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Review Article

Coffee Quality, Processing Cost and the Capacity of the machine and limitation of the Machine during processing-A Review

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Abstract

Coffee firstly blossoms Ethiopia southwestern highlands Kaffa and gave its name to coffee. Coffee production, as well as postharvest operations can influence the quality of coffee beans. Now a day, the coffee processing machines is undergoing a great transformation in order to serve a consumer satisfaction that is becoming increasingly demanding with regard to good quality, lower processing cost with many amounts, and high processing capacity with minimizing machine related problems such as braking, appearance changing, moisture content level, and deflection. Considering the multiple determinants of the final quality of the coffee, one must consider factors that are involved in steps from the pre-harvest stage to end cup of the usage. The purpose of this review was to distinguish the quality of coffee processed by dry and wet processing machine, compare and contrast the cost consumed by machine and determine problems related with it. And also, to review the machine capacity which was developed by some researchers. The finding from the review shows that, wet coffee processing machine gives greater appearance, lower breakage of coffee bean and lower deflection and it can pulp 25-30 quintals/hours whereas the dry coffee processing can have 10 quintals/hours with equal power source. Jimma agricultural engineering research center developed dry coffee processing machine with shelling capacity of 88 kg/hr and department of agricultural engineering in Nigeria developed wet coffee pulping machine with pulping efficiency of 97.8%. In operating cost, wet coffee processing machine consume high cost than dry type having many processing steps. Hence, to increase the quality of coffee and identifying the cost required to process the coffee as well as knowing the capacity of the machine, it is important to review the quality of the coffee processed, cost consumed, the capacity and related problems which was performed by different coffee processing machine.

Keywords: Coffee quality, Coffee processing, Coffee processing machine, Capacity, Cost.

1. INTRODUCTION

Coffee is an important export commodity for Ethiopia. Coffee (*Coffea Arabica*) is a genus of flowering plants whose seeds, called coffee beans, are used to make coffee drink. It is a member of the *Rubiaceae* family. They are evergreen shrubs or small trees that grow approximately 5 m (15 ft.) tall when unpruned. Coffee trees are native to tropical Asia and Southern Africa.

Ethiopia is a major source of genetic resources for origin and diversity of Coffee Arabica. More than 1,000 years ago, coffee was a goatherd in Ethiopia southwestern highlands, David Beatty discovered the Ethiopian province where they first blossom Kaffa gave its name to coffee. Nobody is sure, exactly how coffee originally discovered as a beverage plant; it believed that its cultivation and use began as early as the 9th century in Ethiopia. Among the many legends, Kaldi, an Abyssinian goatherd, who lived around AD 850 found the origin of coffee. Ethiopia is well known not only for being the home of Arabica coffee, but also for its very fine quality coffee acclaimed for its aroma and flavor characteristics. Coffee is the most important cash crop for our country which ranked as the fifth trade commodity after wheat, cotton, maize and rice (*Selamta*, 2014).

Coffee production conditions, as well as postharvest operations, such as fruit selection, processing, drying and storage conditions, can influence the quality of coffee beans (Clemente *et al.*, 2015). In the pre harvest activity such as weeding and weed control as well as the use of foliar sprays based on fungicides or products that prevent the appearance of pathogens are important measures during the harvest since these techniques guarantee sanitary conditions as well as efficiency during harvesting (Ameyu *et al.*, 2017).

2. Coffee processing machine

2.1 Dry coffee processing machine

Dry coffee was processed by using different machine. Among these dehuller machine was exceptional to produce exact size and shape of the coffee beans from the coffee nut. These machines are used to remove parchment layer (endocarp) from wet processed coffee. Hulling dry processed coffee by dehuller machine was to remove the entire dried husk the exocarp, mesocarp & endocarp of the dried cherries. This machine is extremely efficient resulting in higher outputs with lower power consumptions.

2.2 Wet coffee processing machine

Pulper machine was used for wet coffee processing. In this machine the cherry was squeezed by the machine to remove outer red skin (exocarp) and the white fleshy pulp (mesocarp) and the separation of the pulp and beans. Immature cherries are hard and green and very difficult to pulp. For small-scale units, the cherries can be pulped in a pestle and mortar, this is very labour intensive.

The two most common pulpers and most suitable for small-scale units are the drum and the disc pulpers.

2.2.1 Drum pulpers

This involves a rotating drum with a punched sheet surface and adjustable breast plate between which the coffee cherries are pulped, the pulp and the beans separated. The distance between the drum and the breast plate has to be adjusted so that the pulp is removed without the beans being damaged. These can be manually operated or attached to a treadle or bicycle. For larger scale units motorized drum pulpers are available.

2.2.2 Disc pulpers

The same concept is involved with the disc Pulper. The only difference is that rather than the cherries being squeezed between a breast plate and a drum, a disc with a roughened surface is used.

Developed coffee processing machine and their capacity

Tamiru Dibaba *et.al.* (2019) developed dry coffee processing machine in Jimma agricultural engineering research. The machine was tested in the laboratory and field. The machine has maximum shelling capacity 88.10 kg/hr with clearance of 10mm between beating two drums and the recorded minimum mechanical damage of coffee bean with machine was 96.27%. So that the machine is best suitable for farmers who produce small coffee and use for local market.

Ogunlade *et.al.* Developed dry coffee processing machine in Nigeria. They tested the developed machine based on moisture content of coffee bean. They determined the moisture content of the coffee in the laboratory using conventional oven drying method and computed get at 4.6%, 9%, 13.8%, 6% and 8.4% moisture content, and then they determined a mean moisture content of 8.4% which were used in their evaluation. They also set the shaft speed at a constant speed of 300 rpm. Then they tested the machine and get the threshing efficiencies which were 78%, 85%, 89%, 80% and 84% and the capacity of the machine in g/sec and g/min are 860.1g/sec, 963 g/sec, 954.1 g/sec, 943.4g/sec, 1183.5 g/sec and 14.30 g/min, 16 g/min, 15.90 g/min, 15.70 g/min, 19.70 g/min respectively. The average threshing efficiency of the machine and the average capacity of the machine were 83% and 3532kg/hr (3.5tonnes/hr) respectively.

Cercado (2019), developed dry coffee de-huller machine. And he tested the developed machine based on de-hulling time rate for 1 kilogram of coffee beans. After the three trials of 1 kilogram of coffee bean it was found out that the meantime rate of de-hulling is 0.758 minutes. The data reveals that the coffee de-huller machine performs efficiently in terms of time rate used in hulling the coffee beans.

Gelgelo Kibi and Ashebir Hailu (2017) from Bako agricultural engineering research ceneter designed and developed dry coffee threshing machine. They conducted the experiment in a split- plot design having drum speeds in main plots, rear concave clearance in sub-plots with three replications as block. They determined optimum shelling efficiency of 93.80% at the drum was operated at velocity of 500 rpm with 2mm rear concave clearance; whereas the minimum shelling efficiency of 86.80% at the drum speed was 450 rpm with rear concave clearance of 6mm. they also determined the shelling capacity, mechanical damage and cleaning efficiency of the machine at this combination having 241.37 and 218.07kg/hr, 5.56 and 3.49%, and 88.13 and 87.59% were obtained, respectively. They concluded, from the

testing performance of the machine, it can be concluded that the machine can be used by the farmers to de-hull coffee at small scale level.

Kemeru Dalecha and Tamiru Dibaba (2018), from Jimma Agricultural Engineering Research Center developed wet small scale wet coffee pulper machine. For testing the machine, they selected different three sites. And they organized the participants in three FREG groups having 45 members. They determined the evaluation result of machine having pulping capacity of 173.06 kg/hour, 95.5% cleaning efficiency with relatively less grain breakage (9%) for the pulped wet coffee. They also determined perception response of the machine which has good cleaning capacity by 75.6% respondents and 24.4% ranked it to the medium performance. They have no respondent responded for its poor level of pulping capacity. The machine is also preferred for its minimum seed breakage, easy to operate and simple to transport. Generally, they collected feedback data from the farmers which have positively perceived the machine simply by observing its pulping efficiency (%), breakage percentage (%) and pulping capacity (kg/hr) of 95.5, 0.09 and 173.06 values, respectively as it has good performance compared to the local pulping method.

Devaraju and Gaji (2018) developed pedal operated coffee de-huller machine. The developed machines are used to remove the parchment layer from wet processed coffee; hulling method is extremely efficient resulting in higher outputs with lower power consumption. The friction between the coffee beans is less and hence there is no loss due to the generation of coffee dust or breakage and dry cherry coffee. The pedal operating coffee huller machine can be used for hulling both parchment and dry cherry coffee. This machine results in higher outputs with lower power consumption. This hulling method is extremely efficient.

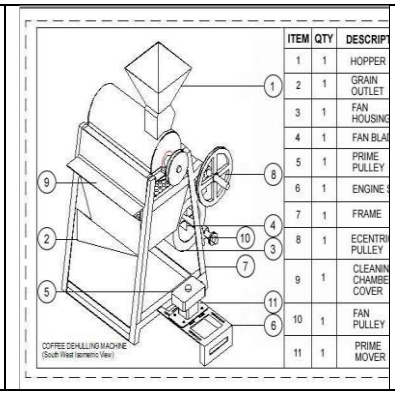
Adeleke *et.al*. (2017) developed small scale hulling machine for improved wet processed coffee. They used 3 HP petrol engine for operation. The machine was constructed from locally available materials at a relatively low cost and cheap running cost. The beaters are made from rubber strip which can deflect when in contact with any obstruction causing little or no stresses on drum members and reducing the risk of damage to both the beans and machine. The machine is portable and detachable which make it fit to be owned by a group of farmers who can move it from one farm to the other, making affordability and running cost easier.

Table. Coffee processing machines description

No.	Machine type	Company name	Machine functions	Capacity	Power required (hP)	Price (ETB)	Net weight (kg)	Related structures
		JM-ESTRADA PLC (Imported)	For wet coffee	5 qt/hr.		150,000	47	Fermentation tank Washing channel Drying beds
			For wet coffee	10 qt/hr	1hP	160,000		
		JM-ESTRADA PLC (Imported)	For wet coffee	25-30 quintals/hrs	2 electrical motor	500,000	70	Fermentation tank Washing channel Drying beds

		Mr. Tariku coffee processing PLC	For dry coffee	10 quintal/hr.	Electric motor with 2hP	85,000 ETB		
		AMIO-engineering PLC	For wet coffee	15-50 kg/hr. with handle,	By hand	25,000 ETB	< 25 kg	Fermentation tank Washing channel Drying beds
			For wet coffee	30-80 kg/hr. with 1 hP engine	1 HP motor	35,000 ETB		
		Jimma Agricultural engineering research center (*Tamiru et.al.)*	For dry coffee	88.10kg/hr with hand operation	By hand	-		

		Bako Agricultural engineering research center	For dry coffee	241.37 kg/hr. operated by engine	Engine operated	-		
		*Ogunlade et.al.*	For dry coffee	3532kg/hr (3.5tonnes/hr)	Engine operated	-	-	
		*Thuong et.al.*	For wet coffee	Can process with list cost	Electric motor			
		Devaraju and Gaji	For dry coffee	Can process in efficient manner	Pedal operated			

		Adeleke *et.al*	Dry coffee		10 HP			

3. Coffee quality associated with dry and wet coffee processing machine

3.1. Removal of pulp from the coffee

In pulping machine, the coffee was processed by mechanical removal of the pulp from the fresh cherry to have parchment coffee. The flesh and skin of the fruits are left on one side and the beans, enclosed in their parchment covering, on the other side. The lighter immature beans are then separated from the heavier, mature beans through specially designed washing channels or by shaking the beans through a strainer into a tank of water (Hicks, 2002).

Murthy and Naidu (2011), recommended that wet coffee processing machine (Pulper) is commonly preferred than dry coffee processing machine (Huller). These machines remove the skin and pulp from the coffee cherries leaving viscous mucilage adhering to the parchment. Mucilage is traditionally removed by the use of natural fermentation process where the natural micro flora degrades it hence facilitating its elimination by washing.

In some pulping machine after pulping, demucilation is carried out in demucilating machines in order to remove the mucilage that remains adhered to the beans. The removal is mechanical and occurs due to the friction between beans and the metal cylinder. In this apparatus, water is added in small quantities for lubrication and cleaning of the mucilage (Malta, 2011). The main advantage of using this equipment is the removal of part of the mucilage without using fermentation tanks; besides facilitating the work of movement and drying in the yard, by this method, the beans do not form agglomerates as they do in the pulped natural cherry process (Alves, *et al.*, 2013).

Where as in the huller machine, it includes the process of removing husk either from the dry parchment coffee or dry cherry in order to give the commercial green coffee. When the coffee gets to this stage, all intrinsic quality (moisture content, color) has already been obtained. The different sorting techniques to which it is subjected can only reduce its percentage of defects in coffee beans. Hulling is achieved by creating frisction among the beans lying along the screw of machine. It is crucial not to heat the beans during hulling otherwise it will affect the final color and taste of coffee. There is another final layer closest to bean, called as silver skin, which may or may not be removed during hulling process. For removal of silver skin, separate equipment following hulling called polishers is needed. The green bean received is then subjected for sorting according to density, size and color. This is a simple method, which does not produce high quality coffee (Wanyonyi, 1999).

Wickramasinghe (2001) also claimed that pulping (wet) method produce better quality green bean than hulling (dry) processing especially in case of Arabica coffee. This is due to the fact that dry cherry contains pulp and mucilage in contact with beans for longer time than dry parchment which means it needs sufficient drying period with more light intensity in order to reduce the moisture level to 12%. In case of dry parchment, the pulp and mucilage is removed within 24 hours and only parchment cover is remained which dries too fast even in low light intensity. The above statements claimed by two persons also support the researcher's opinion with regards to moisture content of bean processed by two methods.

3.2. Moisture content

According to International Coffee Council (ICC) Resolution number 420, for both Arabica and Robusta coffees, a moisture content range of 9-12% has been recommended in order to adopt the quality standards for exported coffees (ICO, 2004). If a moisture percentage below 12% has currently been received, coffee exporting members can work with set purpose in order to ensure that this level is maintained or decreased. Abebe and Tadesse (2015) determined the moisture content of the coffee processed after their research and then, the moisture content of coffee processed by the pulper machine was higher as compared to the huller machine.

3.3. Shape and color or appearance

The coffee produced pulper machine was better shape and makes appearance than the dry processing method or hulling machine (Musebe, *et al*., 2011). In the case of color and appearances the coffee processed by pulper machine, it was good as compared with hulling machine processed coffee, which is due to the bright bluish green nature of coffee (Ramalakshmi, 2007).

3.4. Drying

Tadesse recommended (2015), that dry cherry, containing pulp and mucilage in contact with beans in dry processing, needed longer time to dry than dry parchment in wet processing and the moisture content of sun dried samples was smaller. The bean size in wet processing methods is smaller, which could be because of higher shrinkage levels during drying. Bean size plays an important role for roasted whole coffee beans because many consumers associate bean size to quality; however, larger beans do not necessarily taste better than smaller ones.

3.5. Defection of the coffee beans

In grading the main objective is to determine the size distribution of the coffee along with the assessment of the defective beans and their color. Sensory evaluation focuses on determining the flavor profile while analytical measurements can determine moisture percentage, chemical composition and possible pesticide residues (Wintgens, 2004). Higher levels of defected beans were associated with the coffee processing activities from huller machine and this might be because of the presence of immature and broken beans. In the pulper machine processing on the other hand, resulted in very small defective beans (Musebe, 2011).

A further 13 defect types have been reported in the literature to classify coffee beans (Apaza *et al*., 2014).

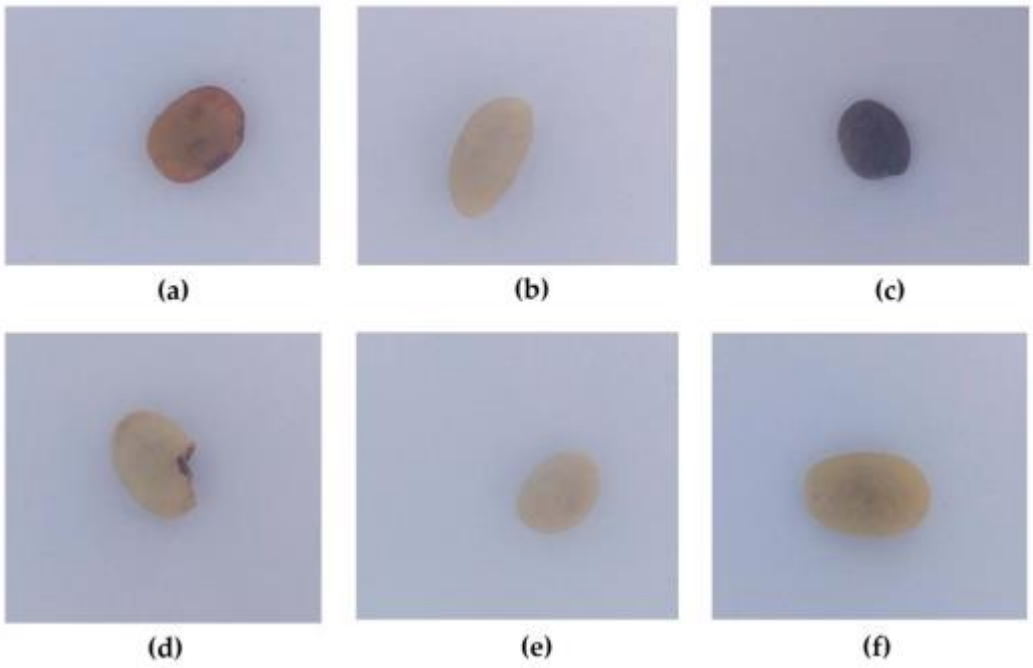


Figure 1. Coffee bean types: (a) sour defect type, (b) very long-berry defect type, (c) black defect type, (d) broken defect type, (e) small defect type, and (f) high-quality coffee bean. (Source: García *et al.*, 2019).

4. Coffee processing machine associated with cost

In dry huller machine, whole cherry is dried and when this is finished, the pulp and the parchment are removed in one single operation. This is simple method which includes less labour cost. The cherries are either sun-dried or machine dried with the outer fruit intact until the fruit gets moisture content of 12%. After drying they are de-hulled mechanically, producing beans that are characteristically lower in acidity, sweet, smooth and more complex in flavor than wet processed coffees. It is also a low cost processing method that does not demand expensive modern equipment like pulping machine (Wanyonyi, 1999).

Although there are fewer operations involved in dry processing than in wet processing, this method is more time consuming as drying cherries takes longer time than drying parchment. The risk of secondary fermentation is greater due to the presence of mucilage which is very hygroscopic (Coste, 2003).

On the other hand, the wet pulping machine is used to separate the pulp from the parchment. In this way slippery mucilage is exposed which is commonly removed by a process commonly called fermentation. This is followed by drying and washing of the beans in the parchment. Removal of parchment by hulling gives the clean coffee. The many steps in the wet method of coffee processing make it rather expensive but, if properly carried out, it gives a very high-quality coffee (Wanyonyi, 1999).

And also, Subedi (2010) concluded that, the economic analysis of two coffee processing methods was done by calculating ratio of benefit to cost for each processing method. Dry method of coffee processing had the higher benefit-cost ratio than wet method.

It is obvious that dry method of processing consists of fewer handling steps than wet method. It consists of drying and hulling steps. The cost of drying cherries is low. Hulling cost of dry cherry and parchment is same for both methods. The total gross return in this method is much higher than total costs. Therefore, the benefit cost ratio is high for dry method. The wet method consists of more handling steps (pulping, drying, hulling). The costs related to these steps are also high. Also, the return in this processing is slightly higher. Due to higher handling costs, the benefit cost ratio is low.

Tiwari (2009) in his report claimed that shifting from dry to wet method of processing has not only improved the quality of coffee but also increased the income of coffee growers. Higher return per unit of the produce (fresh cherry) received by farmers through selling of the fresh cherry at the pulping centers (wet method) has motivated farmers as an incentive to improve production and processing practices to some extent. The researcher agrees on above statement.

5. Problems with puling and hulling machine during coffee processing

Subedi (2010) concluded from his research on two methods and machines for the problems regarding to processing the coffee. He had summarized as follows by classifying as dry method and wet method processing.

5.1. Dry method (dehuller machine)

- The quality of coffee was comparatively found to be inferior to wet processing.
- Farmers did not pay attention to sorting and grading of fresh cherries according to size and color after harvesting.
- It took longer time for drying the coffee cherry to an acceptable level of moisture (11-12%) than dry parchment.
- It was found that the risk of secondary fermentation is high in dried coffee cherries.
- Poor ventilation was observed in a room where dry coffee cherries got stored.
- The silver skin attached to the surface of the green bean was also difficult to remove after hulling the dry cherries.
- At times when the weather is not favorable for drying, deterioration of cherries take place due to fungal attack rendering losses to the processors. Therefore, quality of dry processed coffee is weather dependent.

5.2. Wet methods (pulper machine)

- It requires more processing costs and there are no enough pulping machines in the coffee producing area.
- Farmers and processors did not have easy access for the loan to buy pulping machine.
- Fresh cherries had to wait more than 24 hours after harvest to de-pulp during peak season.
- The fermentation process was not properly followed to remove the mucilage from the parchment.
- Water scarcity was problem especially during pulping season because it needs high amount of the water to process and water pollution was also major issue
- Over and under drying of parchment was also problem.
- The processors also get lack of drying infrastructure (wire mesh tables).
- The harvesting of cherries is laborious and tedious. It incurs higher labour cost.

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