A Comparative Study on Deterioration of Bleachability Index (DOBI) of Crude Palm Oil (CPO) from Different Degrees of Oil Palm Ripeness

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ABSTRACT

The effect of sterilisation on palm oil from different degrees of oil palm ripeness was investigated in terms of deterioration of bleachability index (DOBI) value. The experimental treatment was carried out at different temperatures and durations using Response Surface Methodology (RSM). Results showed that DOBI value in this study, ranging from 2.3 to 4.6, were recorded from crude palm oil (CPO) extracted from unripe and underripe fruits, respectively. Improved DOBI value was obtained compared to conventional method where optimum sterilisation process used was 90°C and in not less than 80 min.

INTRODUCTION

The oil palm produces two different fats, namely, crude palm oil (CPO) and palm kernel oil (PKO). CPO is the oil extracted from the mesocarp of oil palm fruits. It consists of triacylglycerols (TAG) and minor components such as monoacylglycerides (MAG), diacylglycerides (DAG), phosphatides, esters and sterols, hydrocarbons, aliphatic alcohols, free sterols, tocopherols, pigments and trace metals. Free fatty acid (FFA) is one of the fatty acid derivatives present in CPO. The FFA exists as a consequence of cell damage in vegetable tissues during harvesting, storage, transport or initial processing. Cell damage can be caused by bruising of the fruits or seeds (Hadi *et al.,* 2009), freeze-thaw cycling or hot and humid conditions (Siew and Mohamad, 1992) or microbial activity (Likeng-Li-Ngue *et al.,* 2017).

Palm oil quality and price depend on the FFA content in palm oil. The maximum FFA content set by the Palm Oil Refiners Association of Malaysia in CPO is 5%. Due to high demand in palm oil industry market nowadays, various work has been done to improve the quality of palm oil including added deterioration of bleachability index (DOBI) parameter to the Malaysia domestic sales of CPO contract since July 2004 (Junaidah *et al.,* 2013).

Enormous work has been done to date regarding the determination and reduction of FFA in CPO. At present, the milling equipment and the fresh fruits bunch (FFB) conditions play an important role to produce high or low FFA besides other factors mentioned above. Previous studies showed that temperature and duration of sterilisgfation also affect the FFA content when different degree of FFB ripeness was used (Junaidah *et al.,* 2015). The results showed that increased degree of ripeness increases amount of FFA released due to microbial contamination and oxidation that occurs during sterilisation. However, compared to FFA, it is known that heating causes carotene to deteriorate and forming peroxides which lead to low DOBI or poor bleachability on the CPO extracted.

Considering these problems, heating at lower temperature using dry treatment may be used to minimise deterioration of carotenes and hence, increase the DOBI value. At present, the only method of sterilisation of oil palm fruits being practiced is steam sterilisation. It is also known that carotenes content increases as the fruits ripen and it remained nearly constant. Therefore, the objective of this study is to establish data and measure the effect

of heat treatment during sterilisation process based on different degree of oil palm ripeness on DOBI of palm oil.

MATERIALS AND METHODS

Determination of Palm Fruit Ripeness

Oil palm fruits (*Elaeis guineensis* of *tenera*) of various degrees of ripeness were used. The FFB were obtained from a local palm oil mill situated in Labu, Negeri Sembilan. Samplings were performed according to MPOB FFB Grading Manual (MPOB, 2003) with assistance from certified mill FFB grader.

Processing of Palm Fruitlets

With the aid of Design-Expert Version 6.0.1 software (Stat-Ease Inc., Minneapolis, USA), two variables central composite rotatable design (CCRD), with five replicates running at centre point was employed to study the effect of fruits sterilisation condition at different degree of ripeness on the response, namely DOBI, Y_{1-5} (Y_1, unripe; Y_2, underripe; Y_3, ripe, Y_4, overripe; Y_5, loose fruits). The independent operating variables were heating; sterilisation temperature and time, X_1 and X_2, which vary between 70°C to 90°C and 20 min to 90 min, respectively (*Table 1*).

DOBI Analysis

Determination of DOBI and fatty acid composition was carried out using MPOB Test Methods p2.9:2004 and MPOB Test Method p3.4 Part 1:2004, respectively.

RESULTS AND DISCUSSION

The measured DOBI value throughout this study ranged from 2.3 to 4.6, with minimum to maximum values recorded from CPO extracted from unripe and loose fruits and underripe fruits respectively. The minimum to maximum range obtained from overall experimental runs were represented in *Figure 1*.

The values of DOBI obtained (CPO derived from different degrees of fruits ripeness) in this study are still within the specification for production of Malaysian Standard Quality Grade II CPO (MS 814: 2007), *i.e* minimum 2.3. *Figure 1* shows that unripe and loose fruits recorded narrow DOBI range. However, underripe fruits recorded the highest DOBI value followed by overripe, ripe, loose and unripe. In this study, higher DOBI from underripe fruits were obtained compared to overripe fruits as reported by Junaidah *et al.* (2013). This is probably due to solvent extraction employed in this study is able to extract more carotenes embedded in the mesocarp compared to mechanical press.

TABLE 1. EXPERIMENTAL RANGE AND LEVELS (coded and actual) OF THE INDEPENDENT VARIABLES (process factors)

Variables	Range and level				
	Lowest	Low	Centre	High	Highest
	-1.414	-1	0	+1	+1.414
X_1 (°C)	65.86	70	80	90	94.14
X_2 (min)	5.50	20	55	90	104.50

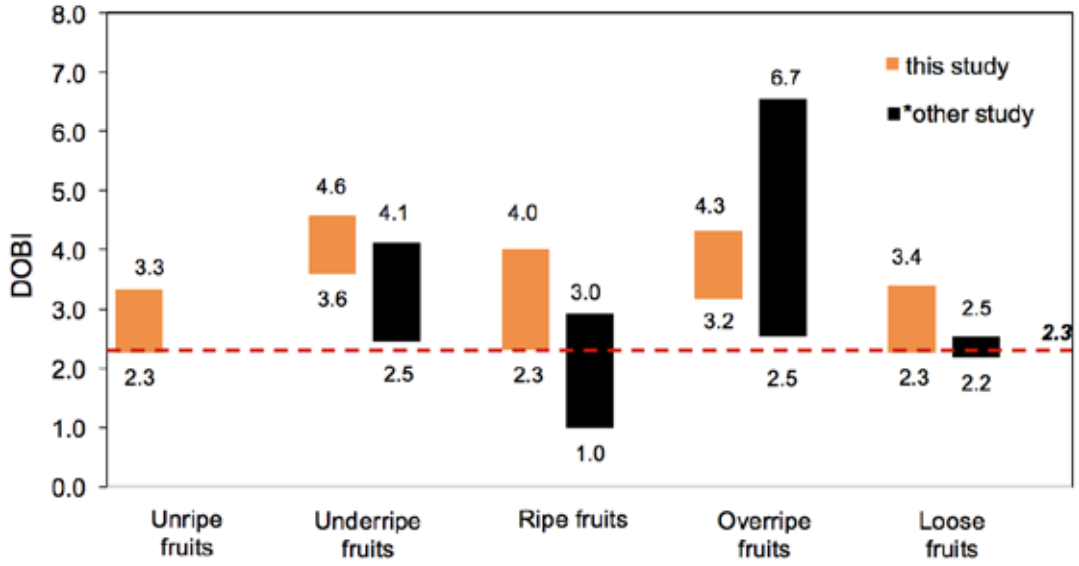
Sterilisation of Oil Palm Fruit

For each experimental run, oil palm fruits obtained from the mill were cleaned to remove dirt on the surface followed by heating under dry treatment. The heated oil palm fruits were peeled and the nuts were removed from the mesocarp. The peeled mesocarp was later extracted for its oil using soxhlet extraction.

Soxhlet Extraction

The peeled mesocarp was subjected to hexane extraction for 6 hr by using soxhlet extractor, at fruit to solvent ratio 1:4 (w/v). The solvent was then removed from the oil by using a rotary evaporator.

All degree of ripeness in this study shows high DOBI values compared to previous report (Junaidah *et al.,* 2013). This is due to lower temperature and duration employed during sterilisation as well as related ß-carotene content and condition of the fruits. When higher amount of carotenes is oxidised, DOBI value will decrease. The relationships between independent and dependent variables were shown in *Figure 2*, and the respective regression equations were shown in the *equations 1-5*. The ANOVA (*Table 2*) showed that the model was significant. The model generated from this optimisation are acceptable with R^2 of 0.9599, 0.9079, 0.9027, 0.8309 and 0.7925 for unripe, underripe, ripe, overripe and loose fruit.



Note: The horizontal dotted line located at 2.3 represents the minimum DOBI specification for production of Malaysian Standard Quality Grade II CPO (MS 814: 2007).
Source: Junaidah et al., 2013

Figure 1. DOBI value (minimum to maximum range) for CPO extracted from different degree of fruits ripeness.

$$\text{DOBI (unripe)} = 3.02 + 0.27X_1 + 0.25X_2 - 0.1\,X^2_1 - 0.16X^2_2 - 2.5^{e0.003}X_1X_2 \quad (1)$$

$$\text{DOBI (underripe)} = 4.52 + 0.071X_1 + 0.16X_2 - 0.17X^2_1 - 0.27X^2_2 - 0.027X_1X_2 \quad (2)$$

$$\text{DOBI (ripe)} = 3.71 + 0.15X_1 + 0.43X_2 + 0.051X^2_1 - 0.29X^2_2 - 0.14X_1X_2 \quad (3)$$

$$\text{DOBI (overripe)} = 3.80 + 0.38X_1 + 0.039X_2 \quad (4)$$

$$\text{DOBI (loose)} = 2.97 + 0.25X_1 + 0.28X_2 \quad (5)$$

TABLE 2. ANOVA OF THE FITTED MODEL FOR UNRIPE, UNDERRIPE, RIPE, OVER RIPE AND LOOSE FRUITS

Source	Y_1(unripe)	Y_2(underripe)	Y_3(ripe)	Y_4(overripe)	Y_5(loose)
X_1	$< 0.0001^s$	0.1193^{ns}	0.0624^{ns}	$< 0.0001^s$	0.0020^s
X_2	$< 0.0001^s$	0.0052^s	0.0004^s	0.4969ns	0.0010^s
X_1^2	0.0205^s	0.0056^s	0.5026^{ns}	-	-
X_2^2	0.0019^s	0.0004^s	0.0048^s	-	-
X_1X_2	0.9565ns	0.6427^{ns}	0.1789^{ns}	-	-
Model (*p*-value)	0.0032^s	0.0070^s	0.0020^s	0.0001^s	0.0004^s
LOF (*p*-value)	0.0829^{ns}	0.1981^{ns}	0.2174^{ns}	0.2331^{ns}	0.0962^{ns}
R^2	0.9599	0.9079	0.9027	0.8309	0.7925
Adjusted R^2	0.9313	0.8421	0.8333	0.7970	0.7510
Predicted R^2	0.7638	0.5227	0.5056	0.6712	0.5998

Note: s- significant at p<0.05, ns- not significant at p>0.05, LOF- lack of fit.

As observed in *Figures 2a-e*, linear coefficient for processing temperature, (X_1) has lesser effect on underripe, ripe and loose fruits but with greater effect on unripe and overripe fruits. This indicates that there was a significant effect of linear factor of time (X_2) on DOBI. *Figure 2a* illustrates that DOBI increases when high temperature is used. However, this effect appears only when high heating duration was employed. *Figure 2b* shows that increase in DOBI occurred when temperature increased from 70°C to 80°C or when heating duration decreased from 90 min to 65 min. *Figure 2c* indicates that temperature has a positive effect on DOBI with longer heating duration. According to *Figure 2d*, a continuous increase in DOBI can be noticed when temperature increases whereas *Figure 2e* shows interaction between temperature and time. It indicates that DOBI increases by increasing temperature and sterilisation duration. Both X_1 and X_2 for unripe and loose fruit seemed to play almost equal role in affecting DOBI.

This result confirms previous finding made by Junaidah *et al.* (2013) that the change in processing temperature is less significant than the change in processing time. This might be due to the fruits started to ripen and each fruit contained almost similar carotenes content. Besides, they also contain almost similar fatty acid composition (*Table 3*). Thus, their physical and chemical characteristics are almost similar. Besides, carotenes content increases significantly from unripe to ripe fruit and become nearly constant. This can also be observed from the yellowish colour of the unripe fruit compared to ripe fruit that are deeper red in colour.

The results from CCRD also showed the best conditions for the sterilisation to obtain the optimum DOBI value (*Table 4*). The suggested optimum temperature was 90°C for all palm fruit ripeness except for underripe fruits, where lower temperature and shorter time are required. Thus, greater DOBI can be obtained when temperature for sterilisation was 90°C for duration of not less than 80 min. The parameters were optimised with the target of obtaining maximum DOBI within the range for each parameter. Based on the results, DOBI continuously increased with time and temperature until it reached a maximum value. In this study, optimum temperature suggested by the software was within high temperature/ time range, indicating their carotenes are still preserved and not deteriorated. Further increases in temperature or time will maintain the maximum DOBI and later reduced when excessive oxidation occurred as observed by Junaidah *et al.* (2013).

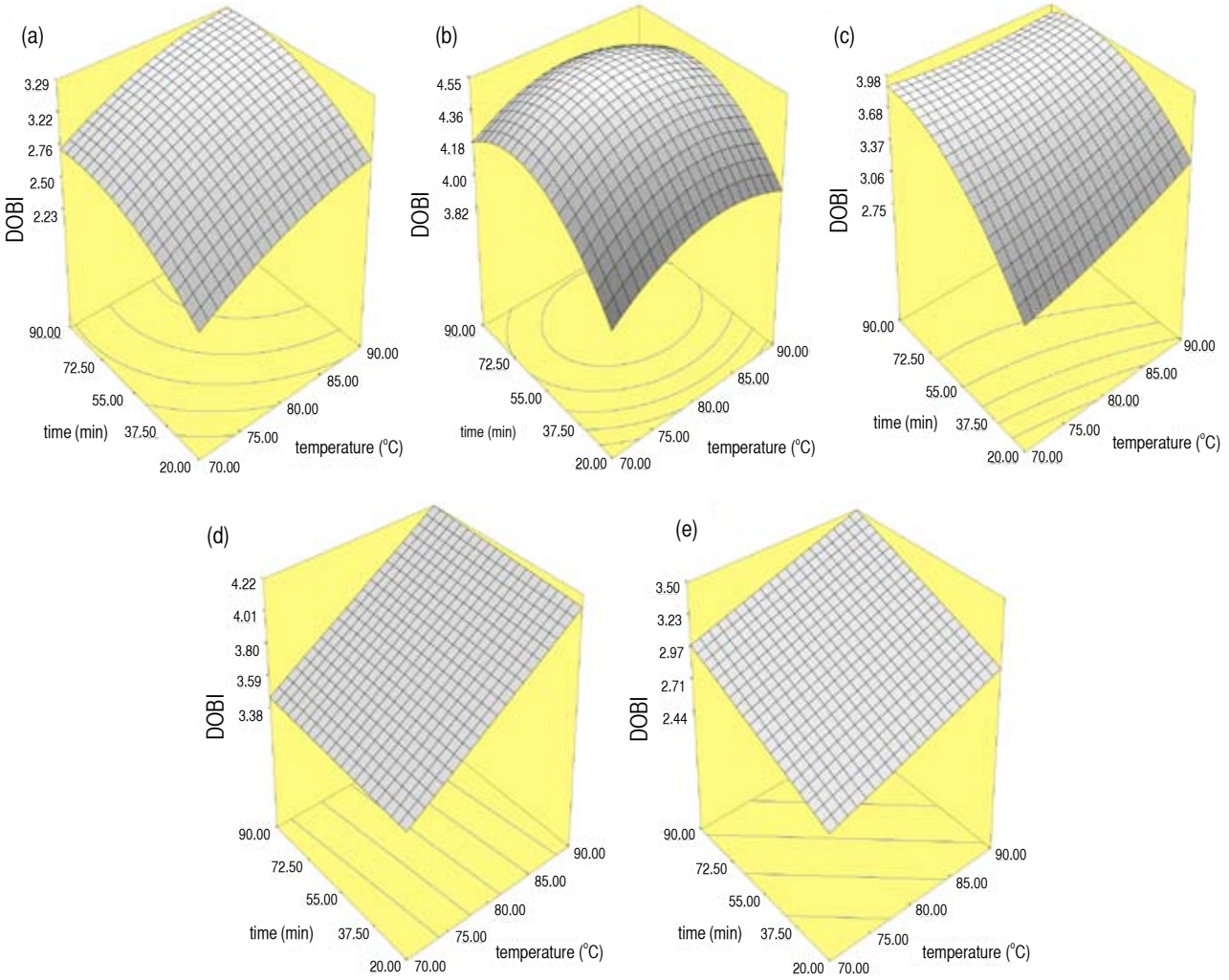


Figure 2. Response surface plot on the effects of sterilisation process on DOBI of CPO extracted; (a) unripe fruit, Y_1 (b) underripe fruit, Y_2 (c) ripe fruit, Y_3 (d) overripe fruit, Y_4 and (e) loose fruit, Y_5.

TABLE 3. FATTY ACID COMPOSITION (wt % as methyl esters) DURING RIPENING OF FRUITS*

Fatty acid	C14:0	C16:0	C18:0	C18:1	C18:2
Unripe	0.8	40.4	5.0	42.9	10.9
Underripe	1.0	47.2	0.9	40.2	10.7
Ripe	1.0	45.3	2.6	41.9	9.2
Overripe	1.7	48.5	2.5	38.9	8.3
Loose	1.2	48.0	1.0	40.1	9.7

Note: *fruits sterilised at 90°C for 90 min.

TABLE 4. OPTIMUM STERILISATION PROCESSING CONDITION FOR DIFFERENT DEGREE OF OIL PALM RIPENESS

Degree of ripeness	Process variables		Predicted responses (DOBI)	Desirability
	X_1(°C)	X_2 (min)	Y_{1-5}	
Unripe	90	81	3.28	0.96
Underripe	82	65	4.54	0.97
Ripe	90	72	3.98	0.99
Overripe	90	90	4.22	0.92
Loose	90	85	3.46	1

CONCLUSION

This study showed that DOBI is influenced by fruit ripeness and sterilisation process. Greater DOBI is observed when lower sterilisation temperature was employed compared to conventional method. Based on fruit ripeness, all degrees of ripeness are able to produce satisfactory quality according to industrial standard and able to preserve the carotenoids content in the palm oil.

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