

A field survey on coffee beans drying methods of Indonesian small holder farmers

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Abstract. Drying agricultural product is a post-harvest process that consumes significant energy. It can affect the quality of the product. This paper deals with literature review and field survey of drying methods of coffee beans of Indonesia farmers. The objective is to supply the necessary information on developing continuous solar drier. The results show that intermittent characteristic of sun drying results in a better quality of coffee beans in comparison with constant convective drying. In order to use energy efficiently, the drying process should be divided into several stages. In the first stage when the moist content is high, higher drying air temperature is more effective. After this step, where the moist content is low, lower drying air temperature is better. The field survey of drying coffee beans in Sumatera Utara province reveals that the used drying process is very traditional. It can be divided into two modes and depend on the coffee beans type. The Arabica coffee is firstly fermented and dried to moisture content of 80% using sun drying method, then followed by Green House model of drying up to moisture content about 12%. The latter typically spends 3 days of drying time. On the other hand, The Robusta coffee is dried by exposing to the sun directly without any treatment. After the coffee beans dried follow by peeled process. These findings can be considered to develop a continuous solar drying that suitable for coffee beans drying.

1. Introduction

Coffee (*CoffeaSp*) is one of the famous agricultural products in the world. It is easily find in our daily life. According to International Coffee Organization [1], in 2016 the total coffee production in the world is about 9.09 million of tons. Indonesia is known as the fourth largest coffee producer in the world after Brazil, Vietnam, and Colombia. According to Ministry of Agricultural Republic of Indonesia, in 2016 Indonesia produces 667,655 tons of coffee [2]. Indonesia people consumed around 270,000 tons of coffee. The Indonesian coffee is mainly exported to USA, Germany, Japan, Italy, etc. Coffee production has a significant effect for economy growth of Indonesia. The main player of the coffee production in this country is small holder farmer. The small holder farmers produce up to about 95% of Indonesia coffee. Sumatera Utara province is known as a coffee producer in Indonesia. Not only in quantity but it also knew for the good quality of coffee. The arabica coffee from Mandailing, Lintong, Sidikalang regencies are known as arabica coffee of Indonesia with special quality.



Producing coffee from raw beans into roasted beans or coffee powder can be divided into several steps. In general, small holder coffee farmers practice the following coffee processing. The coffee cherry is piled-up usually for 2 to 10 days and followed by drying for 5 days. After this, it is heaped and dried again. The last drying process usually takes 10 days to meet moisture content of 11% to 20%. These steps show that drying process is a significant step in coffee process. Even though Indonesia is one of the biggest of coffee producers in the world, however, study on the drying process of coffee beans in Indonesia is very limited.

In this study, we perform a literature review on drying process of coffee beans and field survey of drying process practiced by small holder coffee farmers in Sumatera Utara province of Indonesia. As a note, our final goal is to develop continuous solar drier with integrated hybrid solar collector and desiccant as thermal energy storage. The developed drier will be tested for drying coffee. Thus, the present study is a first step for this study. The results are expected to supply the necessary information on developing the continuous solar drier for coffee beans.

2. Method

As stated above this studies consist of two types of review. The first review is a literature review on the reported study on drying coffee. The second review is a field visit to review the drying methods of Indonesian small holder coffee farmers. In the first review, peer reviewed reported studies related to the drying coffee will be reviewed. The review includes drying method, quality, heat and mass transfer mechanism. In the second review, a field survey is carried out in several regencies in Sumatera Utara province. The survey includes interviews to explore the drying time and barriers.

3. Results and Discussions

3.1. Drying coffee beans

Drying is a process to reduce the moist content of an object dried. This process is known and has been used by mankind since ancient era. Drying process of dried grape using solar energy can be tracked has been done by Greek in 1490 BC [3]. Drying is a simultaneous heat and mass transfer problems between drying media and the object as shown in Figure 1. In brief, the moist inside the object diffuses to the surface due to concentration difference. In the fluid-solid interface, the water evaporates into vapour and it will flow out with drying air. In addition, evaporation needs an amount of energy to supply latent heat of phase change of water into vapour. The need of energy for evaporation will be a driving force for heat transfer between the object and drying air. This fact shows that there are three different mechanisms occur at the same time, they are heat transfer, mass transfer and phase change. This process is also known as a significant energy consuming process [4].

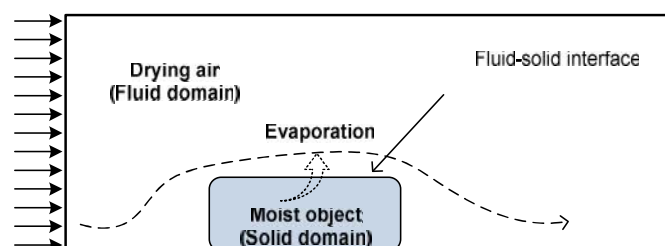


Figure 1. Heat and mass transfer mechanism in drying

Study on drying coffee had been reported by several researchers. Livramento et al [5] reported a study on the proteomic analysis of coffee grains exposed to different drying process. The objective of the study is to analyse the proteomic profile and identify differentially abundant proteins in coffee arabica L. grains subjected to two different drying conditions. The samples of coffee grains were collected from the municipality of Bom Sucesso, state of Minas Gerais, Brazil, from a plot at 1100 m altitude. Two different drying methods are natural coffee and pulped coffee dried with mechanical hot air drying at 60°C. It is observed that fruits dried in a dryer at 60°C showed an altered proteomic profile, with a reduction in the most abundant proteins compared to those yard-dried grains. The results show that post-harvest processes of the coffee quality are related to changes in protein abundance, indicating that proteomic analysis may be effective in the identification of biochemical changes in coffee grains subjected to different post-harvest processes. The study concluded that drying has been considered as one of the factors that cause impact on the final beverage quality. Ishwarya and Anandharamakrishnan [6] reported a study on spray-freeze-drying (SFD) approach for soluble coffee processing and its effect on quality characteristics. The SFD method is compared with spray-dried (SD) and freeze-dried (FD) methods. The analysed qualities are aroma, volatile, solubility, morphology, flow properties and colour measurement. The results show that different drying technique can affect the quality of the dried coffee. In their study, SFD technique can be potentially employed for the production of soluble coffee with improved product characteristics. Keinwachter and Selmar [7] investigated the influence of drying on the content of sugars in wet processed green Arabica coffees. It is well known that sun drying yields much better green coffee quality than machine drying. However, this conclusion was made based only on traditional knowledge and experience. Thus, the objective of their research is to elucidate the reasons for the putative quality differences between sun and machine dried green coffees. Two different drying methods are compared. The first method is continuous drying and the second method is pause method to mimic day-and-night-rhythm. The comparison quality is carbohydrates content in dried coffee. Dong et al [8] reported their study on the effect of different drying techniques on bioactive components, fatty acid composition, and volatile profile of Robusta coffee beans. There tested five different drying methods. They are room-temperature drying (RTD), solar-drying (SD), heat-pump drying (HPD), hot-air drying (HAD), and freeze drying (FD). The compared qualities are bioactive components, fatty acid composition, and volatile compound profile. The results showed that drying methods affect the quality of the dried coffee beans. All drying methods show significant differences in the contents of organic acids, total UNSFAs, and amino acids. However, the other parameters such as SFA, caffeine, and trigonelline content are not affected by drying methods. The HAD and HPD drying methods resulted in a significant alteration in the dried coffee bean volatile compound profile likely. This is because of the high temperatures and intensive ventilation treatments. Overall, the different metabolic responses to the drying methods resulted in the multiple metabolic association and clustering on the planes of PCA and heat map. The FD method is a good drying method that can be utilized to preserve fat, organic acids, and monounsaturated fatty acids. The HAD method is ideal for retaining polyunsaturated fatty acids and amino acids, whereas the HPD method produced the largest number of volatiles as well as the highest content of saturated fatty acids and ratio of unsaturated fatty acids to saturated fatty acids. The study suggested that the conventional drying methods can be effectively replaced by HAD or HPD methods in the future. Considering its drying efficiency, good quality retention and production cost, the HPD has the broadest market prospect for potential application.

Suzihaque and Driscoll [9] investigated the effect of solar radiation, buoyancy of air flow and optimization study of coffee drying in heat recovery drier. The objective was to develop an efficient heat recovery dryer and to investigate its performance so as to optimize design parameters.

Hernandez-Diaz et al [10] reported a study on modelling heat and mass transfer during drying of green coffee beans using prolate spheroidal geometry. Three-dimensional governing equation in prolate spheroidal coordinate system was solved numerically. The objective was to describe the drying of green coffee beans. The results showed that the method can provide valuable information about the moisture distribution profiles inside the grain during drying. It is suggested to use the model to design the optimal design of coffee driers. Burmester and Eggers [11] performed experimental work to investigate heat and mass transfer during the coffee drying process. The objective is to determine transport coefficient of the coffee beans during drying process. The experiments were performed using a hot air drying where the temperature and humidity were controlled. The results show that drying rate is mainly influenced by the temperature of the drying gas. Increasing drying temperature can be used to enhance efficiency of the process. However, sensitivity of the coffee beans should be taken into account. An increase of drying medium velocity does have an influence on the process, as long as drying medium becomes saturated. Lower relative air humidity has small impact on drying rate, but strongly affect the equilibrium humidity of the coffee. In order to optimize the drying process, the application of higher gas temperature at the beginning of the process and lower temperature at the end of the drying process is recommended. Putranto et al [12] proposed reaction engineering (REA) approach to develop mathematical modelling of intermittent and convective drying of coffee. Results show that the REA models the drying kinetics of coffee with well agreement between predicted and experimental data. The comparison with diffusion-based model, it is claimed the REA perform comparably or even better. Nilnont et al [13] performed finite element simulation for coffee drying to describe moisture diffusivity, shrinkage, equilibrium moisture content. It was shown that the mean diffusivity value of the coffee bean is $1.173 \times 10^{-10} \text{ m}^2/\text{s}$. The shrinkage of coffee bean is a linear function of moisture removal.

Those literatures reveal that the focus of the researchers can be divided into two groups. The first group focuses on the investigation on the effect of drying method to the quality of the dried coffee bean. The qualities of dried coffee beans can be expressed in several parameters such as qualities bioactive components, fatty acid composition, volatile compound profile, sugar content, etc. It is clear that drying method strongly affect the quality of coffee beans. Another valuable information can be drawn here is that the intermittent characteristic of sun drying results in a better quality in comparison with constant convective drying. This information can be used to develop an optimum sun drier. However, there is a very limited study on the effect of solar drier and the quality of the coffee. The second group of literatures focuses on the numerical solution to the heat and mass transfer during drying process. As a note, drying process consume a huge amount of energy to overcome the latent heat during evaporation. Thus, optimization of the drying process is extremely needed to develop an energy efficient drier. This is the main background to the second focus of those studies. The valuable information can be drawn from the second group is that drying process can be divided into several stages. In the first stage when the moist content is high, higher drying air temperature is more effective. For the steps where, the moist content is low, lower drying air temperature is better.

3.2 Drying methods of Indonesia smallholder coffee farmers

In this study, a field survey of drying methods that are used by Indonesian small holder farmers has been carried out. The survey is conducted in three regencies in Sumatera Utara province which are known as coffee producers. They are Dairi regency known as centre for “Kopi Sidikalang”, Humbang Hasundutan regency known for “Kopi-Lintong”, and Toba Samosir regency.

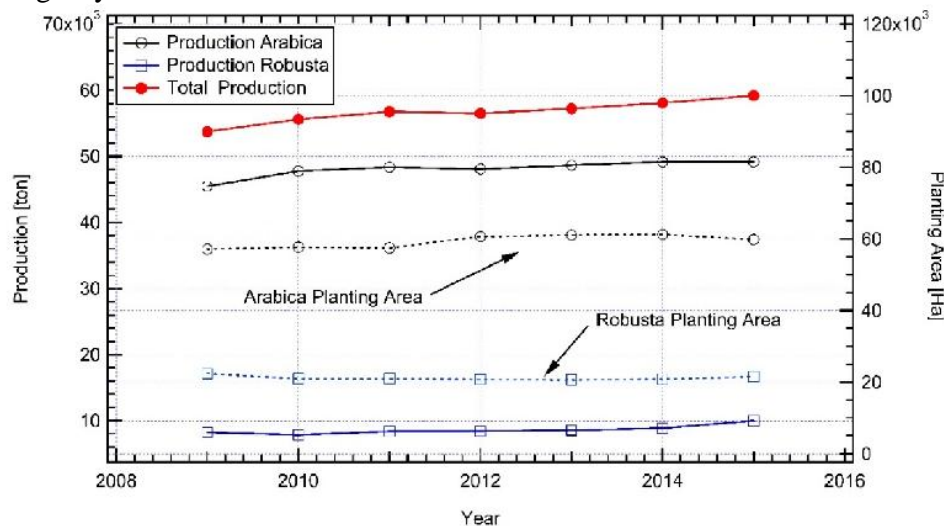


Figure 2. Production and planting area of small holder coffee farmers in Sumatera Utara province

Figure 2 shows production and planting area of small holder coffee farmers in Sumatera Utara province. It can be seen that the production and planting area of coffee in this province are almost flat. In other word, there is no significant change in production and planting. There are two types of coffee plants are found in Sumatera Utara province, Arabica and Robusta coffees. The production of Arabica coffee is the higher than Robusta coffee. In year 2015, the production of Arabica coffee and Robusta coffee are 49,176 ton and 10,022 ton, respectively. The productivity of Arabica coffee is higher than Robusta coffee. During the year 2009 to 2015, the productivity of Arabica coffee varies from 0.79 ton/Ha to 0.84 ton/Ha. On the other hand, the productivity of Robusta coffee varies from 0.37 ton/Ha to 0.46 ton/Ha. This productivity strongly affected by weather conditions during the production year. These values reveal that Arabica coffee is more productive than Robusta coffee. The ratio of Arabica coffee and Robusta coffee productivity is about 50%.

In the field survey in those three regencies, there is a clear different of drying method found in the farmers. The drying method and treatment depend on the type of the coffee. The data was collected from 20 farmers which are located in 5 villages (or Desa). They are Desa Sosor Lontung Kec.Sidikalang (Dairi regency), DesaLintong and Desa Sigumpar (Humbang Hasundutan regency), Desa Tampahan and Desa Parsoburan Tengah (Toba Samosir regency). The survey reveals that drying methods of coffee in this regency is categorized as a traditional method. It is sun drying method. There are several level drying methods are found. In the farmer level, for the Arabica coffee the used method is fully washed and the drying is performed after fermentation. In this step, the target of moisture content is only 80%. The farmers then sell the coffee beans to the dealer. In dealers, Green House drier is used to dry the coffee from moisture content of 80% to about 12%. The drying time usually takes 3 days

drying time. On the other hand, the Robusta coffee is treated differently as found in Sidikalang regency. The Robusta coffee is dried by exposing to the sun directly without any treatment. After the coffee beans dried followed by peeled process. The typical of drying process of coffee in Sumatera Utara province is shown in Figure 3.



Figure 3. Coffee beans drying method found in Sumatera Utara province

4. Conclusions

Literature review and field review of drying method of coffee in Indonesia small holder farmers have been performed. In the literature review it was shown that drying method influences the quality of cocoa beans. The intermittent characteristic of sun drying results in a better quality in comparison with constant convective drying. However, there is a very limited study on the effect of solar drier and the quality of the coffee. The numerical solution review shows that in order to use energy efficiently, the drying process should be divided into several stages. In the first stage when the moist content is high, higher drying air temperature is more effective. For the steps where, the moist content is low, lower drying air temperature is better. The field survey of drying coffee in Sumatera Utara province reveals that drying process is very traditional. It can be divided into two types depend on the coffee beans. The Arabica coffee is firstly fermented and dried to moisture content of 80% using sun drying method. Then followed by Green House model of drying up to moisture content about 12% and it typically spends 3 days of drying time. On the other hand, The Robusta coffee is dried by exposing to the sun directly without any treatment. After the coffee beans dried followed by peeled process.

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