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Application News

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UV-1280 / Spectrophotometric Analysis / Palm Oil

UV-VIS Spectroscopic Analysis of Crude Palm Oil and Palm Oil Products with ISO and MPOB Test Methods

❑ Introduction

Palm oil is an edible oil extracted from the fruit of oil palm (*Elaeis guineensis*). Due to the abundance of oil palm in Southeast Asia and Africa, as well as its relatively lower cost, palm oil has become one of the largest contributors to the global oil market. Crude palm oil (CPO) is usually refined, deodorized and bleached for wider usages such as domestic cooking and food processing. The quality of processed palm oil is governed by several factors such as the oxidative status, stability, bleachability and purity of CPO [1]. Therefore, the quality of CPO is essential for the production of high-quality refined palm oils. Ultraviolet-visible (UV-VIS) spectrophotometers are widely used for qualitative and quantitative analysis due to its ease-to-use operation and short sample analysis time. In this application news, Shimadzu UV-1280 UV-VIS spectrophotometer, a combined monitor double beam spectrophotometer was used for the analysis of CPO and refined palm oil products.

❑ Experimental

A CPO sample was provided by a palm oil manufacturer in Malaysia. Commercially available edible palm oils were purchased from local markets. Analytical grade chemical reagents and solvents used were purchased from Sigma Aldrich, USA and Merck Millipore, Germany. The CPO and palm oil samples were analysed according to the following tests - deterioration of bleachability index (DOBI), carotene content, anisidine value and phosphorous content. All measurements were conducted using the Shimadzu UV-1280 UV-VIS spectrophotometer (Figure 1).

Figure 1: UV-1280 UV-VIS spectrophotometer

DOBI of CPO was determined in accordance with ISO 17932:2011 [2] and Malaysian Palm Oil Board (MPOB) test method p2.9:2004 [3]. DOBI is defined as the numerical ratio of spectrometric absorbance at 446 nm to 269 nm. The CPO sample was dissolved in isooctane (2,2,4-Trimethylpentane) and measured using a 1 cm path length quartz cuvette. The absorbance value of the solution at 446 nm and 269 nm was measured and repeated for 5 times.

Carotene content was measured based on ISO 17932:2011 [2] and MPOB test method p2.6:2004 [3]. The CPO sample was diluted in isooctane and the absorbance value at 446 nm was measured using a 1 cm path length quartz cuvette. The sample was measured for 5 times.

Determination of carotene content, expressed as β-carotene, is calculated using the formula below:

$$\text{Carotene content (mg/kg)} = 383E / Lc$$

Where:

E = observed difference in absorbance value between the sample solution and the solvent iso-octane

L = path length of the cell in cm

c = concentration of the sample solution in g/100 mL

Phosphorus content was determined using MPOB test method p2.8 part 1(b):2004 [3], which is technically equivalent to ISO 10540-1 [4]. The palm oil samples were ashed with magnesium oxide in furnace for 2 hours at 850°C. The ashed samples were dissolved using aqueous nitric acid, followed by reaction with aqueous ammonium vanadate solution and acidic aqueous ammonium molybdate solution. After 20 minutes, the mixture was measured using a 5 mm path length quartz cuvette at 460 nm. The phosphorus content is calculated as follows:

$$\text{Phosphorus content (mg/kg)} = (25m_1) / m$$

where:

m_1 = concentration of phosphorus calculated from the calibration curve in µg/mL

m = mass of oil sample used in g

To determine anisidine value according to MPOB test method p2.4:2004 [3] and ISO 6885 [5], the samples were first diluted in isooctane solution. The sample solution was then reacted with p-anisidine dissolved in glacial acetic acid solution for 8 minutes. The absorbance value at 350 nm was measured using a 1 cm path length quartz cuvette. The anisidine value is calculated based on the equation below.

$$\text{Anisidine value} = 100\ QV\ [1.2(A_1 - A_2 - A_0)] / m$$

where:

Q = Concentration of the sample solution in g/mL

V = Volume used to dissolve the oil sample in mL

A_1 = Absorbance of sample solution after reaction with *p*-anisidine in glacial acetic acid

A_2 = Absorbance of isooctane solution after reaction with *p*-anisidine in glacial acetic acid

m = Mass of oil sample used in g

❑ Result and Discussion

DOBI and carotene content

DOBI indicates the bleachability of CPO based on the amount of carotene and secondary oxidation products present in the oil. It is affected by the quality of oil palm fruits and storage of CPO. Hence, the test is a measure of the ease of refining crude palm oil and its shelf life. A low DOBI value can also indicate difficulty in refining the oil to a low Lovibond colour [2].

The wavelengths used for determination of DOBI are 269 nm and 446 nm which are marked by arrows as shown in the UV-VIS spectrum of CPO in Figure 2. The peak at 269 nm corresponds to the amount of secondary oxidation products, whereas the peak at 446 nm represents the amount of carotenes in CPO [6]. Good quality palm oils have large amount of carotene and lower amount of secondary products. Therefore, higher DOBI value correlates to better CPO quality.

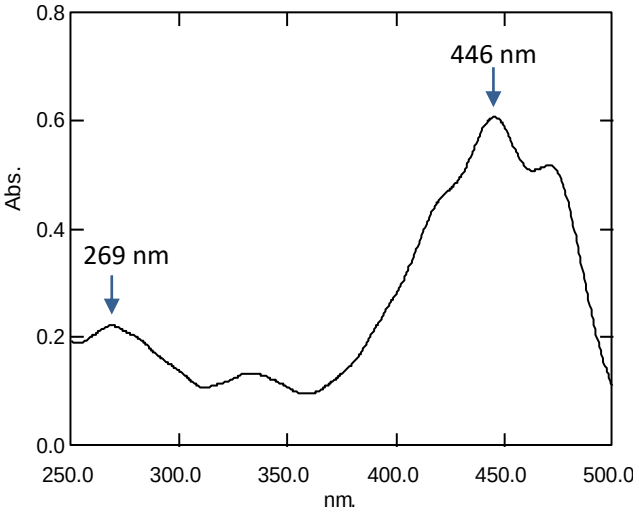

Figure 2: UV-VIS spectrum of CPO

The repeated measurements of absorbance value at both wavelengths and the calculated DOBI value are shown in Table 1. A relative standard deviation (RSD) of less than 2 % indicates that the result is reproducible. The average DOBI value for the CPO sample is 2.72. This value is within the acceptable range of 2.4 - 2.9 which indicates that the CPO [7] is of high quality.

Table 1: DOBI results of CPO

No.	Abs at 446 nm (A446)	Abs at 269 nm (A269)	DOBI Value (A446/A269)
1	0.611	0.224	2.73
2	0.610	0.228	2.68
3	0.616	0.224	2.74
4	0.618	0.224	2.76
5	0.619	0.230	2.70
Average	0.615	0.226	2.72
RSD (%)	0.66	1.25	1.17

Table 2 shows the repeated measurements of absorbance value at 446 nm and the carotene content of the CPO sample. The carotene values of the CPO in Table 2 meets the criteria of Malaysia Standards for palm oil [8], which is the range of 474 – 689 mg/kg. The measurements also have good reproducibility with RSD of less than 2%.

Table 2: Carotene content of CPO

Measurement	Abs at 446 nm	Carotene (mg/kg)
1	0.611	584
2	0.610	583
3	0.616	589
4	0.618	591
5	0.619	592
Average	0.615	588
RSD (%)	0.66	0.70

Phosphorus content in CPO and edible palm oil

The total phosphorus content is a measurement of the total phosphatides impurities, such as phospholipids, or gums, and some inorganic phosphates present in the oil. Prior to deodorization step, the phosphorus impurities are removed during refinery process to avoid colour fixation [9].

The phosphorus calibration curve is shown in Figure 3. A good correlation coefficient of 0.99992 was obtained.

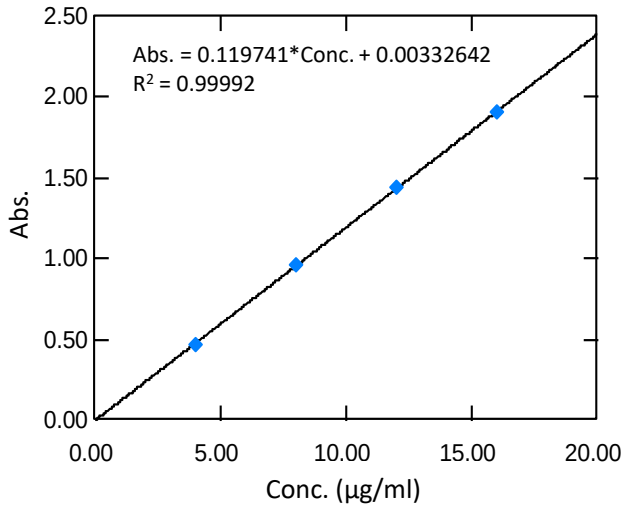

Figure 3: Phosphorus calibration curve

Table 3 shows the absorbance values obtained from 10 replicate measurements of blank solution at 460 nm and the calculated standard deviation (SD). A low SD of 0.0002 was obtained. One method to calculate the limit of quantitation (LOQ) is to use the concentration equivalent to the absorbance value of 10 times the SD of blank. The LOQ of phosphorus in this analysis is 0.018 µg/mL.

Table 3: Ten absorbance values of blank solution and calculated SD

No.	Abs (460 nm)
1	0.00026
2	0.00061
3	0.00053
4	0.00055
5	0.00070
6	0.00061
7	0.00038
8	0.00104
9	0.00070
10	0.00108
SD	0.00022
LOQ	(0.00022 x 10) / 0.119741 = 0.018 µg/mL

The phosphorus content of the CPO sample and two different brands of edible palm oil samples are shown in Table 4. The results show that the CPO contain a higher phosphorus content of 4.34 mg/kg as compared to the two edible palm oil samples. This is due to the present of phospholipids or gums in the CPO. In edible palm oil, these phospholipid compounds are removed through degumming during the refining process as it may interfere the stability of oil products in later stages [10]. Therefore, edible palm oils have much lower phosphorus contents.

Table 4: Phosphorus content in CPO and edible palm oil

Sample	Phosphorus Content (mg/kg)
CPO	4.34
Palm Oil (Brand A)	0.52
Palm Oil (Brand B)	1.39

Anisidine value in CPO and edible palm oil

The anisidine test measures the amount of α, β-unsaturated aldehydes present in oil. A higher quality oil has a lower anisidine value.

Table 5 shows the anisidine value sobtained for the CPO and two different brands of edible palm oil samples. According to the Malaysia Standard for palm oil, the maximum anisidine value for standard quality CPO is 5.0 whereas for refined palm oil is 4.0 [8]. The measured anisidine values of the CPO and the 2 edible palm oil samples are well within the Malaysia Standard specifications.

Table 5: Anisidine value in CPO and edible palm oil

Sample	Anisidine Value
CPO	1.98
Palm Oil (Brand A)	1.53
Palm Oil (Brand B)	0.92

❑ Conclusions

Quality control of CPO and palm oil products based on ISO and MPOB UV-VIS spectroscopic methods can be done using the UV-1280 UV-VIS spectrophotometer as demonstrated in this application news.

❑ References

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