Feature Article

Content and Quality Characteristics of Oil Obtained Under Different Treatment at Various Palm Fruits Ripeness

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ABSTRACT

This study evaluates the chemical changes that occur as oil palm fruits ripen in the bunch in terms of changes in oil content, chemical composition of fatty acid (FA), free fatty acid (FFA), deterioration of bleachability index (DOBI) and carotenes content. Oil was extracted from fruits with different ripeness, using different extraction techniques. It was found that oil content infruit increased over the ripening period, reaching the maximum oil content of 34.7% in ripe fruit which can be related to the optimal time for fruit harvesting based on colour. Results showed that the main changes in FA occurred in terms of palmitic, oleic and linoleic acids content. Meanwhile, FFA, DOBI and carotenes content increased as oil palm fruits ripen and the value remained nearly constant.

INTRODUCTION

The oil palm has the highest oil yield per hectare of all oil crops and is now one of the top edible oils in the world. In optimal harvest time, oil content of the fruit is between 40.5% while its fibre content is about 20% (Macaire *et al.*, 2010). The amount of crude palm oil (CPO) extracted from the mesocarp of the palm fruit is significantly reduced if the fruits are not harvested at the right stage of ripeness or maturity. According to Tan *et al.* (2010), oil extracted from fruits harvested five days before ripeness can cause reduction in oil content up to 7.7%. Thus, harvesting fruits at the appropriate time will ensure maximum oil yield and oil of good quality.

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In general, mills receive fruits of different degree of ripeness for CPO production. Thus, study in CPO production from fresh fruit bunch (FFB) of different ripeness is needed to increase the understanding of fruit development, which is crucial for optimal harvest. According to the FFB ripeness classification established by Malaysian Palm Oil Board (MPOB), FFB ripeness can be classified into five main classes, *i.e.* unripe, under ripe, ripe, over ripe and rotten.

The degree of ripeness may be estimated from the physical appearance such as colour, size and texture of the fruits. Colour is the most commonly used for ripeness determinant. Although it may be helpful, this technique has limitation as oil palm from different varieties gives divergent colour. There is very little information or reports regarding the ripeness of fruit based on colour and its relation with fruits ripening. Moreover, information on oil yields of FFB based on ripening of fruits is also lacking. As such, this work was conducted to identify and distinguish the effect of various degree of fruit ripeness in terms of oil content of the palm fruits, changes in FA composition and the quality of oil extracted.

MATERIALS AND METHODS

Determination of Palm Fruit Ripeness

Oil palm fruits (*Elaeis guineensis* of *tenera)* of various stages of ripeness were used in the following experiments. As the flowers were not hand pollinated, thus fruit ripeness was estimated based on colour and number of loose fruits present on the ground. Over riped fruits are fruits taken from spikelet of over riped bunch which is harvested when the bunch is orange in colour and there are more than five loose fruits present on the ground. A ripe bunch is defined as a bunch which is harvested when the bunch is orange in colour and there are two to five loose fruits present on the ground. Under riped fruits are from under ripe bunch, harvested without any sign of loose fruit on the ground.

Processing of Palm Fruitlets

The palm fruits were sterilised at 90°C for 90 min. The heated oil palm fruits were peeled and the nuts were removed from the mesocarp. The peeled mesocarp was later extracted for its oil by way of solvent extraction.

Soxhlet Extraction

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

Cold Extraction

The peeled mesocarp was immersed in hexane for 24 hr at fruit to solvent ratio 1:1.5 (w/v) and later pressed using fruit press expeller. The extraction solution was filtered through a Whatman filter paper. The solvent was then removed from the oil by using rotary evaporator. The oil content of oil palm extract was determined using equation below.

$$\% \text{ oil content} = \frac{X}{Y} \times 100\% \qquad (1)$$

where, X = mass of oil extracted (g)
Y = mass of oil palm fruits (g)

Following this procedure, the following mesocarp oils were prepared:

1. Under ripe fruits and soxhlet extraction (US)
2. Ripe fruits and soxhlet extraction (RS)
3. Over ripe fruits and soxhlet extraction (OS)
4. Under ripe fruits and cold extraction (UC)
5. Ripe fruits and cold extraction (RC)
6. Over ripe fruits and cold extraction (OC)

Physicochemical Analysis of Extracted Oil

Determination of FFA, DOBI, carotenes contents and fatty acid composition were carried out using *MPOB Test Methods* (2005).

RESEARCH FINDINGS

Oil Content in Fresh Fruits during Ripening of Fruits

Table 1 shows the comparison of oil content in palm fruit from this study and other cultivars reported by Prada *et al.* (2011). It was found that the oil content increased as fruits ripened, ranging from 16.1% to 34.7%. In this study, it was obvious that ripe fruit showed maximum oil content compared to under ripe and over ripe fruits. Ripe fruits (RS and RC) contain 34.7% and 27.4% oil, while over ripe fruits (OS and OC) contained 30.0% and 25.6% of oil. Under ripe fruit (US and UC) contained only 25.1% and 16.1% oil, respectively. As in agreement with the research reported by Prada *et al.* (2011), under ripe fruits in this study can be assumed to be 18 week after anthesis (WAA) and ripe fruits 20 to 22 WAA.

According to Prada *et al.* (2011), lipid synthesis starts at 16 WAA and increased rapidly within the next six weeks. Based on their research, the highest oil content was at 22 or 24 WAA. Thus, Prada *et al.* (2011) suggested from their study that the maximum lipid accumulation in fresh fruits of *Elais guineeensis* occurred after 20 WAA. Another study reported that commercial *tenera* palms from Malaysia reached the maximum accumulation of total lipids at 20 WAA, while for Nigeria palms, the accumulation occured between 18 to 22 WAA (Sambanthamurthi *et al.*, 2000). The trend observed from the results in *Table 2* is similar to those observed from *Table 1*.

Characteristics of Oil Extraction

Table 3 summarises the FA composition obtained in previous studies and the present study. Oils in young fruits contained a higher amount of unsaturated fatty acids than oils from older fruits. Polyunsaturated fatty acids (PUFA) of under ripe fruits obtained in this study were much lower than that reported by Oo *et al.* (1987) at 16 to 20 WAA

TABLE 1. CHANGES IN OIL CONTENT (%) IN FRESH FRUITS DURING RIPENING OF FRUITS

Tenera cultivars	WAA							Reference
	12	14	16	18	20	22	24	
Deli x La Me	4.7	6.1	4.6	15.8	29.6	46.6	40.7	
Deli x Ekona	3.9	7.9	3.3	13.2	28.1	41.9	39.4	Prada *et al.* (2011)
Deli x AVROS	-	1.0	1.1	8.4	22.9	37.9	43.2	
	US	UC	RS	RC	OS	OC		
Malaysia	25.1	16.1	34.7	27.4	30.0	25.6		Present work

TABLE 2. CHANGES IN TOTAL LIPID (OIL) IN MESOCARP DURING RIPENING OF FRUITS FROM DELI x LA ME, DELI x EKONA, AND DELI x AVROS CULTIVARS

WAA	Total lipid (g/100 g of fresh mesocarp)		
	Deli x La Me	Deli x Ekona	Deli x AVROS
12	6.2	5.3	-
14	7.8	10.9	1.2
16	5.9	4.3	1.2
18	20.3	17.6	9.8
20	36.3	37.0	26.2
22	54.7	49.5	42.8
24	49.3	47.1	48.4

Source: Prada *et al.* (2011).

TABLE 3. CHANGES IN MAIN FATTY ACID COMPOSITION (wt % as Methyl Esters) DURING RIPENING OF FRUITS

WAA	14:0	16:0	16:1	18:0	18:1	18:2	18:3	20:0	Others	Reference
8	1.0	27.5	-	4.4	22.2	24.0	13.6	-	7.3	
12	1.0	27.0	-	4.5	22.7	23.9	18.0	-	2.9	
16	0.4	35.2	-	5.4	42.6	13.9	0.8	-	1.8	Oo *et al.* (1986)
20	1.1	40.8	-	5.0	35.9	11.3	0.0	-	5.9	
Over ripe	1.5	44.2	-	5.4	38.7	9.4	0.0	-	0.8	
19	0.6	39.7	0.2	3.3	43.3	12.5	0.3	0.1	-	
20	0.8	43.8	0.2	3.5	40.3	11.1	0.1	0.2	-	Tan *et al.* (1997)
21	0.7	39.4	0.2	4.4	41.7	13.0	0.2	0.3	-	
22	1.3	44.0	0.1	4.7	38.8	10.6	0.1	0.3	-	
14	0.6	29.9	4.5	3.3	19.1	33.3	10.2	-	-	
16	0.4	31.6	2.8	3.2	29.9	28.1	4.6	-	-	
18	0.4	38.3	1.5	4.4	37.4	18.2	0.8	-	-	Prada *et al.* (2011)
20	0.6	40.7	1.2	4.7	39.4	13.7	0.4	-	-	
22	0.9	44.2	1.3	5.0	37.3	11.6	0.3	-	-	
24	1.1	44.9	1.3	4.8	36.8	11.3	0.3	-	-	
US	0.8	41.8	-	4.2	44.1	8.9	0.2	-	-	
UC	0.9	41.4	0.1	4.2	44.6	8.7	0.2	-	-	Present work
RS	1.2	47.1	0.1	4.0	37.3	10.1	0.2	-	-	
RC	1.0	44.1	0.1	4.1	40.3	10.2	0.3	-	-	
OS	0.5	43.9	0.1	3.4	40.1	11.6	0.4	-	-	
OC	0.9	44.5	0.6	3.3	38.6	11.8	0.3	-	-	

TABLE 4. CHANGES IN QUALITY OF OIL PALM DURING RIPENING OF FRUITS

Parameter	FFA (%)	DOBI	Reference
Under ripe	0.65-1.15[a]	2.45-4.12[b]	Junaidah *et al.* (2015)[a]
Ripe	0.89-1.95[a]	0.99-2.96[b]	Junaidah *et al.* (2013)[b]
Overripe	1.71-2.43[a]	2.53-6.69[b]	
Loose fruit	3.2-3.6[a]	2.19-2.53[b]	
US	0.76	3.01	Present work
UC	0.88	3.09	
RS	1.27	4.46	
RC	1.27	4.61	
OS	1.01	3.86	
OC	1.01	4.14	

TABLE 5. CAROTENES CONTENT VARIATION DURING RIPENING OF FRUITS (ppm)

Tenera cultivars	WAA							Reference
	12	14	16	18	20	22	24	
Deli x La Me	7135	3549	536	586	831	573	808	
Deli x Ekona	1335	1775	424	756	514	905	1531	Prada *et al.*, (2011)
	US	UC	RS	RC	OS	OC		
Malaysia	356	327	645	593	641	588		Present work

(*Table 3*). Moreover, for both oil extracted, the oleic acid content were higher, ranging from 44.1%-44.6%. A comparison was made with previously reported FA composition. It was found that the main changes in FA occurred in palmitic, oleic and linoleic acids. The results were in agreement with other researchers as reported in *Table 3*. Prada *et al.* (2011) reported that PUFA values decreased whereas monoson saturated fatty acids (MUFA) and saturated fatty acids (SFA) values increased during fruit development.

Oil extracted from under ripe, ripe and over ripe fruits showe slight difference in the percentage of FFA, DOBI and carotene content. The FFA, DOBI and carotene content of under ripe fruits were lower than ripe and over ripe fruit for both types of extraction. The FFA content in this study ranged from 0.76%-1.27% (*Table 4*). These results were supported by research done by Junaidah *et al.* (2015). In this study, low FFA content of under ripe fruits was due to high unsaturated fatty acid levels. DOBI value throughout this study ranged from 3.01 to 4.61 (*Table 4*). DOBI obtained from this study is in the range of fair to good DOBI grade.

Similar result for DOBI was also recorded by Junaidah *et al.* (2013). Ripe fruits recorded higher DOBI than under ripe fruits due to the rich and deep orange colour found in ripe oil palm fruits, indicating high carotene content as shown in *Table 5*. DOBI depends on the carotenes content, but is more affected by oxidation state of the oil. In this study, results showed that the carotenes content was higher when oil was solvent extracted. *Table 5* shows carotene contents of CPO extracted from under ripe, ripe and over ripe fruits with carotenes content ranging from 327 ppm to 645 ppm. An increase in concentration of carotenes during ripening of the fruit coincide with the time when lipids were synthesised (Tan *et al.*, 1997; Prada *et al.*, 2011).

CONCLUSION

The results of oil content, FA composition, FFA, DOBI and carotenes content of CPO extracted from palm fruits of different ripeness were analyses and compared with CPO extracted from other cultivars. It was found that the oil content present in this study reached maximum values when ripe fruits were harvested. At this stage, oil content in the fruits was between 27.4%-34.7%, major fatty acid being palmitic, oleic, linoleic and stearic acid. Ripe fruits showed higher FFA, carotenes content and DOBI value compared to over ripe and under ripe fruits.

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