TM (T) coffee industry the honey and natural (H/N) post-harvest methods do not show differences in moisture content. The resulting moisture content of the small-scale coffee industry with the honey post-harvest method is lower than the natural post-harvest method. In honey post-harvest processing of coffee beans, the removal of cherry skin through a pulper machine accelerates the drying process, typically completed in about 15 days. In contrast, the natural processing method extends the drying time to around 25 days. The highest water content in the Raosan small-scale coffee industry Natural post-harvest method is 11.63 a, which is still low from the SNI standard of 12.5 %. Moisture content lower than 12.5 % can extend shelf life and mold growth [15].

Number of defective coffee beans from the raw materials of three small coffee industries

Coffee bean defects are one of the coffee bean quality standards to determine the grade/quality of coffee beans produced from three industries (Raosan, Rope and TM Coffee) based on Specialty Coffee Association of America (SCAA). Total defect~~s~~ values from the three industries produced ranged from 0.47 - 10.57. The highest defect values ~~was~~ were found in the Raosan (R) industry and the lowest in the industry T (TM) natural post-harvest method. The TM industry has consistently carried out post-harvest treatment in accordance with standards and Good Manufacturing practices, resulting in the lowest quality defects.

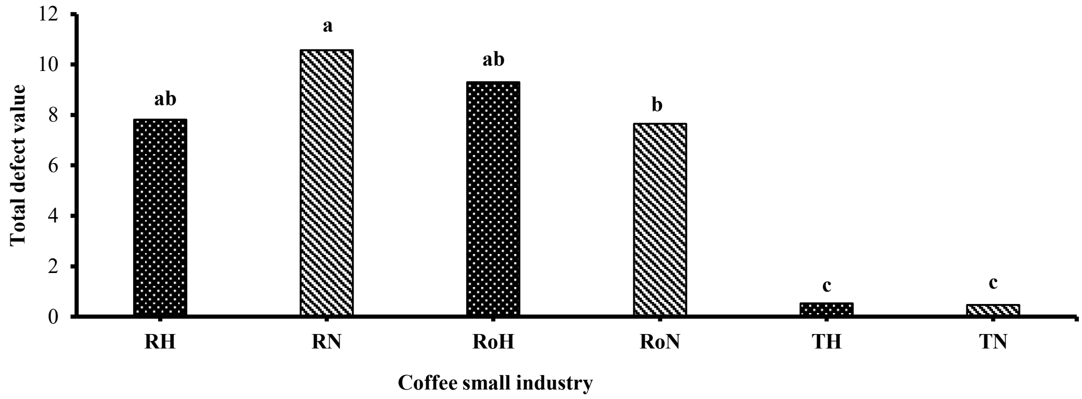

Figure 3 Total defect value in the raw materials of three small industries (R = Raosan, Ro = Rope, T = TM) with 2 postharvest methods (Honey and Natural).
Notes: 1) Each data analysis is the mean of 3 replicates ± standard deviation.
2) Numbers accompanied by different notations indicate significant differences ($\alpha = 0.05$)

Figure 3 shows the number of defect values in the three ground coffee industries based on SCAA assessment, in that the TM ground coffee industry has a defect value of less than 5 coffee beans. Data on the types of coffee bean defects in all raw materials used are taken from the first replicate data, not average data. Based on the calculation of the number of defective coffee beans, only the TM coffee industry has the potential to produce fine robusta coffee beans (**Table 4**). The range of defect values of natural and honey-processing coffee samples are 0.1 - 9.3 and 1.1 - 7.7, respectively; this is in accordance with Antezana and Luna-Mercado [28], which states that honey-processing provides better physical quality than natural processing.

Table 4 Number of quality defects and coffee quality grade of three SMEs (Raosan, Rope, and TM Coffee).

Sample	Type of Defect	Defect Value	Number of Items	Amount Defect Value	Grade
Raosan/Natural	Broken Seeds	1/5	8	1.6	
	Partially Black Seeds	1/3	12	4	
	Hollow Seeds	1/10	37	3.7	
				9.3	Premium
Raosan/Honey	Broken Seeds	1/5	11	2.2	
	Partially Black Seeds	1/3	4	1.3	
	Hollow Seeds	1/10	10	1	
	Hollow Seeds > 1	1/5	16	3.2	
				7.7	Premium
Rope/Natural	Broken Seeds	1/5	3	0.6	
	Partially Black Seeds	1/3	13	4.3	
	Hollow Seeds	1/10	11	1.1	
				6.0	Premium
Rope/Honey	Broken Seeds	1/5	1	0.2	
	Hollow Seeds	1/10	9	0.9	
				1.1	Fine

Sample	Type of Defect	Defect Value	Number of Items	Amount Defect Value	Grade
TM/Natural	Hollow Seeds	1/10	1	0.1	
				0.1	Fine
TM/Honey	Hollow Seeds	1/10	9	0.9	
	Broken Seeds	1/5	2	0.4	
				1.3	Fine

The total defect value is obtained from the defect value multiplied by the number of coffee beans. Furthermore, the number of defect values is summed up to get each sample's total number of defects. The value of 9.3 is obtained from Raosan natural, the summation of the defect value of broken seed (1/5) multiplied by the number of coffee beans (8) with the result of 1.6. and the number of second defect values obtained is 4, so the total number of defect values is 9.3. This value is adjusted to the type of defect value, such that the Raosan natural defect type has no primary defects (**Table 3**) and is classified as having a premium coffee grade because the number of quality defect values is more than 5.

The criteria for green coffee beans to get fine are the types of coffee bean defects: No black beans, brown beans, logs, moldy beans, beans with more than one hole, beans other than coffee/ranting, and stones. Based on **Table 2**, 50 % have the potential to produce coffee beans with fine robusta coffee criteria, namely TM natural, TM Honey, and Rope Honey. This research is by Analianasari *et al.* [29], farmers in West Lampung harvesting based on robusta coffee clones in natural, honey, and full wash processing produce fine robusta coffee beans. In contrast, 50 % have the criteria to produce premium coffee beans, namely the Rope natural, Raosan natural and Raosan honey industry. In the Raosan industry with the honey processing method, the primary defect of hollow beans is more than one. Tirfe *et al.* [30] primary defects play a significant role in the quality of green coffee beans. The results of the study are in accordance with what has been done by Analianasari *et al.* [31] that farmers who have implemented the processing process in accordance with GMP standards produce the best quality coffee (fine robusta). Coffee beans that contain primary defective beans (black beans, brown beans) produced by the coffee industry in Tanggamus, Indonesia, produce an unfavorable taste, green/grassy and slightly bitter [32].

Relationship between volatile compounds and roasting temperature (°C)

Before carrying out the roasting process, the small-scale coffee industry takes steps to homogenize the size of the coffee beans to produce uniform roasted quality to get excellent taste quality [33,34]. The roasting stage is one of the main processes that cause changes in the chemical properties of coffee [22].

Based on volatile compounds in different post-harvest processes in three West Lampung Coffee industries, they produce different volatile compounds. Volatile compounds are produced during roasting, which can determine the final aroma of coffee [35,36]. The aroma of Robusta coffee that has gone through the roasting process is analyzed using GCMS [37]. GCMS is an effective tool for analysing volatile compounds in controlling the roasting process. Natural post-harvest processing produces fewer volatile compounds than honey post-harvest (**Figure 4**). Different post-harvest methods produce bioactive compounds and affect the volatile compounds produced from specialty coffee [38].

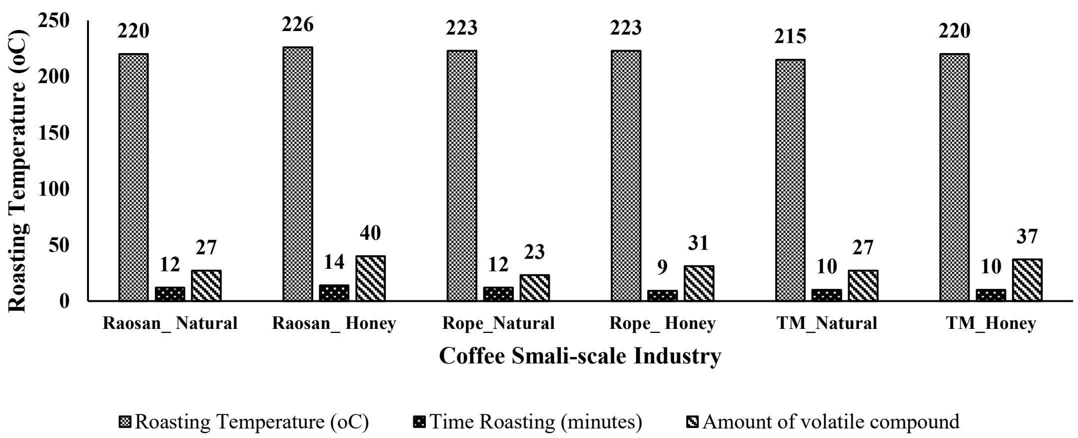

Figure 4 Number of volatile compounds in three small-scale industries with different postharvest processing.

Figure 4 shows that honey post-harvest processing produces more volatile compounds than coffee beans that have undergone the roasting process. Raosan coffee beans with honey processing provide more volatile compounds compared to natural processing. Different from other coffee samples, TM Honey contains p-ethyl guaiacol volatile compounds that give coffee a strong flavor [39]. The honey post-harvest method, characterized by high roasting temperatures, yields a greater variety of compounds. In the Raosan coffee, honey processing of coffee beans is roasted at a temperature of 226 °C and a roasting time of 14 min with a full city roast level. While the least volatile compounds (23) are found in IKM Rope with natural processing with a roasting temperature of 223 °C, a time of 12 min with a roasting level of city rose. The higher the roasting temperature, the more volatile compounds are produced [39,40]. This is in accordance with research [41] that volatile compounds in some soybeans at a temperature of 180 °C with a time of 25 min produce the most volatile compounds compared to a temperature of 160 °C at the same time. Oosterveld *et al.* [42] added that roasting conditions and time are determining factors in producing color, aroma, and taste characteristics and subsequently product quality.

Hierarchical clustering analysis

Figure 5 shows multivariate analysis using hierarchical clustering analysis (HCA) displayed through a heat map graph. HCA is a method to group similar samples into a cluster [43]. It can be used as an analytical method to distinguish coffee processing based on volatile components [44]. HCA successfully identifies different types of processing, namely natural (cluster A) and honey (cluster B). Cluster A is a sample high in caffeine and carbamic acid, while cluster B produces coffee low in carbamic acid. The results of this study indicate that the distribution of volatile compounds in coffee samples can be a way to distinguish coffee based on its processing type.

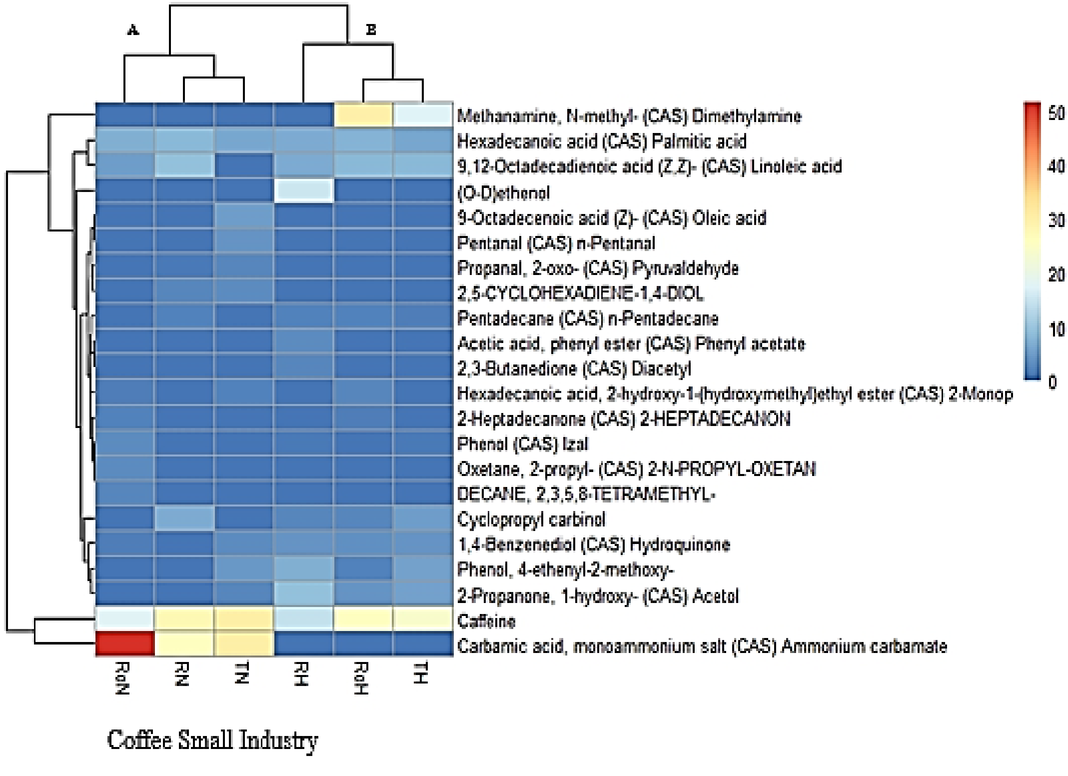

Figure 5 HCA graph of volatile compounds in three ground coffee products processed by three industries (Raosan/R, Rope/Ro, T/TM) with two dry processing (Honey and natural).

All samples contain palmitic acid, namely hexadecenoic acid (CAS), which is classified as an antioxidant and is also found in silver-skin coffee [45-46]. Korbecki and Bajdak-Rusinek [47] added that palmitic acid has a function as an anti-inflammatory and anti-cancer potential. Ground coffee processed by the Rope coffee industry with natural processing, the ground coffee industry from TM natural processing, and the ground coffee industry from Raosan with natural processing produces 2 components that are high in content, namely carbamic acid and caffeine. In honey processing, both the Rope, TM, and

Raosan coffee industries do not contain carbamic acid. However, in the Rope industry with natural processing, there is a carbamic acid content, which is the highest content in the sample, indicated by the red color. This carbamate content is thought to be from insect pesticide contamination, namely carbofuran (carbamate). Pesticide residues are thought to remain in plants and can pose a health risk due to their toxicity [48]. Carbamic acid is found on average in naturally processed coffee beans; this is thought to occur during the processing or drying process. [49] found Carbamic acid compounds hydrazine carboxamide in fresh coffee skin with a concentration (0.18 %). Carbamate compounds are thought to be derived from pyraclostrobin, which is found in pesticides [50] and fungicides in coffee leaf rust caused by Hemileia vastratic [51]. This finding is of particular concern regarding consumer safety for monitoring pesticide residues in roasted coffee produced by the industry.

Ground coffee produced by the Rope industry with honey processing is characterized by dimethylamine and caffeine. Dimethylamine compounds increased in concentration as the roasting temperature increased. The Raosan honey industry, with a roasting temperature level of 220 °C for 14 min, produces higher dimethylamine compounds, followed by the TM Honey industry, with a roasting temperature of 220 °C for 10 min. The TM industry with natural processing is characterized by oleic acid, which has a higher concentration than other industrial ground coffee. The Raosan industry with natural processing has linoleic acid characterizing compounds that are relatively higher than those produced by other industrial ground coffee. Roasting is the main process that causes changes in the chemical properties of coffee. The composition of volatile organic compounds, minerals and polyphenol content allows distinction between robusta coffee clones as well as different roasting intensities [22].

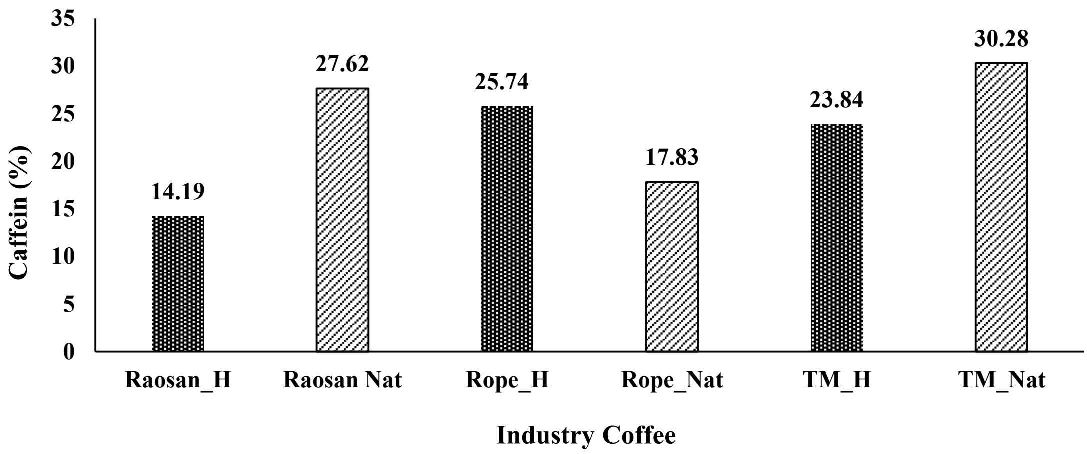

Figure 6 Non-volatile compounds (caffeine content) in 3 industrially processed ground coffee products (Raosan/R, Rope/Ro, T/TM) with 2 dry process processing (Honey and natural).

The caffeine compound (1,3,7-trimethylxanthine) is one of the main compounds contained in coffee and is one of the indicators of good or bad coffee [52]. Nugraha [45] stated that caffeine has a contribution to flavor. The caffeine content in **Figure 6** shows the highest caffeine content in coffee beans produced by the T (TM) industry with the Natural Processing process and the lowest in the Raosan Honey industry.

High concentration caffeine levels in all industries with natural post-harvest methods ranged from 17.83 - 30.28 %, while with honey post-harvest methods ranged from 14.19 - 25.74 %. There is a tendency for natural post-harvest method PSDs to have higher caffeine levels than coffee beans processed with honey post-harvest method. However, this result contradicts [53,54] which states that the post-harvest method does not significantly affect caffeine content. Another statement added that had no significant effect on ~~of~~ wet and dry processing on caffeine levels [55,56]. The difference in caffeine levels in the treatment of post-harvest methods is due to differences in roasting temperature. Hečimović *et al.* [57] states that caffeine is found in robusta coffee on average in the highest concentration of 20 %. There is a 30 % reduction in caffeine content during roasting. Different roasting process conditions affect the caffeine content in the study; this is in line with the study [58]. Furthermore, Anacona *et al.* [59] added that the amount of caffeine was significantly affected by the degree of roasting. The difference in caffeine levels shows that the honey post-harvest method provides lower caffeine levels than natural post-harvest. It is important to recommend to caffeine-sensitive consumers to use roasted coffee beans from the honey post-harvest process. Anacona *et al.* [60] stated that the honey post-harvest process also gave the best results on the cup profile.

Conclusions

This research describes the results of the small-scale coffee industry managed by farmers who can produce coffee beans that can be widely traded at the national and international levels. The moisture content of coffee beans is by SNI 01-2907-2008, which is no more than 12.5 %. As much as 50 % has the potential to be specialty or fine robusta coffee, which can provide the highest quality taste (> 80) because the coffee beans produced do not have primary bean defects. Honey processing provides better results by providing volatile compounds that are more removed from the roasting process, and non-volatile compounds (caffeine) are lower in concentration than natural processing. Finally, the study found that in the 3 ground coffee industries processed by the natural post-harvest method, carbamic acid compounds are thought to be from carbamate class insect pesticides (carbofuran) and the fungicide pyraclostrobin.

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