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Analysis of carotene content in CPO to assess the quality of RBD palm olein (cooking oil)

Puji Lestari¹, Yosy Cinthya Eriwaty Silalahi², Faisal Yusuf³

¹Faculty of Pharmacy, Institut Kesehatan Deli Husada Deli Tua, Deli Serdang, Indonesia

²Faculty of Health and Pharmacy, Universitas Sari Mutiara, Medan, Indonesia

³Faculty of Pharmacy, Sekolah Tinggi Ilmu Kesehatan Arjuna, Toba Samosir, Indonesia

ARTICLE INFO	ABSTRACT
<i>Article history:</i> Received Jun 10, 2025 Revised Jun 17, 2025 Accepted Jun 24, 2025 <i>Keywords:</i> Carotene Cooking Oil CPO DOBI Quality	Fresh fruit bunches (FFBs) from oil palms serve as the primary raw material for crude palm oil (CPO) production. Among various quality parameters, the Deterioration of Bleachability Index (DOBI) and carotenoid content—particularly β-carotene—are critical indicators of CPO quality. A higher DOBI value generally reflects a lower concentration of oxidized carotenes, which facilitates the bleaching process, as the color imparted by oxidized carotenoids is more difficult to remove through conventional heating. The samples are CPO were randomly collected from production facilities located in North Sumatra. Range DOBI is 2.27 – 2.66 and range carotene 401 – 492 ppm. Average DOBI is 2.44 is showing that the quality of CPO is fair and can be used to processed as cooking oil. <i>This is an open access article under the CC BY-NC license.</i> 

Corresponding Author:

Puji Lestari,
Pharmacy,
Institut Kesehatan Deli Husada Deli Tua,
Jl. Besar No.77, Deli Tua Timur, Kec. Deli Tua, Kab. Deli Serdang, Sumatera Utara, 20355, Indonesia
Email: pujilestari87@gmail.com

INTRODUCTION

As the world’s leading producer of palm oil, Indonesia places significant importance on quality, which serves as a key attribute in the trade and commercial value of edible oil products (Lestari et al., 2024). The quality standard for CPO as stated in SNI 01-2901-2006 includes a maximum of 5% free fatty acid (FFA) content, 0.25% moisture, and 0.25% impurities. Another parameter that can determine the quality of CPO is the DOBI, although it has not yet been included in the official SNI standard. Nevertheless, several domestic refining industries and importing countries have required DOBI as a quality specification for CPO (Hasibuan, 2018). The degradation of the bleaching index (DOBI) can be used to approximate the impurity level for CPO. While a low DOBI value suggests low levels of carotene and/or oxidized sludge oil, both of which might be harmful to the processing of CPO, a high DOBI value (e.g., DOBI > 2.99) indicates excellent quality CPO and ease of processing (Wong et al., 2023).

Elaeis guineensis fruit's mesocarp is the source of palm oil (Steffens et al., 2024). Palm oil is rich in various minor components, including tocopherols, tocotrienols, squalene, phytosterols, phenolic compounds, and carotenoids. Among the carotenoids present in CPO, β -carotene (56%) and α -carotene (35%) are the most abundant, both known for their provitamin A properties (Hoe et

al., 2020). The oil palm (*Elaeis guineensis*) fruit is used to make RBD palm olein, a cooking oil. Quality is an important and useful aspect of edible oil commodities and their transactions from a business standpoint (Lestari et al., 2024).

Fresh fruit bunches (FFBs) from oil palms serve as the primary raw materials for CPO mills. The inherent properties and quality of these FFBs significantly influence the attributes of the palm oil extracted and its derived products (Wening et al., 2012). Palm oil is separated to provide two different fractions to liquid palm olein and solid palm stearin by fractionation process (Ahmad Bustamam et al., 2022). CPO is converted to palm oil by heating it to 270°C for degumming, bleaching, and deodorization. The liquid fraction known as palm olein is then separated (Loganathan et al., 2020). In many nations, RBD Palm Olein is a common used as cooking oil (Lestari et al., 2024).

In experience, during 77 days of storage at room temperature (28 ± 1 °C) and 60 °C, the oxidation indicators and minor components of freshly extracted crude palm oils and low free fatty acid (FFA) changed. While the amount of carotene and vitamin E dropped over time, parameters including the peroxide value (PV), FFA, and extinction coefficients (K233 and K269) increased. After storage at 60 °C, the carotene content in low FFA crude palm oil dropped to 4.24 ppm and DOBI values declined, apart from recently extracted oil that is kept at room temperature (Tan et al., 2017).

The amount of carotene in an oil sample determines its bleachability. However, the oil's oxidation state, antioxidant content, and contaminant presence have a greater impact on bleachability (Squire, 2005).

Research findings indicate that prolonged storage duration negatively affects DOBI and carotenoid content, causing both to decrease. At the same time, it leads to an increase in free fatty acid (FFA) levels, moisture content, and impurities (Basyuni et al., 2017). Beta-carotene is a provitamin A that can be converted into vitamin A in the body through metabolic processes. It is also one of the key indicators used to assess the quality of crude palm oil (CPO) in international trade (Saputra Harahap et al., 2020). Approximately 90% of global vegetable oil production and consumption comes from palm oil, due to its versatility and widespread use across various industrial sectors. As the world's largest producer of palm oil, Indonesia also holds the position as the leading global exporter (Tiara et al., 2023). The palm oil commodity is expected to experience continued growth in the foreseeable future. This trend is primarily driven by the sustained consumer preference for palm oil over alternative vegetable oils, such as soybean oil, corn oil, and sunflower oil, due to its cost-effectiveness, functionality, and high yield characteristics (Prayitno & Widyawati, 2021).

β -carotene functions as both an antioxidant and a natural coloring agent commonly utilized in food products (Mezzomo & Ferreira, 2016). The naturally occurring substances called carotenoids are what give palm oil its reddish-orange hue. These compounds support human health by boosting the immune system and functioning as antioxidants (Puteh et al., 2022). The ubiquitous supplementary pigments known as carotenoids are essential for both photosynthesis and defending living things against photodynamic harm. β -Carotene's antioxidant properties and ability to effectively squelch singlet oxygen and other reactive free radicals are well-known (Sandhiya & Zipse, 2022).

FFBs from oil palms serve as the primary raw materials for CPO mills. The inherent properties and quality of these FFBs significantly influence the attributes of the palm oil extracted and its derived products (Wening et al., 2012). The Deterioration of Bleachability Index (DOBI) and carotenoids are crucial indicators of CPO quality (Nokkaew et al., 2019).

RESEARCH METHOD

Materials

The samples were randomly selected from crude palm oil produced in North Sumatra. Before being used, samples were heated to 60°C and well agitated to make sure complete melting and homogenization. Analytical grade compounds are all utilized.

Determination of carotene content

The carotene content in crude palm oil, expressed as β -carotene in parts per million (ppm), was measured using a UV-vis spectrophotometer at 446 nm, following the method described in (Baharin et al., 2001). Samples were homogenized, accurately weighed (± 0.0001 g), and diluted in a 25 mL volumetric flask. A 1 mL aliquot from each of the three varieties was further diluted with n-hexane to the desired concentration. The absorbance was recorded at 446 nm using a 1 cm quartz cuvette, with cuvette error accounted for at the same wavelength (Basyuni et al., 2017). The carotene concentration was then calculated according to Equation 1:

$$\text{Carotene (ppm)} = 25 \times \frac{383}{100 \times W} (as - ab)$$

Where: as = absorbance of the sample, ab = cuvette error, W = weight of sample (g)

Determination of DOBI

The MPOB Test Method was used to calculate DOBI. After measuring out around 0.10 grams of the oil sample, it was put into a 25 mL volumetric flask and diluted with isooctane until it reached the calibration line. After being moved into a 10-mm quartz cuvette, the resultant solution was examined at wavelengths of 446 and 269 nm using a UV-Vis spectrophotometer (Chew et al., 2021). The DOBI value was then calculated using Equation 2:

$$DOBI = \frac{a_{446}}{a_{269}}$$

Where a_{446} = absorbance values of the liquid samples at 446 nm, a_{269} = absorbance values of the liquid samples at 269 nm.

RESULTS AND DISCUSSIONS

The research and data analysis results is presented in Table 1. These results show result DOBI and Carotene Content from CPO (crude palm oil) samples. Ten CPO samples were examined, all of which originated from CPO produced in North Sumatra.

Table 1. Carotenoid content from CPO

Sample	DOBI (ppm)	Carotene (ppm)
1	2.55	455.95
2	2.27	491.54
3	2.66	401.24
4	2.33	437.84
5	2.48	423.44
6	2.32	401.56
7	2.41	482.49
8	2.38	460.57
9	2.36	462.63
10	2.65	490.93

Based on the test results of samples, the DOBI values ranged from 2.27 to 2.66, and the β -carotene content ranged from 401.24 ppm to 491.54 ppm. In general, all samples showed DOBI values above 2.2, indicating that the quality of the CPO was relatively good and still within

acceptable limits according to industry standards. A high DOBI value reflects good oxidative stability, minimal oxidation, and suggests that the palm fruits were likely processed shortly after harvesting. The carotene levels were also relatively high across most samples, with the highest value observed in sample 2 (491.54 ppm) and the lowest in sample 3 (401.24 ppm). Carotene acts as a natural antioxidant and contributes to the color and nutritional value of the oil. High carotene concentrations are generally positively correlated with DOBI values, since oxidative degradation of CPO leads to carotene breakdown, which in turn reduces both parameters.

However, even though there is a positive trend between carotene content and DOBI, the relationship is not always linear. For example, sample 2 had the highest carotene content but one of the lowest DOBI values (2.27). This suggests that despite the high carotene level, oxidation may have occurred in other components of the CPO, negatively affecting the DOBI value. Conversely, sample 3 showed the highest DOBI value (2.66) but the lowest carotene content (401.24 ppm). This may indicate that carotene had already degraded, but oxidation products had not yet significantly accumulated, or the initial carotene content of the oil was inherently low.

PORIM (Palm Oil Research Institute of Malaysia) has established CPO quality classifications based on DOBI measurements as table 2 (Baharin et al., 2001). A high initial DOBI indicates that the oil was less oxidized, which results in an RBD olein that is less likely to rancidize early, has lower post-refining peroxide and anisidine values, and has greater oxidative stability while being stored (Véronique Gibon et al., 2007).

Table 2. Quality classifications based on DOBI

DOBI (ppm)	Carotene (ppm)
< 1.7	Sludge palm oil
1.8 - 2.3	Poor
2.4 - 2.9	Fair
3.0 - 3.2	Good
> 3.3	Excellent

DOBI as an Indicator of the Ratio Between Carotene and Oxidation Products

DOBI reflects the ratio between absorbance at 446 nm representing carotene content and absorbance at 269 nm, which corresponds to secondary oxidation products such as aldehydes and ketones formed during oil degradation. In essence, a higher DOBI value indicates a greater proportion of carotene relative to oxidative by products. Reduced levels of oxidized carotenes are indicated by a greater DOBI value, making the oil easier to bleach through heating, since color caused by oxidized carotenes is challenging to eliminate. DOBI values ranging from 2.5 to 4.0 reflect moderate to good quality crude palm oil, while values below 2.0 suggest poor quality oil that is more difficult to bleach effectively (Silva et al., 2014).

Carotene as a Marker of Oil Freshness and Quality

If carotene undergoes oxidation commonly due to delayed processing of FFB its concentration decreases, leading to a lower DOBI value. β -carotene is a natural pigment responsible for the reddish-orange color of CPO. It also acts as a natural antioxidant but is highly susceptible to degradation when exposed to heat, light, or oxygen (Raj et al., 2021). If carotene undergoes oxidation commonly due to delayed processing of FFB, its concentration decreases, leading to a lower DOBI value.

CONCLUSION

Mean DOBI from sample CPO is 2.44 ± 0.14 , Range DOBI is 2.27 – 2.66 and range carotene 401 – 492 ppm. Based on PORIM ranges, average DOBI is 2.44 is showing that the quality of CPO is fair, all oils exceed the industry minimum of 2.2 for commercial acceptance. The industry must use best practices for handling Fresh Fruit Bunch (FFB) and processing time management, avoid FFB

bruising and overripe fruit, maintain optimal sterilization conditions in order to maintain high DOBI value in CPO. Higher DOBI and carotene scores are rewarded with better pricing under grading schemes, which will encourage growers and millers to use better methods, cutting waste and raising quality.

Further research is expected to be able to investigate the effects of bleaching and deodorization, particularly under different temperatures and processing durations on DOBI, as well as on trace oxidation products such as 3-MCPD, glycidyl esters, and volatile compounds like ketones and aldehydes. This analysis will help determine whether these refining steps diminish or conceal oxidative markers, and how they ultimately influence the stability of the final oil product.

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