Mechanical expression of oil from grated and preheated coconut meat

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ABSTRACT

Coconut oil was extracted from grated coconut using a hydraulic pressing method after the coconut gratings were preheated at heating medium air temperature in the range of 30-90°C and heating durations ranging from zero to 45 minutes. Oil yields from the preheated copra indicated that adding distilled water to fresh grated copra in the ratio of 3:1 prior to heating the mixture in sealed plastic bags resulted in higher oil yield at all heating temperatures when compared to unheated copra. The oil yield also increased with increase in heating medium temperature up to 70°C but declined with any further rise in heating medium temperature. Lowering the moisture content by drying copra in an air oven at 40°C followed by oil extraction resulted in an increase in oil yield. It was noted that the oil yield increased with increase in the duration of preheating at all temperatures although the maximum increase was observed at heating temperatures of 50 and 60°C. Grating the coconut to flakes of approximately 1mm thickness had the effect of increasing oil yield when compared to 2mm thick flakes.

Keywords: copra, oil extraction, oil yield, heating temperature, heating duration.

INTRODUCTION

The coconut tree is widely grown in many parts of the tropics because of its many uses. The tree itself is used to provide shade during the day, the leaves can be used for roofing while the stem is a building material that gives structural strength to buildings. The tree can also be used as a fuel and/or as food. Although the main food product from coconut fruit is oil, there are some minor food products that can be derived from it such as coconut water, nata de coco, coconut chips and coconut jam. Other products that can be made by mixing coconut and cow milk are cheese and yoghurt (Lombard, 2001; Ohler, 1999; Banzon, 1984).

The mature coconut fruit consists of a very thick and hard, fibrous brown husk surrounding a single seed. Before the seed matures, it is filled with "coconut milk" which as the seed matures turns to a white creamy material (meat) which technically is the seed's albumen. Hard and dry coconut meat is known as copra and when pressed yields coconut oil (Ohler, 1999).

Coconut oil is extracted from copra for use either as edible oil or for industrial use. The residue, copra meal is normally used in animal feeds manufacturing. The extraction method includes the full press method, the pre-press solvent method and the full solvent method. Other patented methods that some times combine a number of techniques have also been used over the years (Ohler, 1999). However, in the rural areas of tropical countries where oil crops are grown it is the pressing method that is predominantly used (Axtell, 1992; Bachmann, 2004; Hayman, 2005) and it is therefore this method that needs to be vigorously investigated for this group of people.

There are a number of other factors or conditions that can be manipulated during extraction in order to maximize yield when using mechanical extractors (Casten and Snyder, 1985; Khan and Mohammad, 1997; Singh and Bargale, 2000). These factors include the moisture content of material, size of particles and the temperature of particles. The pressure applied during extraction and the duration of application of the pressure also has a direct effect on the yield although the control of these two factors might be limited due to design and operation requirements in some types of extractors (Singh and Bargale, 2000; Uziak et al., 2002).

The effect of these factors on oil yield from oil bearing materials has been studied by a number of researchers (Baryeh, 2001; Fasina and Ajibola, 1989; Ajibola et al., 1990; Fasina and Ajibola, 1990). In all these studies the authors have established that there exists an optimum value of moisture content for each product at which oil yield will be highest provided that all other variables are held constant. The oil yield has also been found to increase with the extracting pressure and duration of pressing within a limited rage of either factor but to level out on exciding this range. Baryeh (2001) while working with palm oil established that a preheated product yielded higher quantities of oil and that the longer the duration of heating at a preset heating medium temperature yielded higher oil quantities for heating medium temperatures below 100°C above which temperature yields started falling. Fasina and Ajibobola (1990) however found the oil yield to decrease with post-heating medium temperature within the range of 65-100 °C for Conophor. They also did find a relationship between yield and both preheating moisture content and post-heating moisture content.

The premise of the current work is that there exist a relationship between the actual moisture content of the oil bearing material at the exact moment of extraction and the oil that it yields. This study therefore aims to determine the effect of either adding water or removing water to copra followed by preheating in an air oven on the oil yield. The effect of heating duration and size of copra gratings on yield is also investigated.

MATERIALS AND METHODS

Sample preparation

Fresh coconut fruits were obtained from the market and sorted so as to retain only the high quality ones. The coconuts were then stored in a refrigerator set to a temperature of 5°C until required. To prepare the product for oil extraction, each coconut was cut into two halves and the coconut meat grated out using either a fine or a coarse hand grater. The fine coconut grater had teeth spacing of 1mm while the coarse grater had teeth spacing of 2mm therefore producing flakes that were approximately 1mm and 2mm thick, respectively. The length of the copra flakes however was the same for both graters. The grated meat (copra) was then given one of three possible pretreatments before oil was extracted by compressing the mass using a hydraulic press mechanism.

Copra grated using the coarse grater with 1mm teeth spacing was divided into seven samples of 80 grams each and 250ml of distilled water added to each sample. The wetted samples were sealed off in plastic bags and heated for a period of 30 minutes inside a hot air oven. The heating temperature was set at 30, 40, 50, 60, 70, 80 or 90°C during the entire heating period and the sample was at once extracted for oil after removal from the oven. There were a total of 14 samples after replicating each of the seven treatments.

In another set of experiments fine grated copra was weighed into samples of approximately 80 grams each. The samples contained in sealed plastic bags were then heated at a set constant heating temperature for heating durations of 10, 15, 25, 35 or 45 minutes. The heating process could be set at a constant heating temperature of 30, 50, 60, 70 or 80 °C. At the end of the heating duration the samples were removal from the heating medium and immediately extracted for oil. There were therefore a total of 25 treatments (5 heating durations x 5 heating temperatures) and 50 samples after replication.

The final set of experiments involved both coarse and fine coconut meats. For samples to be used in the determination of the effect of moisture content of copra on oil yield, the initial moisture content of the copra was determined using a calibrated commercial moisture metre. Seven samples of copra (for each copra size) each weighing approximately 200g were then weighed and one sample was extracted for oil without any further treatment. The remaining six samples were put into aluminum can holders and the mass at which the moisture content would have fallen by 2, 4, 6, 8, 10 and 12% computed using Eq.1. The samples were then dried in a hot air oven maintained at a set air temperature of 40°C and by checking their mass periodically a single sample was withdrawn at each of the six predetermined moisture contents and extracted for oil. There was a total of 28 samples (7x2x2) representing seven moisture content levels, two copra sizes (coarse and fine) and 2 replicates.

$$W_x = W_1\left(\frac{1-MC}{1-MC_2}\right) \qquad (1)$$

Where, W_X is mass of sample after the moisture content is lowered by x%, grams

W_1 mass of sample initially, grams

MC_1 initial moisture content of sample, decimal wet basis,

MC_x = $(MC_1-X/100$, moisture content after being lowered by x%, decimal wet basis

All the samples that were used for oil extraction including the replicates were 92 and can be presented in the simplified form of Table 1 below.

Table 1. Experimental setup for oil extraction from grated copra

Condition	Heating temperatures, °C	Duration of heating, minutes	Moisture content, % wb	No of samples
Water added to copra	30, 40, 50, 60, 70, 80 or 90	30	Fixed, sealed sachet during heating	14
No water added	30, 50, 60, 70 or 80	10, 15, 25, 35 or 45	Fixed sealed sachet during heating	50
No water added	40	variable	Lower than initial moisture content by 0, 2, 4, 6, 8, 10 and 12	28

Oil extraction

Each sample was removed from the sealed plastic bag or aluminum heating container, inserted into a compression sachet made of muslin cloth and put into a prefabricated perforated metal cylinder (oil extraction cell). A dallchi keiki compression hardness tester (Model no. 198 Tanifuji Machine co. ltd., Tokyo, Japan) was then used to compress the ground material at a constant force of 20 kgf for a pressing duration of exactly 30 minutes. The oil extracted was captured using glassware and recorded as yield in grams. The percentage oil yield was later computed from the ratio of mass of oil to the initial mass of copra sample.

RESULTS AND DISCUSSION

Fig 1 shows how the oil yield from heated copra changes with change in the temperature of the heating medium. The highest oil yield recorded was 43.75% which is reasonable considering that oil content in coconut may range between 45 and 69% in fresh copra (Akpan, et al., 2006). Although the temperature of the copra is actually slightly lower than that of the heating medium it can reasonably be assumed that for the same duration of heating a copra mass that is surrounded by a higher temperature medium will also be hotter than one that is surrounded by a cooler medium. Thus it can be seen from Fig 1 that as the copra temperature increases the oil yield from the coconut gratings also increases until we reach a heating medium temperature of 70°C. Further increase in medium (or copra) temperature however results in decrease in oil yield. This observation was also made by Fasina and Ajibola (1989) in their work on the mechanical expression of oil from camphor nut. Their supposition that an oil reduction occurred at higher heating temperatures due to brittleness cannot be acceptable under the present experimental condition because the moisture content was maintained constant during heating. However their suggestion that the decrease occurred due to thermal degradation is more valid.

The colour of the oil was also observed to be very clear for heating medium temperatures 60 and 75°C and the oil also had a faint sweet smell. However, above 80°C the colour turned slightly brown further reinforcing the supposition that a change in the properties of the oil was taking place at the higher temperatures. Also, the stickiness of the oil as determined by rolling it between thumb and fore finger was noted to decrease with increase in heating medium temperature.

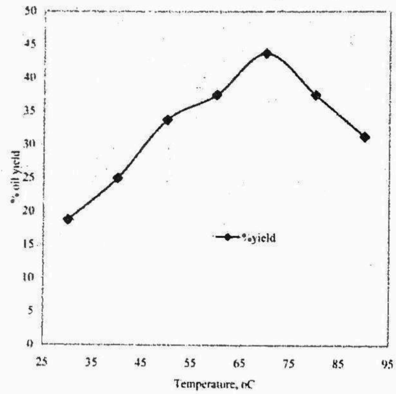

Fig 1. Variation of percentage oil yield with change in the preheat temperature of grated and compressed coconut gratings.

Fig 2 represents the results of oil yield from copra masses that were heated in sealed plastic papers but without the addition of any water. It is evident from the results presented in Fig 2 that oil yield increased with the duration of heating of the grated sample for all heating air temperatures. At the heating medium temperature of 30°C, there was a gradual increase in oil yield with increase in the duration of heating. However yield increased by only 7 percentage points when the heating duration was increased from 10 to 45 minutes. On the other hand a similar increase in the duration of heating resulted in an increase in oil yield of 12 and 13 percentage points when the heating medium temperature was set at 50 and 60°C, respectively. When the heating medium temperature was further increased to 70 and 80°C the oil yield only increased by 7 and 4 percentage points respectively showing that the effect of the heating duration was decreasing as the temperature increased. It was also found that the oil yield increased with increase in duration of heating at all temperatures and all heating durations. However the increase in yield when heating duration was increased from 10 t0 15 minutes when heating copra at 80°C was the only change that was not significant at $p<0.05$.

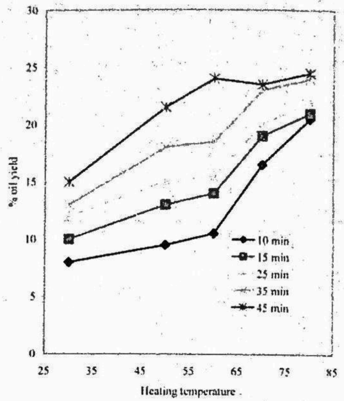

Fig 2. Change in oil yield from grated coconut with both the duration of heating and heating temperature

The general trend of the change in oil yield from fresh copra with both the heating duration and the heating temperature are like those observed by Mpagalile and Clarke (2005) when dealing with dried copra. This is despite the fact that the two products have different levels of moisture content with fresh copra having an average moisture content of 52% w.b. while dry copra has a moisture content of 6-15% w.b.

The change of oil yield with decrease in the moisture content of copra for both fine and coarse particles is presented in Fig 3. It can be seen that there is a sharp increase in yield as the moisture content makes the initial two percent drop in moisture content. This is probably because of the copra adjustment in temperature from the ambient temperature of about 25°C to the temperature of the drying medium which was set at 40°C. As the moisture content of the copra is further decreased by 4, 6, 8 and 10% increase in oil yield is gradual and there is near linear relationship between yield and moisture. However when the decrease in moisture exceeds the 10% level the increase in yield suddenly shoots up probably indicating a change in the water bonding relation that eases the flow of oil from the compressed copra mass. The moisture content at which this occurs is 42% (wet basis) and it is evident that the yield would continue to rise with reduction in moisture content beyond the range of the present experiment. This would support the work of Mpagalile and Clarke (2005) who found the moisture content of 11% to be the optimum value for extracting oil from dried coconut gratings.

The oil yield from fine copra was significantly higher at the 99% level of confidence compared to the yield from coarse copra, although the difference in yield decrease with increase in the amount of moisture removed from the copra as can be seen in Fig.3.

CONCLUSION

This research work has established that the hydraulic pressing method can extract up to 44% (w/w) oil from wetted and heated copra provided that the heating medium temperature does not exceed 70°C. Also the work shows that both the heating duration within the range of 10 to 45 minute and size of the grated particles affect the amount of oil that we can extract from the copra using the hydraulic press method and that the longer period is preferable.

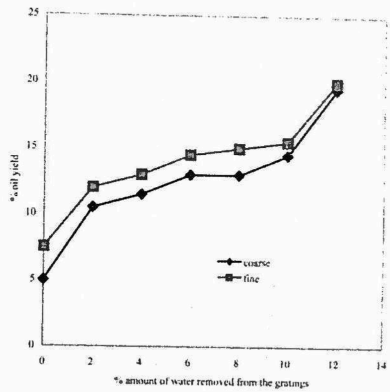

Fig 3. Change in oil yield from coarse and fine grated coconut with increase in the amount of water removed from the gratings

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