Literary Review: Coffee Technologies

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Abstract. The following article is focused on technologies that can be used to increase or improve the production of coffee. In the modern days the most popular drink can be considered coffee. Its consumption is increasing each year with the increase of population of the planet. Therefore, it is important to use throughout the whole process of getting to the final product of coffee the best available techniques. The objective of this work is to review in the literature different technologies applied to coffee. Authors conclude that technologies that improve crop yields such as artificial intelligence are novel and need to be implemented. On the other hand, the production processes have robust machinery that is well known to coffee growers. Finally, the laboratory technologies to measure the phytochemical qualities of the coffee should be further refined to guarantee the results.

1 Introduction

Artisanal production falls short to supply the demand for coffee that has increased over the years worldwide. For this it is necessary to apply specialized equipment in the production of coffee. Thanks to technological advances this has become very feasible. This allows the application of specialized technologies to coffee farms for a faster production.

Soil spatial variability occurs naturally due to soil forming factors and processes and can be attributed to changes in relief, landform, or microclimate, leading to changes in vegetation cover and erosion deposition processes of materials that change soil uniformity [1].

The different technologies applied to coffee in its different stages ensure that this beverage is energizing for each consumer. Allowing to appreciate its qualities in taste and smell, so the objective of this work is to review in the literature different technologies applied to coffee. For coffee harvesting and instrumentation equipment authors has review in the literature to explain the development and advantage of these technologies. For industrial equipment authors have interview some of the Honduran coffee makers to understand the technologies implemented in the region.

2 Technological applications in coffee harvesting

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There are many processes within a coffee farm that can be made more efficient by using some type of technology to solve them. One of the most important processes within the coffee farm is irrigation. Irrigation is considered the key to ensure a stable and sustainable production in coffee plantations. Supplemental irrigation is often necessary to meet the water needs of coffee at different stages of growth. Using different technological equipment, it is possible to create an irrigation system that allows the application of water to the entire coffee plantation.

Fig. 1. Coffee harvesting

Generally, when carrying out the irrigation process on coffee plantations, it is necessary to use abundant water. Consequently, the waste or misuse of water is very common. However, through an irrigation system, the amount of water used can be just the right amount. This is very useful, since the availability of water for agriculture is progressively decreasing. The main cause of this is due to increased competition between different users. Therefore, the efficient use of resources is indispensable [2].

For this reason, several researchers have taken on the task of designing an automated irrigation system. The authors Flores Chávez & Rodríguez Castro, (2018) designed and implemented an automated drip irrigation system for coffee cultivation using microcontroller technology with a wireless control system [3]. Through this system it is possible to monitor the status of a tank for the supply of the water resource, the control of the closure and actuation of the electrovalves of the tank. This includes the current state of the coffee plantations through the feedback of their humidity and temperature. Similarly, the author Quispe Tapara, (2018) developed an automated sprinkler irrigation system for coffee nurseries using arduino technology. Seeking to attack the same problem, making use of low-cost technology and with great benefits [4].

Irrigation is not the only process that can be controlled in an automated way to have greater efficiency in coffee planting. In fact, throughout the entire process that coffee plantations go through it can become a controller. In the same way, several researchers have proposed to have control over the whole process of coffee plantations. In fact, the author Abad Alameda, (2016) developed a monitoring system of environmental parameters in coffee plantations. She designed a remote measurement or monitoring system, based on

the installation and operation of an automatic weather station [5]. The main action of the station is to remotely monitor the environmental conditions under which a coffee plantation grows. This is possible because the station is equipped with the appropriate sensors to measure the most relevant environmental parameters, including ambient temperature, relative humidity, solar radiation, and rainfall. It is also capable of monitoring the parameters of the soil where the plant is located, which are the temperature and humidity of the soil at 3 different levels. Plant parameters such as leaf moisture are obtained. Finally, with the monitoring of these parameters it is possible to determine the level of health of the plant and the level of productivity. This allows more precise decisions to be made to increase production.

Similarly, technologies with a higher degree of complexity are used. Such as artificial intelligence. Making use of automatic learning algorithms to help in certain problems or processes. The researchers Torres Caballero & Reyes Duke, (2020) developed a neural network for the detection of coffee leaf rust. Being one of the biggest problems in certain coffee plantations [6]. In fact, Central American countries have accounted for millions of dollars of up to 500 million dollars due to rust infections in their coffee plantations. For this reason, these researchers set themselves the task of detecting this disease through image processing. In this way, coffee farms can act against these pests that cause them so many losses each harvest period. These image processing algorithms are also often used for other applications within a coffee farm.

The researchers Serrano Fuentes et al., (2020) were able to determine the coffee fruit through artificial vision and a neural network. The system can classify a coffee fruit [7]. This allows coffee producers to reduce costs, time and even increase the quality of the final product. With the use of a deep learning algorithm, they were able to develop a system that can classify correctly, with an accuracy of 97.6%. Other implementations as robots for monitoring coffee harvesting can be part of a complete solution [8].

3 Industrial machines in coffee

The use of machinery in production has been gradually increasing. Since it facilitates and speeds up the entire production process. Machinery is generally used in the coffee drying and roasting process. Otherwise, the process can take up to more than a week, in the case of the drying process.

In the drying process, a type of machine commonly used is the rotary dryer. This is mainly because the coffee is uniformly distributed. The dryer can have different types of combustion systems, either gas, diesel, or husk-based equipment. It has drums that are assembled, minimizing disassembly and maintenance. In addition, the air distribution inside the drum is uniform. Another type of dryer that is used for larger quantities of coffee is the continuous column or vertical dryer with cross flow. In this type of dryer, the air flow is perpendicular to the flow of beans. This achieves particle reduction, with a low noise level and lower energy consumption per ton.

This type of crossflow dryer is the most widely used in the world, due to its popularity. This popularity is based on the simplicity of the principles of its construction and operation. Add to this the acceptable or moderate initial cost of the dryer compared to other types of dryers. These dryers are characterized, mainly, by the air flow that is perpendicular to a layer of grains. Each layer of grains is in constant movement between perforated plates. Generally, the most used commercial configuration and shape is the tower type.

Threshing is a process that separates the parchment husk from the grain, thus leaving the grain in gold. Roasting is the other process of coffee production where industrial machinery is used to increase production and at the same time obtain a better quality. The manufacture of machinery for the roasting of coffee varies according to the supplier,

including the level of control that it can have over the entire process. For example, the W140A coffee roaster is a roaster developed to have a high level of control over the entire process. W140A has a capacity of 140 kg per batch and can roast up to 560 kg/hr. It operates fully automatically. Operation is based on a natural gas and propane system. This coffee roaster also includes standard equipment such as a low stationary burner, low noise fans and drum speed control. In addition, the roaster operates with an external cyclone with an automatic chaff collection gate. In Figure 2, this threshing can be seen. Another type of industrial roaster is the TKM-SX 500 roaster, which, unlike the previous one, is based on an electrical system for its operation.

Fig. 2. Coffee thresher

4 Instrumentation equipment in coffee

Throughout the entire coffee production process what is sought is quality. To obtain the highest quality coffee possible, it is necessary to monitor or keep track of the final product as well as throughout the entire production process. For this reason, certain researchers have focused on the detection and follow up of these parameters, such as the aroma or fragrance of the coffee as a final product.

The flavor and aroma of coffee are often not well controlled due to the lack of a method to identify the standard odor. Researchers Thepudom et al., (2013) set out to classify the aromas of instant coffee. They used metal oxide semiconductors (MOS) as sensing materials to detect changes in coffee odor under different conditions [9]. They studied the factors affecting the taste and aroma of coffee using an electronic nose.

A schematic diagram of the e-nose is presented in Figure 3. The electronic nose (e-nose) is a device that plays an important role in odor evaluation due to its low cost and wide-ranging applications. Currently, e-nose is widely used in the food industry, such as coffee, wine, beer, etc. The e-nose is composed of a flow system, a sensor array, and data acquisition/analysis. It was found that the e-nose can distinguish different brands of instant coffee products and can classify coffee odors in different blends. The electronic nose has a sensor system consisting of eight commercial gas sensors, each of which was specially selected to detect coffee volatiles, these gases are hydrogen gas, organic solvent vapors, hydrogen sulfide, LP gas and solvent vapors.

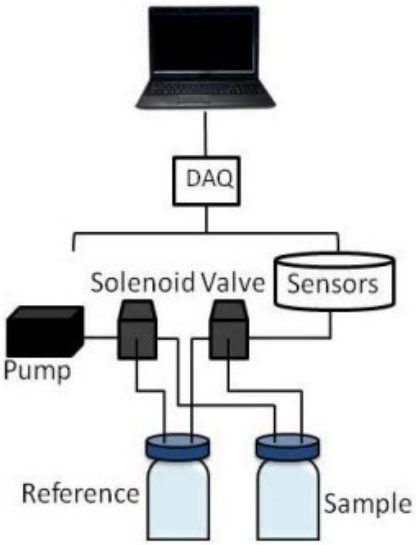

Fig. 3. A schematic diagram of the e-nose [9]

The authors were able to classify coffee into 4 different brands. This classification illustrates the effect of changing concentrations on coffee flavor, similar to the results mentioned above. The results reveal that concentrations and temperatures can affect the odor and quality of coffee.

Apart from the flavor and aroma or fragrance of coffee, it is also convenient to analyze other parameters, such as pH. In fact, Hendrawan, Widyaningtyas, et al., (2019) used machine or computer vision for the detection of purity, phenol and pH of Luwak coffee bean [10]. Because the computer vision method is a non-invasive biodetection method it can be easily used for the detection of these parameters. Image analysis consisted of using color features (red-green-blue, gray, hue saturation value, hue-saturation-luminosity, L * a * b *) and Haralick texture features with color matching matrix including entropy, energy, contrast, homogeneity, sum mean, variance, correlation, maximum likelihood, inverse difference moment and clustering tendency.

On the other hand, Rodrigo Santos et al., (2016) made use of infrared spectroscopy from a near position as an analytical tool for online monitoring of acidity during coffee roasting [11]. They focused on monitoring one of the main characteristics of the organoleptic profile of coffee, acidity, during coffee roasting. For the tests they roasted batches of arabica and robust coffee with varieties of different origins following different process conditions. Simultaneously, online real-time monitoring of the coffee roasting process was performed with near infrared spectroscopy (NIRS) using a diffuse reflectance probe. Spectral data were analyzed with chemometric tools and acidity profiles were estimated directly from NIR spectra. They demonstrated that NIRS is a reliable non-invasive technique for real-time monitoring of coffee roasting processes and can be used as a final roast signaling tool.

Similarly, the authors Chokkareddy et al., (2019) developed an electrochemical sensor based on lignin polymer nanocomposites for sensitive detection of chlorogenic acid in coffee samples [12]. For this purpose, they used an innovative nanocomposite of multi-walled carbon nanotubes (MWCNTs), copper oxide nanoparticles (CuONP) and lignin polymer (LGN) were successfully synthesized and used to modify the glassy carbon electrode for chlorogenic acid (CGA) determination. Cyclic voltammetry (CV) emphasized a quasi-reversible, adsorption-controlled, pH-dependent electrode procedure. The synthesized nanoparticles and nanocomposites were characterized by Fourier transform

infrared spectroscopy (FTIR), transmission electron microscopy (TEM) and X-ray diffraction (XRD) analysis. The developed sensor was successfully applied for the analysis of CGA content in coffee samples.

5 Conclusions

The work was done to outline some techniques that are used in lifespan of coffee making. Some commonly used and innovative methods were listed in this work. Technologies applied to coffee in its different stages have different impacts. Technologies that improve crop yields such as artificial intelligence are novel and need to be implemented. On the other hand, the production processes have robust machinery that is well known to coffee growers. Finally, the laboratory technologies to measure the phytochemical qualities of the coffee should be further refined to guarantee the results. If correctly carried out, these methods can positively effect on the quality of the coffee in it final stage.

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