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Micro-structural characterisation of palm fruit at sterilisation and digestion stages in relation to oil expression

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Abstract

Micro-structural characterisation of palm fruit was carried out under different conditions of sterilization and digestion. Samples were sterilised at 30, 60 and 90 min, digested for 3, 5 and 10 min and subjected to micro-structural analysis under transmission electron microscope. The analyses indicate increase in cell content disintegration and the possibility of oil release increase with increase in sterilisation time and digestion time. It is evident that the objective of reaching oil point quickly and hence achieving high oil yield can be met by different combinations of the processing operations and this would be useful in the optimisation of the palm oil extraction operations. Since melting of oil globule was observed to have commenced at sterilisation time as low as 30 min and that this was enhanced by increase in digestion time, it is being suggested that small scale processors should adopt 60 min sterilisation time and digestion time of 5 min to conserve energy and preserve the quality of product. A critical look has to be taken into sterilisation time in the large scale plants since they utilise pressurized sterilizer as they may have to reduce the sterilisation time based on the current study.

Keywords: Palm fruit; Microstructure; Processing operations; Oil expression; Oil yield; Optimisation

1. Introduction

Palm fruit processing into palm oil involves five basic operations, viz: fruit sterilisation, fruit loosening, fruit digestion, oil extraction and oil clarification. Sterilisation is a heat rendering operation involving steaming of fruits. The operation aids loosening of fruits from the bunches as well as digestion operation by softening the fruit mesocarp for an efficient maceration. The operation functions as heat-treatment and moisture adjustment. Increase in sterilization temperature and time (bringing about increase in heat-treatment and moisture conditioning) has been found to increase yield of oil from palm fruits (Babatunde, 1987; Owolarafe, Faborode, & Ajibola, 2002). The steriliser is a major equipment used for this operation and it is available in different capacities and versions. Two versions of the steriliser are available viz: horizontal and vertical steriliser (Hartley, 1988, Chapter 14). In the traditional palm fruit processing, sterilisation is done arbitrarily, ranging from one and half hours to three hours. However duration of about 45–60 min is adopted in the modern processing methods (Hartley, 1988, Chapter 14; Owolarafe, 2005). The overall effect of sterilisation is on the final oil yield; when fruits are understerilised, less oil is obtained due to the fact that the heat is not sufficient to reduce the viscosity of oil. When viscosity reduces, flow resistance is reduced and flow is easier and faster from the cells. However, over-sterilisation of fruits on the other hand has been reported to weaken the kernel shell leading to nut-breakage (Owolarafe, 2005).

Digestion of palm fruit is a size reduction and a wet communition process carried out in a digester. Digester is also available as horizontal and vertical versions. Palm fruit digestion is an important operation necessary to facilitate oil extraction and it involves subjecting fruits to random motion by the movement of the digester arms through the fruit load. Vibration is induced in the

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mesocarp tissue and this prepares the materials for subsequent oil expression. This process is described as impulse rendering (Babatunde, 1987). The degree of fruit maceration (impulse rendering) determines to a large extent the effectiveness of oil extraction operation and hence the oil yield. The method (horizontal or vertical) also affects the yield of oil. The vertical digester has been found to be more efficient than horizontal digester (Babatunde, 1987; Taiwo et al., 2000). It has been a difficulty to ascertain the time required for adequate digestion of well-sterilised palm fruit. In the traditional method which involves the use of pestle and mortal and foot-mashing digestion period is arbitrary and based on the texture of the resulting mash as physically observed and felt between fingers. As a result, palm fruit digestion may take several minutes depending on the experience of the operator/processor. At the small scale processing utilising modern technology, palm fruit sterilisation and digestion is also yet to be properly characterised. Babatunde (1987) reported that using a vertical and horizontal digester, oil was observed to be flowing from mash produced from palm fruit sterilised for one hour and one and half hours when digested for 3 min using digestion speed of 100 rpm and 175 rpm. He noted further that it was difficulty to categorically state or suggest the time for palm fruit digestion within the limit of the experimental factors used. Also incomplete digestion of the sterilised fruit has been reported to reduce oil yield (Owolarafe et al., 2002). It is evident therefore that most of the processing operations are yet to be optimised.

Studies on the microstructure of food materials have been used for several purposes such as improvement of the quality of existing food, and creation of new products (Aguilera, 2005) as well as optimisation of food processing. Applications of the later are common in oil expression (Mrema & Mc Nulty, 1984; Young & Schadel, 1990, 1993). The effect of processing conditions on microstructure of oil seeds has been extensively studied. Young and Schadel (1990) reported that the factors that influence structural modification of seeds include maturity of seed, environmental condition under which they are grown, processing conditions, as well as storage conditions and duration. Processing conditions such as moisture conditioning, heat-treatment, pressure application, size reduction and solvent treatment have been observed to significantly influence microstructure of most oil seeds. Roasted peanut (at 160 °C for 16 min) observed under SEM was found to have the cytoplasmic network disrupted as well as the protein bodies and starch grains distended. In addition, the middle lamella between parenchymal cells was observed to be disintegrated (when observed under TEM). Similar results were also recorded by Huang, Hess, Weber, Purcell, and Huber (1990) and Funebo, Ahrne, Kidman, Langton, and Skjoldebrand (2000) on microwave heating of potatoes. Huang et al. (1990) observed that heat-treatment caused swelling and disintegration of starch granules. Funebo et al. (2000) reported cell separation and disruption of cell walls of apple heated with microwave. Furthermore, the middle lamellae between cells of soft beans were observed to be dissolved during cooking (Aguilera, 2005)

Size reduction in the form of grinding and rolling, heat-treatment (roasting or oil cooking), moisture conditioning and pressing of peanut were reported to have induced fusion of oil droplets, coagulation of cell nucleus, rupturing of oil cells, destruction of starch grains and release of cell constituents (Woodroof & Leahy, 1940; Young & Schadel, 1990, 1993). These results have been used to optimise processing conditions in the expression of oil from peanut and other oil seeds. Pretreatment processes are thus planned to ensure minimum energy input that will ensure rapid oil recovery.

There is little information on the microstructure of palm fruit particularly at different sterilisation and digestion conditions as they affect palm oil extraction. Hence to optimise palm fruit processing operations, this work aims at studying the structural modification of the palm fruit at different sterilisation and digestion times in relation to expression of oil from the fruit.

2. Materials and method

2.1. Sample conditioning

The raw material used for the study is *tenera* specie of palm fruit. Fresh *tenera* fruits were collected from the Teaching and Research farm of Obafemi Awolowo University, Ile-Ife, Nigeria. They were immediately processed to avoid deterioration.

Part of the fruits collected was sterilised for 30 min, 60 min and 90 min (respectively) based on the earlier work (Olabige, 2004) and Owolarafe, Olabige, and Faborode (2007). The steriliser used for the study is a vertical version fabricated in the Department of Agricultural Engineering, Obafemi Awolowo University, Ile-Ife, Nigeria (see Fig. 8) .The laboratory steriliser has the capacity to hold about 80 kg of fruit at a time. It has a false bottom which holds water for steam production. The fruit compartment and the false bottom are separated by an elliptical plate perforated for the passage of steam. The steriliser is electrically heated. The temperature of the steam produced in the steriliser was measured by a thermometer and observed to be in the range of 95–100 °C. Samples at these three sterilisation times were collected separately and stored in the freezer for subsequent analysis. Fruit sterilised at the three different sterilisation times mentioned above were subjected to digestion in a vertical digester (fabricated in the same Department as above for the study) for 3 min, 5 min and 10 min (based on the work of Olabige, 2004 & Owolarafe et al., 2007). The laboratory digester has the capacity to hold about 40 kg of sterilized fruit. Fig. 9 shows the picture of the digester. The samples collected were designated as shown in Table 1.