Journal of Food Engineering 143 (2014) 123–131

Contents lists available at ScienceDirect

Journal of Food Engineering

journal homepage: www.elsevier.com/locate/jfoodeng

Pre-treatment of oil palm fruits: A review

Christine Jamie Vincent, Rosnah Shamsudin *, Azhari Samsu Baharuddin

Process & Food Engineering Department, Faculty of Engineering, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia

ARTICLE INFO

Article history:
Received 8 November 2013
Received in revised form 15 May 2014
Accepted 13 June 2014
Available online 8 July 2014

Keywords:
Sterilization
Palm oil
Dry-heating
Microwave-heating
Continuous sterilizer

ABSTRACT

The sterilization process in the oil palm mill is a crucial step in extracting and yielding good quality oil. However, this process requires a vast amount of steam to be released to the atmosphere and with that, several attempts in replacing the current steaming sterilization process by means of dry(oven) heating, microwave heating and the invention of a continuous sterilizer were carried out by researchers to provide a greener technology for this purpose. This paper reviewed among the methods and past invention proposed and it can be concluded that the oil yield and the quality depend very much on two major factors, that is the pre-processing conditions and the sterilization and extraction methods used. Bunch strippability is enhanced through the use of continuous sterilizers of low temperature subjected to the fruits. Thorough comparison studies should be done on the current sterilization method and the new techniques introduced since both the current and new methods gave equally good benefits.

1. Introduction

Palm oil is an edible, highly saturated vegetable oil that is commonly and abundantly used as cooking ingredient, especially in the food processing industries in Africa, Southeast Asia and in certain regions of Brazil. It is attained from the oil palm fruit's mesocarp (Hadi et al., 2009), primarily the African oil palm *Elaeis guineensis* and a lesser extent from the *Elaeis oleifera*, an American oil palm and the *Attalea maripa*, a maripa palm. Babatunde and Okoli (1988) stated in their study that the oil palm fruit is a drupe with a fleshy outer part called mesocarp that surrounds a hard core called palm nut. They also added that the fruits are prolate spheroid in shape and has a variation of 25–50 mm in length and about 19–38 mm in diameter.

Palm oil has the color of a rich, deep red which is said to be derived from its rich carotenoid contents, which are known as pigments often found in plants and animals. Palm oil is a viscous semi-solid and a solid fat in temperate climate because the major components of its glycerides are the saturated fatty acid palmitic. The viscosity of oil in room temperature (25 °C) is 77.19 mPa s and during the sterilization process (121 °C) is usually in the range of 4.9–5.1 mPa s (Anonymous, 2014). Besides that, there is also oil that is derived from the kernel of the same fruit, which is known as the palm kernel oil and it contributes about 10% of the quantity of palm oil produced.

2. Current method of oil palm processing in mills

In the Palm Oil industry, the palm oil is usually obtained by means of a string of processes in the mill that involves mechanical systems. There are many operation units in a typical mill. In summary, oil palm processing in mill involves the reception of fresh fruit bunches from the plantations, sterilizing and threshing of the bunches to free the palm fruits, digesting and mashing of the fruits and pressing out the crude palm oil, clarification, purification, drying and storage. For the kernel line, there are steps such as nut/fiber separation, nut conditioning and cracking, cracked mixture separation, kernel drying and storage (Poku, 2002). Kernel crushing facilities often existed in some integrated plants for the extraction of the crude palm kernel oil, which are then further treated to purify and to dry it for storage and export.

2.1. The sterilization process

The first step in the sequence of processes to extract the oil in palm oil mill is the sterilization process, which is a heat pre-treatment process subjected to the fruits. Pre-treatment refers to the solubilization and separation of one or more of the four major components of biomass-hemicellulose, cellulose, lignin and extractives: to make the remaining solid biomass more accessible to further chemical and biological treatment (Graf and Koehler, 2000). Pre-treatments are sometimes crucial in order to make material handling easier through subsequent processing steps. The sterilization process functions in supplying heat for fruits softening and encourage loosening and easier detachment of the fruits from fresh

* Corresponding author. Tel./fax: +60 389466366.
E-mail address: rosnahs@upm.edu.my (R. Shamsudin).

http://dx.doi.org/10.1016/j.jfoodeng.2014.06.022
0260-8774/

fruit bunch (FFB) stalks, prevents the rise of Free Fatty Acids (FFA) in the oil by inactivating the enzyme reaction especially since a study by Ngando-Ebongue et al. (2006) has also stated that palm mesocarp is one of the plant tissues that contain the highest amount of lipase, and also condition the nuts in the following cracking process (Vijaya et al., 2010; Olie and Tjeng, 1974; Mongana Report, 1955).

Malaysian Palm Oil Association (MPOA) has established that the Free Fatty Acid (FFA) content in Crude Palm Oil (CPO) for trading purpose must not exceed 5% (Nor'aini and Siew, 1990). Ngando-Ebongue et al. (2006) clearly stated in his study that it is of utmost importance that the fruits be heated immediately after harvest to inactivate lipase activity. According to another study by Sambanthanmurthi et al. (1991), low temperature is one of the other main factors that contributes to the in situ lipase activity of the fruit and therefore supports the fact that heat pre-treatment plays a very important role not only by increasing the freedom of the nut from the fibers but also as mentioned by Kandiah et al. (1992) that when heat penetrates into the pericarp of the fruitlets, it works in the inactivation of lipase enzyme that has the tendency to disrupt the quality of the palm fruits.

On the other hand, Poku (2002) described that the Free Fatty Acid (FFA) content of the oil in a fresh ripe and un-bruised fruit is below 0.3%. However, he also mentioned that the exocarp of the ripe fruit will turn soft and is prone to be attacked by lipolytic enzymes, giving rise to the FFA of the oil through hydrolysis, especially at the base when the fruit becomes detached from the bunch. Research has also shown that the FFA in the damaged area of the fruit tends to increase rapidly when it is bruised (Rajanaidu and Tan, 1983). Therefore, depending on how bad the bruising is, there is a great variety in the composition and quality within the bunch. Numerous studies are also done in research centers to study the various types of oil produced from these breeds, and from different parts of the fruitlets, mainly the mesocarp and the kernel.

The total weight and the maturity of the fresh fruit bunch (FFB) is what usually defines the sterilization cycle. With the use of saturated steam at 40 psi (140 °C) for 75–90 min (Sivasothy, 2000; Chow and Ma, 2007), the sterilization process is currently carried out in batches (Let, 1995; Sivasothy, 2000) to deactivate the biological factors that are mainly responsible for the deterioration of the oil quality (Let, 1995). Heat also encourages the breaking up of the oil bearing cells of the fruit mesocarp to release the oil during the digestion process (Mahidin, 1998). Inadequate sterilization affects the subsequent milling processing stages adversely.

However, Hadi et al. (2012) mentioned in his studies that, to ensure complete heating up till the inner layers of the bulky fresh fruit bunches (FFB), lengthy steaming period and vast quantities of steam used is compulsory. The batch process of the sterilization process is slow and inefficient because much heat is used to heat up the sterilizer cage, also absorbing large portion of the manpower in the mill (Sivasothy, 2005). Tan et al. (1999) also claimed that there were also other losses reported in association with a steam heating process. Latest development of new sterilization processes focuses on producing a continuous sterilization process (Sivasothy et al., 1993; Loh, 1994; Chow and Ma, 2001). Apart from that, it was also observed in a study by Ma (1999), that large amount of steam used is released during the sterilization process, while a portion of the steam is released as sterilizer condensate, forming parts of the Palm Oil Mill Effluent (POME). Stringent requirements of the discharge standards by the Malaysian Department of Environment (DOE) require complicated and rigorous treatment of the discharge.

Past studies on the inventions of continuous sterilizers, sterilization by means of microwave and oven heating were studied in order to further improve the effectiveness of the sterilization process by replacing the steaming method. The huge avail of the technology used in a conventional palm oil mill can be accredited to the compendious research that was carried out in Congo in the 1950s as reported in the Mongana Report (1955). However, to date, there is still no significant technology or modern process in relation to the oil extraction process that has been practiced since the 1960s. As the years passed by, there is the need for the Malaysian palm oil industry to be on par to cater to new challenges, including a much strict environmental protocols, labor scarcity and competition from other palm oil producing countries. The palm oil industry in Malaysia is highly reliant on immigrant workers due to the acute labor shortage (Sivasothy et al., 2006).

3. Methods of pre-treatment to replace the sterilization process

There are various exploratory studies by researchers on the attempt to replace the currently practice sterilization process by means of steaming in oil palm mill, such as the invention of a continuous sterilizer, as well as, sterilization by means of microwave and dry (oven) heating with the combination of a solvent extraction method to extract the oil from the palm mesocarp.

3.1. Continuous sterilizers

In the conventional milling process, bunches are cooked in batches at 40 psig steam for a period of 70–90 min (Sivasothy et al., 2005). The process hinders oil quality deterioration owing to the biological enzymatic factors and it also helps fruits stripping from bunch stalks and the oil and kernel extraction (Mongana Report, 1955). Continuous processing for batch/conventional sterilization is hard to achieve due to the use of high pressure steam with alternating pressure discharges which is paramount to accomplish good sterilization. Numerous techniques have been proposed for a continuous sterilization system (Mongana Report, 1955; Sivasothy et al., 1993; Loh, 1994; Olie and Tjeng, 1974) but none has proven to be 100% effective and at the same time being economically viable. However, there are recent efforts on converting the palm oil milling technology and this new process was pioneered by the Malaysian Palm Oil Board (MPOB) (Sivasothy et al., 2006).

Fig. 1 illustrates the latest invention of a continuous sterilization process system. Laboratory-scale and pilot-scale studies (Sivasothy and Rohaya, 2000; Sivasothy et al., 2000, 2002, 2005) established the mechanical and economic viability of the new process and later on, a commercial-scale system was constructed in the Malaysian Palm Oil Board (MPOB) Palm Oil Mill Technology Centre (POMTEC) located in Labu. Based on the study of a continuous sterilization process by Sivasothy et al. (2006), the first step involves the use of a double-roll crusher to distort the closed-knit arrangement of the spikelets in bunches. In a previous study by Sivasothy et al. (2005) on the same subject, they inferred that usage of the double-roll crusher provides advantages such as minimal to zero nut breakage, user-friendly design, low investment, operating and maintenance cost, good power consumption and the ability to handle bunches of all kinds. The design of the continuous sterilizer applies the use of forward and return paths conveyors to transport the bunches from the crusher to the sterilizer and then discharge (Sivasothy et al., 2005). This allows for an even user-friendlier design as the whole system is a complete combination process of crushing the bunches and sterilizing and at the same time reduces vast manual labor that is needed in the batch sterilization process to transport the cages of fruit bunches to and from the sterilizer (Sivasothy et al., 1993). Then, with the use of a double-deck scraper conveyor of none multiple-peak cycles, the bunches are heated while being conveyed at low pressure (atmospheric pressure) and inside an enclosed vessel (as shown in Fig. 1) called the continuous sterilization chamber, to facilitate continuous processing. The use of low pressure and without the use of multiple-peak cycles in