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Effect of Drying Methods and Load Volume on Microbial Contaminants and Cup Quality of Arabica Coffee

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Abstract

The effect of drying on bare concrete, portable drying beds, greenhouse-type dryer, and mechanical dryer at 10kg load/m^2 and 20kg load/m^2 of parchment coffee were assessed for microbial including ochratoxin *A* (OTA) contamination and cup quality. The shortest drying time of 40 hours was attained by mechanical drying. However, under sun drying, the shortest drying duration was attained from greenhouse-type dryer. Most microbial contaminants were isolated on the parchment coffee dried in all drying methods. Some were still associated on the green coffee beans but none on those dried in the greenhouse-type dryer. The fungal species identified were *Penicillium sp.*, *Saccharomyces cerevisiae, Fusarium xylariodes, Cladosporium cladosporioides, Aspergillus ochraceus, Aspergillus niger, Fusarium oxysporum* and *Mucor sp*. The dominant fungal species were *Penicillium sp.* and *Saccharomyces cerevisiae*. OTA was found on the parchment coffee dried by mechanical dying at 10kg load/m^2 and on bare concrete and portable drying beds at 20kg load/m^2. However, OTA was not detected in the green coffee beans. All the drying methods except for the bare concrete, produced specialty coffee while coffee dried at 10kg load/m^2 had better cupping quality.

Introduction

Arabica coffee (*Coffea arabica*) production in the Cordillera Administrative Region (CAR) is confined mostly in the highlands of Benguet, Mountain Province, Kalinga, and Ifugao due to the suitable climatic conditions of these areas (Agatep, 2018). Unlike the other coffee species C. Robusta (*C. canephora*), Excelsa (*C. excelsa*) and Liberica (*C. liberica*), which attain optimum yields on elevations as low as 600 meters above sea level, Arabica coffee yields better in elevations ranging from 900 to 1,200 meters above sea level (Winston et al., 2005).

The emerging trends on coffee consumers' preferences, such as organically-grown coffee and the proliferation of coffee shops for specialty coffee, require high quality green bean coffee. The identified constraints in producing quality green coffee beans (GCB) are poor production and postharvest processing practices.

In Benguet, coffee drying is mostly done through sun-drying by spreading the coffee on sacks laid over pavement or on concrete roads, Galvanized Iron sheets, or in winnows placed over their houses' roofs (Tad-awan et al., 2013). These practices are laborious and pose drawbacks, such as uneven drying and prolonged drying period, which may lead to fermentation that could adversely affect the coffee flavor. Moreover, there is the possibility of re-wetting the coffee due to unpredictable sudden rains and/or high humidity in some areas that favor the growth of molds. These conditions result in the deterioration and unfavorable flavors that negatively affect coffee cup quality.

Alvindia and Acda (2010) reported high fungal diversity in coffee beans from Benguet, Davao, and Cavite with 26 species from 14 genera of mycobiota. Their study found that the most common fungal species belong to Aspergillus and Penicillium, with some species found to be mycotoxin-producing filamentous fungi. However, the diversity of fungi in coffee beans, either after harvest, drying, or roasting, provides little information on the degree of mycotoxin contamination. With an end view of safety for consumers, fungal contamination in the different stages of coffee postharvest processing need to be assessed because their presence does not necessarily imply the existence of mycotoxins in coffee beans (Culiao & Barcelo, 2015).

Cross-contamination can also occur in various stages from harvest, postharvest processing, including drying and storage. Drying process is the most crucial stage where microbial contamination could develop. Thus, drying methods need to be evaluated to determine best practices for reducing or eliminating mycotoxin contamination of Arabica coffee beans. Hence, this study aimed to assess the effects of drying and load volume on the occurrence of microbial including OTA contamination, and cup quality.

Materials and Methods

This study was conducted at the Benguet State University Pine-based Arabica coffee farm, Puguis, La Trinidad, Benguet, Philippines, from January 2019 to May 2020. Harvested ripe coffee berries of the Red Bourbon variety were processed within the day following the wet or washed method. After washing, the parchment coffee were simultaneously subjected to the different drying methods and load volume.

Drying Methods

Bare Concrete (Fig.1.a)

A cement pavement. Wet coffee parchments were spread on the pavement every morning, then retrieved and kept indoors in the afternoon or when the sun no longer shines or at foggy conditions.

Portable Drying Beds (Fig.1.b)

The design was modified from the "all-weather dryer" developed by the Philippine Center for Postharvest Development and Mechanization. The dryer was constructed from Benguet pine wood with layers of plastic mesh and black net as flooring. It measures 2m long, 1m wide, and 0.76m tall. The roof was covered with transparent polyethylene plastic, and the roof was designed to be flexible that can be lifted when raking or retrieving the dried parchment coffee inside. The parchment coffees were left in the portable drying beds until the desired 11-12% coffee moisture content was attained.

Greenhouse Type (Fig.1.c)

This greenhouse measures 4m wide and 18.3m long, with walls covered with fine black nets and a transparent polyethylene roof. Drying beds inside were constructed from pine wood with black nets as floorings. The parchment coffee were dried until 11-12% moisture content.

Mechanical Dryer (Fig.1.d)

The dryer was fabricated based on the Maligaya flatbed dryer designed and developed by the Philippine Rice Research Institute. The drying bin measures 7.31m long, 3.65m wide, 1.5m high, and 0.46m deep. The floor was made of perforated metal, supported with steel frames. The panelized walls were made up of pre-cast concrete. Heat is supplied via a furnace using wood or hulls as fuel, and hot air is blown towards the drying bin by a tube-axial fan powered by a 12HP diesel engine. This dryer was continuously operated for eight hours in a day the coffee had reached 11-12% moisture.

Load Volume

This results to the layer thickness per unit area of fresh parchment coffee laid over different drying methods at 10kg and 20kg per square meter.

Temperature

The temperature at the different drying methods were monitored at a three-hour

Figure 1

Drying Structures: a) On Bare Concrete, b) Portable Drying Beds, c) Greenhouse-type, and d) Mechanical Dryer

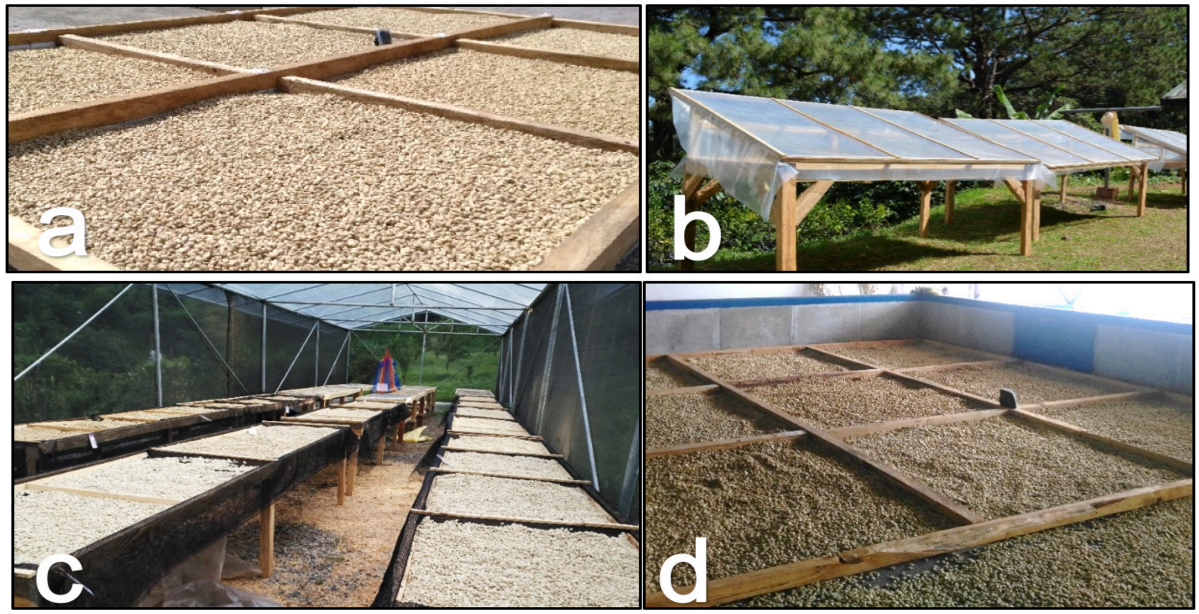
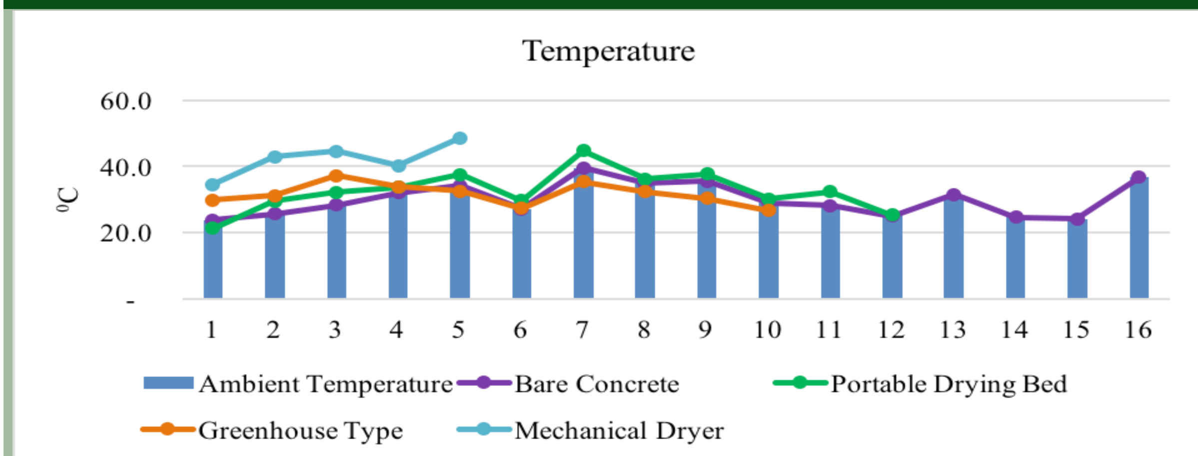


Figure 2

Mean Temperature and Duration (Days) of Drying at the Different Drying Methods



interval (9 AM, 12 NN, and 3 PM) using a digital thermohygrometer (Testo 608-H1) (Figure 2).

Moisture Content

Moisture content (MC) of green coffee beans were monitored at 9 AM, 12 NN, and 3 PM using a coffee moisture meter (*CoffeePro*) until the recommended 9.0-12.0% MC (Bureau of Agriculture and Fisheries Standards [BAFS], 2012) is attained (Figure 3). Initial moisture content of 52% was recorded from the wet parchment coffee.

Sunlight Duration and Intensity

In the sun drying methods, the actual duration of bright sunshine and sunlight intensity were

Figure 3

Coffee Moisture Meter

recorded using a light meter (Extech LT300) throughout the drying duration (Figure 4).

Isolation and Identification of Microbial Contaminants

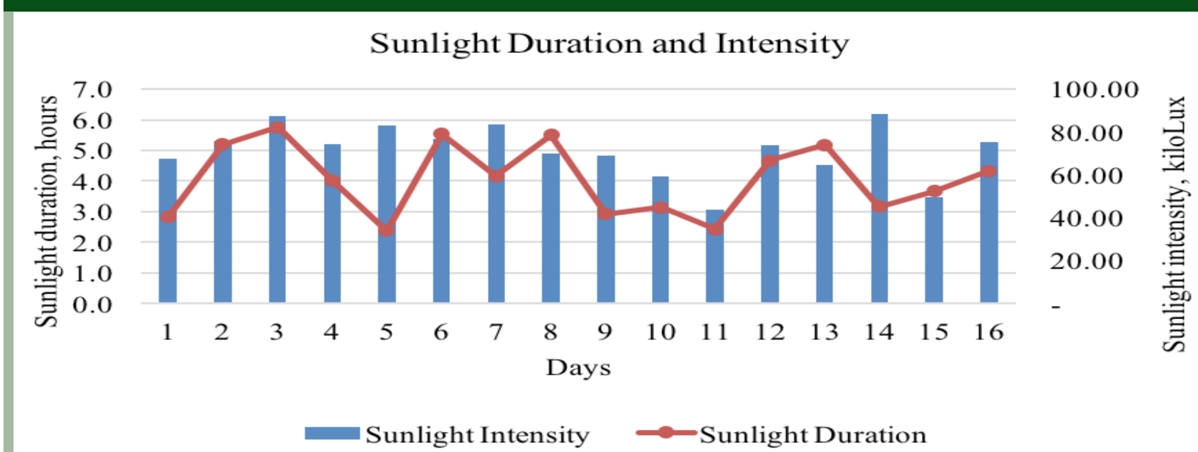
Fifty-gram samples of dried parchment coffee and consequently their green coffee bean (GCB) form were aseptically collected, placed in zip lock polyethylene pouches then brought to the BSU-Plant Health Clinic for the isolation of microbial contaminants. The samples were sterilized with 10% sodium hypochlorite (NaClO) for 30 seconds, rinsed three times with sterile distilled water, blot dried on sterile tissue paper, and aseptically transferred on the prepared Potato Dextrose Agar (PDA). Four whole coffee samples per treatment were loaded per plate with three replications. The Petri plates were sealed with parafilm and incubated for 5-7 days at 25 to 28 °C. Distinctive colony growths were separately sub-cultured on PDA while Malt Extract Agar (MEA) for yeast. Isolates were identified based on cultural and morphological characteristics. Cultural features were the colony color at the top and bottom of culture media. Morphological features were the septation of hyphae and fruiting structures, shape, color, and size of conidia cells. Identification of the isolates was based on previous works of authors for specific microbial isolates. Identification of *Aspergillus* spp. followed the procedures of Klich (2002); *Cladosporium* sp. by Braun and Schubert (2007); *Fusarium* spp. by Leslie and Summerell (2006); and *Penicillium* spp. based on the key published by Frisvad and Samson (2004). Identification of yeast was based on morphological standards recommended by Kurtzman et al. (2011). Photo documentation of the isolates in pure culture and microscopic structures were done.

Occurrence of Ochratoxin A

A sample of 100 grams each of parchment, consequently 100g from their GCB form were

Figure 4

Sunlight Duration and Intensity during Drying



aseptically placed in polyethylene bags then sealed. These were submitted to the Regional Feed Chemical Analysis Laboratory of the Department of Agriculture- Cordillera Administrative Region (DA-CAR) for the OTA analysis. The analysis was done through enzyme-linked immunosorbent assay (ELISA) following prescribed procedures of Veratox kits for Ochratoxin®, Neogen® Corporation U.S. The lowest limit of detection for Neogen® Veratox® is at 1.0 ppb.

Cup Quality Evaluation

Two kilograms of GCB from each treatment were roasted at a light level of roast using a hot air-type coffee roasting machine. The coffee cup quality evaluation was performed following the established Specialty Coffee Association (SCA) cupping protocol. A panel of three Q-graders conducted the cupping evaluation. The samples were scored in terms of fragrance/aroma, flavor, acidity, body, and balance. The descriptive and numerical scale of scores are as follows: Good: 6.00 to 6.75; Very Good: 7.00 to 7.75; Excellent: 8.00 to 8.75; and, Outstanding: 9.00 to 9.75.

Experimental Design and Statistical Analysis

The experiment was arranged in a two-factor, completely randomized design with three replications. Quantitative data were subjected to analysis of variance (ANOVA), and significant means were separated by LSD using GenStat 15th Edition software.

Treatments:

Factor A: Drying Methods
- D1- Bare concrete
- D2- Portable drying beds
- D3- Greenhouse-type
- D4- Mechanical dryer

Factor B: Load Volume
- L1- 10kg/m^2
- L2- 20kg/m^2

Results and Discussion

Drying Duration

Drying Method

Drying is done to efficiently decrease the high-water content of coffee to a safe level of 9-12% to get a stable, safe, and good quality product (Bureau of Agriculture and Fisheries Standards [BAFS], 2015). The drying time to attain 9-12% moisture significantly varied between the drying methods. Parchment coffee subjected to mechanical drying was the earliest to dry at 40 hours heating which took 5 (five) days, followed by the greenhouse-type with 54.5 hours (10 days), portable drying beds at 70 hours (12 days), while the longest was from the bare concrete at 94.5 hours in 16 days (Table 1).

The short drying time using mechanical drying could be attributed to the constant and higher temperature (42.6ºC) inside the drying bin; and, 8 hours continuous heating in a day Meanwhile, all the sun drying methods were simultaneously done, thus exposed to the same sunlight duration ranging from 2.4 to 5.8 hours and sunlight intensity which ranged from 44.0 to 88.20 kilo Lux (Figure 4). However, the portable drying beds had a higher mean temperature of 33.24ºC followed by 31.63ºC inside the greenhouse-type dryer while 30.01ºC on the bare concrete (Figure 2). Although the temperature inside the portable drying bed was higher than in the greenhouse-type dryer, the greenhouse-type dryer attained a shorter drying time. This result could be explained by the black net walls of the greenhouse-type dryer that is permeable to wind, which facilitated the exit of moist saturated air. On the other hand, drying on bare concrete exposed the parchment coffee to higher humidity and lower ambient temperature than the other methods.

Results of this study are comparable to some drying methods used in other coffee-growing countries and the drying time. In Ethiopia, coffee dried on a raised bed covered with mesh wire took 15 days drying period, while 13 days for coffee dried on brick terraces (Tsegaye et al., 2014). While in Brazil, sun-drying in pavements with shifting every 30 to 40 minutes took 6 to 7 days for washed coffees, 8 to 9 days for pulped naturals, and 12 to 14 days for natural (dry-processed) coffees (Coffee Research Institute, n.d.). For mechanical driers, drying time varies from 20 to 60 hours depending on the type of mechanical driers used (Ghosh & Venkatachalapathy, 2014).

Load Volume

Load volume and layer thickness significantly

(p=<0.001) affected the drying time with 10kg load/m² attaining the required moisture content at 56.75 hours which is 21.20% faster than drying at 20kg load/m² (Table 1).

Interaction Effect

Interaction between drying methods and load volume did not differ significantly. Though numerically, parchment coffee dried on bare concrete at 20kg load/m² had the longest drying time (103 hours), while the quickest drying of 32 hours was through mechanical drying at 10kg load/m² .

Microbial Contaminants

Eight (8) fungal species belonging to 6 genera were isolated from parchment and green coffee beans from the different drying methods and load volume. The highest occurence were from *Penicillium* sp. (38.30%), followed by *Sacharomyces cerevisiae* (31.91%). There were two species, each from *Fusarium* and *Aspergillus*, while only one from *Mucor* sp. (Table 2).

Generally, parchment coffee had more microbial contaminants than in the GCB form. Only the GCB from the greenhouse-type dryer at 10kg load/m² and 20kg load/m² were free from microbial contaminants (Table 3). *Penicillium* sp. and *Saccharomyces cerevisiea* prevailed in parchment and GCB from the different drying structures and load volume but none in the GCB

Table 1

Drying Hours as Affected by the Different Methods and Load Volume

Factors	Drying Hours	Days
Drying Method		
Bare concrete	94.5^{d}	16
Portable drying bed	70^{c}	12
Greenhouse-type	54.5^{b}	10
Mechanical dryer	40^{a}	5
Load Volume		
10kg/m²	56.75^{a}	8
20kg/m²	72.75^{b}	10

**Mean values with similar letter(s) in a column are not significantly different at 5% LSD.*

from the greenhouse-type dryer. Meanwhile, *Aspergillus niger* was found only in the parchment coffee dried from bare concrete and mechanical dryer at 10kg load/m². *Aspergillus ochraceus* was isolated from parchment coffee dried in a portable drying bed, greenhouse-type dryer, and mechanical dryer at 20kg load/m². *Fusarium oxysporum* was detected in the green coffee bean from the bare concrete dried at 10kg and 20kg load/m², yet it was not found on its parchment form. On the other hand, *F. xylarioides* was found on the parchment coffee dried at 10kg load/m² and on the parchment coffee and green coffee bean at 20kg load/m² from bare concrete. It was also detected on both parchment and green coffee

Table 2

Profiles of Fungal Isolates Associated with Drying of Arabica Coffee

Isolated Fungal Genera	Species of Fungus	Frequency (N=94)	Percent (%)
Penicillium sp.	Unidentified	36	38.30
Saccharomyces sp.	*Saccharomyces cerevisiae*	30	31.91
Fusarium sp.	*Fusarium xylariodes*	10	10.64
Cladosporium sp.	*Cladosporium cladosporioides*	9	9.57
Aspergillus sp.	*Aspergillus ochraceus*	3	3.19
Aspergillus sp.	*Aspergillus niger*	2	2.13
Fusarium sp.	*Fusarium oxysporum*	2	2.13
Mucor sp.	Unidentified	2	2.13
	Total	94	100

Table 3

Fungal Isolates Associated with the Different Drying Methods and Load Volume

Load Volume	Coffee Form	Drying Methods			
		Bare Concrete	Portable Drying Bed	Greenhouse-type	Mechanical Dryer
$10 kg/m^2$	Parchment	*S. cerevisiea, Penicillium sp., F. xylarioides, C. cladosporioides, A. niger*	*Pennicillium sp. C. cladosporioides S. cerevisiea*	*Pennicillium sp., S. cerevisiea*	*F. xylarioides, Penicillium sp., S. cerevisiea, A. niger, Mucor sp.*
	Green Beans	*S. cerevisiea, Penicillium sp., F. oxysporum*	*Pennicillium sp. S. cerevisiea, C. cladosporioides*		*Penicillium sp., S. cerevisiea*
$20 kg/m^2$	Parchment	*S. cerevisiea, Penicillium sp., F. xylarioides*	*Pennicillium sp. S. cerevisiae F. xylarioides, A. ochraceus*	*Pennicillium sp. S. cerevisiea, C. cladosporioides A. ochraceus*	*Penicillium sp., C. cladosporioides, A. ochraceus, Mucor sp., S. cerevisiea*
	Green Beans	*Pennicillium sp., F. xylarioides, S. cerevisiea, F. oxysporum*	*S. cerevisiea, Pennicillium sp., F. xylarioides, C. cladosporioides*		*S. cerevisiea, Penicillium sp., C. cladosporioides*

bean from the portable drying bed at 20kg load/m^2 and the parchment coffee from the mechanical drying at 10kg load/m^2. Meanwhile, *Mucor* sp. was found on the parchment coffee from the mechanical dryer at both load volumes.

The dominance of *S. cerevisiae* was expected as they were commonly found on wet-processed coffee for their role in the fermentation process (Silva et al., 2000; Masoud et al., 2004). In Thailand, Nasanit and Satayawut (2015) reported an increased number of yeasts after 24 hours of fermentation, where *Saccharomyces* were the most common along with *Candida, Pichia, Debaryomyces*, and *Kluyveromyces*. Likewise, *Penicillium sp*. was also present in all treatments allegedly because of their pectinolytic activity during fermentation (Martin et al., 2004; Mamma et al., 2008).

Occurrence of Ochratoxin A

Ochratoxin A (OTA) was found only on the parchment coffee dried at 20kg load/m^2 from the bare concrete (1.7 ppb) and portable drying bed (2.0 ppb). Meanwhile, 1.2 pbb of OTA was detected from parchment coffee dried in the mechanical dryer at 10kg load/m^2 (Table 4). However, OTA was not detected inthe green coffee beans. The OTA contaminations could be inferred to the presence of toxigenic microbial species, either *Aspergillus sp*. or *Penicillium sp*. However, the presence of the toxigenic microbes in some drying methods, without detected OTA contamination, could be attributed to either undetectable level or complete absence of the mycotoxin. Relative to the results, Pitt (2000) stated that *Aspergillus ochraceus* is thought to be the most important OTA-producing fungi in coffee. However, *Aspergillus niger* and *Aspergillus carbonarius* were found also to be potential OTA producers in coffee (Bucheli & Taniwaki, 2002; Frank, 2001; Joosten et al., 2001). Likewise, *Penicillium verrocosum* (Pitt, 1987) and *Penicillium nordicum* and *verrocosum* (Ostry et al., 2013) are also detected as sources of OTA.

Though OTA was detected only on the parchment coffee and the levels detected in this study are below the maximum limits of 5.0ppb, the results indicate the risk of OTA contamination during coffee drying. Thus, drying should be sufficient to attain the standard 9-12% moisture content at the shortest possible time. At 12% and below, the water activity (aw) is low at 0.67 to 0.7 which is

Table 4

Occurrence of Ochratoxin A as Influenced by Drying Methods and Load Volume

Load Volume	Coffee Form	Drying Methods			
		Bare Concrete	Portable Drying Bed	Greenhouse-type	Mechanical Dryer
$10kg/m^2$	Parchment	BDL	BDL	BDL	1.2 pbb
	Green Beans	BDL	BDL	BDL	BDL
$20kg/m^2$	Parchment	1.7 pbb	2.0 pbb	BDL	1.2 pbb
	Green Beans	BDL	BDL	BDL	BDL

Note: BDL = below detection limit
Maximum level for OTA is 5.0 ppb for food and spices (Codex Standard 193-1995)

adequate to protect the parchment coffee by preventing fungal growth. Moreover, the OTA-producing fungi can be present but incapable of producing toxin at aw <0.8 and cannot grow at aw 0.78-0.76 (BAFS, 2015).

Cup Quality

Drying Method

Coffee dried from the greenhouse-type dryer scored significantly high with 82.71, followed by coffee from a portable drying bed with 82.38, and mechanical dryer with 80.92 (Table 5). Following the Specialty Coffee Association (SCA) standards, coffee with scores ranging from 80-100 is classified as specialty coffee, while <80 is not a specialty coffee and referred to as commercial grade. Coffee dried on bare concrete had the lowest score, with 79.00. This result could be due to the prolonged drying duration leading to the development of off-flavors. Meanwhile, the elevated beds allowed free air movement through the mesh wire floors, promoting effective moisture loss and shorter drying period. Thus, maintaining the inherent quality of the coffee. These results are comparable with Tsegaye et al. (2014) findings that coffee dried on raised beds covered with bamboo mats and raised beds with mesh wire received specialty grade with overall cup quality scores of 84.25. Further, sun drying is an effective method of producing high-quality coffee under good ambient conditions (Musebe et al., 2007; International Coffee Organization [ICO], 2005).

Table 5

Cup Quality of Arabica Coffee as Influenced by Drying Methods and Load Volume

Factors	Cupping Score
Drying Method	
Bare concrete	79.00^d
Portable drying bed	82.38^b
Greenhouse-type	82.71^a
Mechanical dryer	80.92^c
Load Volume	
$10kg/m^2$	81.69^a
$20kg/m^2$	80.81^b

**Mean values with similar letter(s) in a column are not significantly different at 5% LSD.*

Load Volume

Arabica coffee dried at different load volumes significantly differed in cupping score. Coffee dried at 10kg load/m² had better cup quality scoring 81.69 than 20kg load/m², with an 80.81 score, although both coffee scores are classified as a specialty. This result indicates that drying at lesser volume hastens the drying duration and helps preserve the intrinsic qualities of the coffee. It conforms with the report in Ethiopia, that coffee dried with thin layer thickness took a shorter drying period, had a clean odor, and high mean total cup quality value (Tsegaye et al., 2014).

Interaction Effect

The interaction of drying methods and load volume significantly (p=<0.01) affected the cupping quality of Arabica coffee (Table 6). The coffee dried on portable drying beds at 10kg/m² load recorded the highest cupping score with 83.00. This method was followed by coffee dried from the greenhouse-type dryer at 10kg load/m² and 20kg load/m² with 82.75 and 82.67, respectively. Mechanical drying also produced specialty grade coffee whereas coffee dried on bare concrete at 20kg load/m² had the lowest score with 77.75, classified as below specialty.

The variation in cup quality could be due to the differences in the duration of drying. The prolonged drying could encourage the growth of molds and the absorption of undesirable odor which are inherently present in the concrete pavement. Coffee with scores below the specialty grade was described to have an undesirable odor like wet paper and chalky flavor. In contrast, coffee that had scored within the specialty grade had good aroma attributes.

Results concur with most studies on coffee post-harvest processing, which report better coffee quality from sun-drying using raised beds. Mekonnen (2009) and Beza (2011) revealed good physical and overall cup quality of coffee

Table 6

Interaction Effect among Drying Methods Layer Thickness on the Cup Quality of Arabica Coffee

Drying Method	Load Volume	Cupping Score	Attributes
Bare Concrete	10kg/m²	80.25[f]	Sweet fragrance with toasted nut, sugarcane, guava, rice bran/hay, papery and tamarind taste. The body is medium but has chalky after taste, tangy acidity and wet paper odor.
	20kg/m²	77.75[g]	Sweet fragrance with molasses, woody, vegetal, and toasted nuts taste. Light body or watery and tangy acidity with chalky aftertaste and wet paper odor.
Portable Drying Bed	10kg/m²	83.00[a]	Sweet fragrance and had muscovado, roasted corn, guava, mild caramel, rasp berry flavors. The body is smooth and medium. It had fruity wine like acidity with clean and no off odor.
	20kg/m²	81.75[c]	Sweet fragrance, chocolatey, citrusy, toasted bread, floral and rasp berry flavors. It had medium body with moderate brightness.
Greenhouse-type	10kg/m²	82.75[b]	Fruity aroma with muscovado, jackfruit, vegetal and mild black tea flavors. Body was smooth, rich with dried lemon feel or citrusy acidity. Clean with no off flavor.
	20kg/m²	82.67[b]	Juicy and sweet aroma, muscovado, malty, toasted bread, spicy flavors. Clean with no off flavor.
Mechanical Dryer	10kg/m²	80.75[e]	Sweet fragrance had roasted peanuts, caramelized sugar, guava flavors. It had citrus acidity, smooth and no off odor.
	20kg/m²	81.08[d]	Sweet fragrance with roasted peanut, arnibal, hay, citrusy flavors. It has fruity winey acidity but goes off as gets cold. Had smooth, light body and chocolatey after taste with no off odor.

**Mean values with similar letter(s) in a column are not significantly different at 5% LSD.*

sun-dried on raised beds with mesh wire, and Anwar (2010) reported similar results from drying using raised beds. It is in contrast to Sunarharum et al. (2018) who found out that mechanical drying produced higher quality green coffee beans and scored better than sun-dried coffee. Furthermore, the results of this study reveal that drying methods and load volume affect the overall cup quality of Arabica coffee.

Conclusions

The drying of Arabica coffee affects the presence of microbial contaminants, including OTA, cup quality, and profitability. Sun-drying using portable drying beds and spreading the parchment coffee in lesser load at 10kg load/m^2 resulted in less microbial contamination, very good cup quality, and the most profitable method.

The results reveal that drying duration among the sun drying methods was shorter using the greenhouse-type dryer at 54.5 hours but the mechanical dryer is still quicker at 40 hours. Similarly, drying duration was shorter by 21.20% when coffee is dried at 10kg load/m^2. Microbial contaminants were present in the parchment coffee from all types of drying methods and load volume. Eight (8) fungal species belonging to six (6) genera were identified, namely: *Penicillium sp., Saccharomyces cerevisiae, Fusarium xylariodes, Cladosporium cladosporioides, Aspergillus ochraceus, Aspergillus niger, Fusarium oxysporum* and *Mucor sp*. Ochratoxin A (OTA) was detected only in the parchment coffee, though below the maximum limit of 5.0 pbb, it indicates the risk of OTA contamination during drying. However, after the removal of the coffee hull, green coffee beans were negative from OTA. Meanwhile, drying using portable drying beds, greenhouse-type dryer, and mechanical dryer at either 10kg load/m^2 or 20kg load/m^2 produced very good cupping scores while drying on bare concrete at 20kg load/m^2 had poor cup quality.

Recommendations

Based on the result, using greenhouse-type dryer is appropriate considering the least number of microbial contaminants in the parchment coffee form and the total absence in its green coffee bean form and specialty grade cup quality.

Future studies should be conducted towards assessing other contaminants during the post-harvest processing of Arabica coffee, including but not limited to chemical and heavy metals contaminants. Moreover, the development of drying systems for small-scale Arabica coffee production can also be explored.

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