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Sultan Qaboos University

The Intended Blessed Tree in the Quran - Is it Olive Tree or Palm Oil Tree?

Mostafa Koutb

Current Address: Department of Biology, Faculty of Applied Science, Umm Al-Qura University, 715 Makkah, Saudia Arabia. Permanent address: Department of Botany and Microbiology, Faculty of Science. Assiut University, 71516 Assiut, Egypt. Email: mmkoutb@uqu.edu.sa.

ABSTRACT: This article aims to provide an alternative scientific interpretation for verse 35 in Surat An-Nur. This verse addresses the very famous simile in the Quran which describes the light of Allah. In this verse Allah mentioned that 'Allah (is the) light (of) the heavens and the earth. (The) example (of) His Light (is) like a niche in it (is) a lamp; the lamp (is) in a glass, the glass as if it were a star brilliant (which) is lit from a tree blessed - an olive, not (of the) east and not (of the) west, would almost its oil glow, even if not touched it fire' [1]Despite all the most commentators who have addressed this verse singled the olive tree as the blessed tree, the intended tree still has one characteristic that is enigmatic. Regarding this characteristic 'not east and not west', all previous interpretations directed this characteristic to the compass directions. But they did not give any logical and acceptable justification. Dealing with this verse with another linguistic concept, particularly with three words in the verse 'zaytūnatin, sharqiyyatin, and gharbiyyatin' can change the story of the intended blessed tree. The first word in the Arabic language could be considered as an adjective for exaggeration meaning a high oil producer rather than the genus olive. More interestingly, this word has been mentioned as an indefinite noun without 'Al' which makes the noun definite when it is used as a prefix; therefore, in this case, it is not specific to olive but it could refer to any tree producing high amount of oil. The second word 'sharqiyyatin' comes from the verb 'sharek', which in Arabic means, particularly for dates, that they became reddish in color as a sign of maturity. The third word 'gharbiyyatin' derives its meaning from the verb 'gharb' which means it became black. When these new meanings are applied to the verse, the first word will now mean any tree with high oil production. The other two words, will mean reddish and black colors of the fruit not the east and west directions. These two characteristics could be considered to be distinguishable features for palm oil tree not for olive trees. In this paper two additional evidences supporting this idea have been addressed. Therefore, the palm oil tree, particularly the subspecies *nigrescens* could be a potential candidate for the blessed tree in the Quran.

Keywords: Palm oil tree; Olive tree; Scientific interpretation of Quran; Carotenoids; Almost glow.

الشجرة المباركة في القرآن - هل هي شجرة الزيتون أم شجرة نخيل الزيت؟

مصطفى قطب

الملخص: هذا البحث محاولة لطرح تفسير علمي بديل للآية القرآنية 35 من سورة النور. هذه الآية تتناول المثل القرآني المشهور الذي يصف نور الله. في هذه الآية يقول الله تعالى 'ٱللَّهُ نُورُ ٱلسَّمَٰوَٰتِ وَٱلۡأَرۡضِۚ مَثَلُ نُورِهِۦ كَمِشۡكَوٰةٖ فِيهَا مِصۡبَاحٌۖ ٱلۡمِصۡبَاحُ فِي زُجَاجَةٍۖ ٱلزُّجَاجَةُ كَأَنَّهَا كَوۡكَبٞ دُرِّيّٞ يُوقَدُ مِن شَجَرَةٖ مُّبَٰرَكَةٖ زَيۡتُونَةٖ لَّا شَرۡقِيَّةٖ وَلَا غَرۡبِيَّةٖ يَكَادُ زَيۡتُهَا يُضِيٓءُ وَلَوۡ لَمۡ تَمۡسَسۡهُ نَارٞ (النو-35) .على الرغم من أن كل المفسرين الذين فسروا هذه الآية ذكروا أن الشجرة المباركة المقصودة في المثل قد تكون هي شجرة الزيتون إلا أن هناك صفة في هذه الشجرة ما زالت غامضة. هذه الصفة هي أن هذه الشجرة تتميز بأنها لا شرقية ولا غربية، وحيث أن كل التفسيرات السابقة وجهت هذه الصفة إلى الإتجاهات الجغرافية الأصلية إلا أنها لم تقدم مبررات مقبولة لهذا التفسير. لكن بالتعامل مع هذه الصفة - من وجهة نظر لغوية مختلفة، وتحديدا بالمعنى اللغوي للكلمات الثلاث: زيتونة و شرقية وغربية ، يمكن أن يغيرفهمنا لقصة الشجرة المباركة. الكلمة الاولى وهي 'زيتونة' في اللغة العربية تعني صيغة مبالغة دلالة على كثرة إنتاج الزيت وجدير بالذكر أن هذه الكلمة ذكرت في هذه الحالة بصيغة النكرة وهي تعني العموم وليست خاصة لجنس معين. بينما الكلمة الثانية وهي 'شرقية' جذر هذه الكلمة هو 'شرق' وهي تحمل معان عدة وخصوصا عندما تستخدم للبلح أي 'شرق البلح' تعني أحمرّ لونه وهذه إشارة للنضج. والكلمة الثالثة هي'غربية' وجذر هذه الكلمة في اللغة هو 'غرب' وهي أيضا لها معان عدة منها غرب الشيء يعني أصبح أسود اللون. وعند تطبيق هذه المعاني على الشجرة المباركة ، فإنها تؤول إلى معنى 'كثرة إنتاج الزيت'، وأن لون ثمرتها لا حمراء ولا سوداء هو لشجرة نخيل الزيت وليست شجرة الزيتون فقط. هناك أدلة أخرى تثبت هذه الفكرة ستتم مناقشتها في البحث. ومن

[1] 'ٱللَّهُ نُورُ ٱلسَّمَٰوَٰتِ وَٱلۡأَرۡضِۚ مَثَلُ نُورِهِۦ كَمِشۡكَوٰةٖ فِيهَا مِصۡبَاحٌۖ ٱلۡمِصۡبَاحُ فِي زُجَاجَةٍۖ ٱلزُّجَاجَةُ كَأَنَّهَا كَوۡكَبٞ دُرِّيّٞ يُوقَدُ مِن شَجَرَةٖ مُّبَٰرَكَةٖ زَيۡتُونَةٖ لَّا شَرۡقِيَّةٖ وَلَا غَرۡبِيَّةٖ يَكَادُ زَيۡتُهَا يُضِيٓءُ وَلَوۡ لَمۡ تَمۡسَسۡهُ نَارٞۚ' (النور – 35)

ثم يمكن القول بأن الشجرة المباركة في هذه الآية قد تكون هي شجرة نخيل الزيت وخصوصا تحت النوع *Elaeis guineensis .nigrescens* subspecies.

الكلمات المفتاحية: شجرة نخيل الزيت؛لا شرقية ولا غربية؛ لا حمراء ولا سوداء لون الثمرة الناضجة؛ كاروتينيدات؛ يكاد زيتها يضئ.

1. Introduction

Generally, similes in the Quran are very crucial and popular as an eloquent language style to simplify the meaning for humankind. One of these similes is represented in the Verse 35 in Surat An-Nur. In this verse Allah mentioned that 'Allah (is the) light (of) the heavens and the earth. (The) example (of) His light (is) like a niche in it (is) a lamp; the lamp (is) in a glass, the glass as if it were a star brilliant (which) is lit from a tree blessed - an olive, not (of the) east and not (of the) west, would almost its oil glow, even if not touched it fire' (An-Nur - 35). The oil palm tree, also known as '*Elaeis guineensis Jacq*', is a plant that grows well in tropical regions. The oil palm tree was developed and used as an agricultural crop [1]. The use of palm oil in food dates back to 5000 BC, as evidenced by the discovery of the oil in the tomb at Abydos in Egypt [2]. Oil palm can accumulate up to 90% oil in its mesocarp, the highest level observed in the plant kingdom. In contrast, the closely related date palm accumulates almost exclusively sugars [3]. Oil palm can produce higher amounts of oil than other oil-producing species (about nine times more than soy and 4.5 times more than rapeseed) per unit of land area [4]. Oil palm is now the most productive oil crop in the world (3.5 tons/ha/y), with 36% of global production [5]. Most palm oil is derived from the mesocarp which, can comprise up to 90% of the dry weight. This is, by far, the highest oil content reported for any plant tissue [3]. The fuel properties of optimized biodiesel were found to be comparable to those of diesel and were in accordance with the latest biodiesel standards. The calorific value of optimized Tung seed biodiesel was 9100 Kcal/Kg which is lower than diesel fuel [6]. The flash and fire point of palm seed biodiesel were determined to be 180 °C and 194 °C, respectively which are higher than diesel fuel.

Regarding the value of palm tree as a genus in the Quran, it has been mentioned 20 times throughout the Quran, while the olive tree was mentioned five times in addition to this time under investigation. If I could prove that the intended tree in this verse is the palm tree, it will be recorded in the Quran 21 times. Moreover, the palm tree also gained the attention in Sunnah, as Narrated Ibn `Umar: 'The Prophet (PBUH) said, 'Amongst the trees, there is a tree, the leaves of which do not fall and is like a Muslim. Tell me the name of that tree?' Everyone started to think about the trees in the desert areas. And I thought of the date palm tree. The others then asked, 'Please inform us what is that tree, O Allah's Messenger (PBUH)?' He replied, 'It is the date-palm tree'. Additionally, Anas ibn Malik reported that the Prophet, may Allah bless him and grant him peace, said, 'If the Final Hour comes while you have a shoot of a plant in your hands and it is possible to plant it before the Hour comes, you should plant it.' Although several plant species can propagate by shoots when this process is mentioned in the Arabic language, it is understood by default to be about the palm tree. Accordingly, all the above hints recorded about the palm tree in the Quran and Sunnah reflect the important value of this tree. As mentioned above, regarding the common interpretations of the verse under investigation, all previous interpretations directed this character to the compass directions. But they did not give any plausible and acceptable justification. Most of the previous scholars directed the word 'zaytūnatin' to the genus olive and the words 'sharqiyyatin, gharbiyyatin' have been directed to east and west directions [7,8]. Also, some scholars have mentioned that this tree is a desert tree, others mentioned that in the middle of the trees, and others mentioned that it is not an earth tree rather it paradise tree [8,9]. Moreover, when Allah wanted to specify olive itself, he mentioned in Surat Al-Tin 'By the fig, and the olive' (Al-Tin – 1) and in Arabic 'wal-tīni wal-zaytūn'.

In this current paper, I try to give a new vision about the intended blessed tree in this verse by using other alternative Arabic meanings to the linguistically accepted words 'zaytūnatin', 'sharqiyyatin' and 'gharbiyyatin'. Additionally, by directing the pronoun in 'not east and not west' to the palm oil fruit and particularly to its color orientation. This must not be understood as swimming against water current, because all the previous commentators reported that the intended blessed tree in this verse is the olive tree rather it is considered to be a different insight and concept for a new interpretation. Recently, a new insight as a scientific interpretation of the verse 43 in Surat Al-kahf has been introduced, although all previous commentators have provided a completely different concept of interpretation [10]. Therefore, in this manuscript I am trying to give an alternative interpretation to this verse with plausible justifications that might change the story of the candidate for the blessed tree in the Quran from the olive tree to the palm oil tree.

2. Fruit color and ripening

One of the main challenges in the fruit industry is to identify the right fruit to harvest. To preserve and maintain the quality of palm oil products, it is crucial to harvest the palm oil fresh fruit bunch (FFB) at the right stage [11]. According to Fadilah, *et al*. [12], most palm oil fruits grading is based on two, three or four stages that are unripe, reddish black as under-ripe, red as ripe, and reddish orange as over-ripe. Other research by [13,14,15] focused on two stages, which are ripe and unripe of FFB and achieved high accuracy results.

Some researchers have determined and evaluated the maturity of oil palm fruits using a variety of techniques, including hyperspectral imaging [16,17], fluorescence detection [18,19], computer vision and an optical sensor [20,21], inductive detection [22,23], near-infrared spectroscopy [24,25], laser detection [25], and lidar detection [26]. Advanced color-based machine vision was able to categorize distinct fruits into correct groups with an accuracy of 90% [27,28]. Further studies have been conducted with high accuracy values, including 95.48% [29], 97.9% [30] and 98.70% [31].

3. Not east and not west

First, the fruit of the palm oil tree is the intended by this description in the verse 'tree blessed - an olive, not (of the) east and not (of the) west', despite Allah mentioned apparently the tree. There are three clues that can support this approach, first, the fruit can be used to represent the whole tree as Allah mentioned in the story of Adam and Eve. 'Then when they both tasted the tree' (Al-A'raf – 22), in this case, it could be they tested the fruit or not. Secondly, Allah mentioned that this tree is 'zaytūnatin' which means highly produced oil and the source of oil production is the fruit not the whole tree. Thirdly, when Allah mentioned that 'is lit from a tree blessed' this means the lamp is lit by the oil and not by the whole tree, so the oil in this case represented the tree as the fruit can.

The Arabic verb 'sharek' which is the source of the word 'sharqiyyatin', has various lexical meanings, including the east direction and particularly, for dates means colored reddish, and in reference to the face it refers to reddish shyness. In addition, the word 'Asharqiyy' in Arabic means the red pigment [32]. Moreover the word 'shark' does not always refer to the east direction as Prophet Mohamed (PBUH) mentioned in Hadith An-Nawwas b. Sam'an said he heard the Apostle (PBUH) say: 'On the Day of Resurrection the Qur'an and those who acted according to it will be brought with Surat Al-Baqara and AI 'Imran preceding them. The Messenger of Allah (PBUH) likened them to three things, which I did not forget afterwards. He (the Holy Prophet) likened them to two clouds, or two black canopies with 'shark' (light) between them, or like two flocks of birds in ranks pleading for one who recited them'. In this case, the word 'shark' in Arabic means 'light' or 'silt' or 'barrier between. ' On the other hand the verb 'gharb', which is the root of the word 'gharbiyyatin' in Arabic language, also has several meanings, including west direction and for an object means it became blackish. As Allah mentioned 'And in the mountains (are) tracts, white and red (of) various [their] colors, and intensely black' (Fatir – 27). In Arabic, the term 'gharābību' means black, and it has the same root in the language with the word 'gharbiyyatin'. Moreover the word 'Algharb' in Arabic means a big, green tree from which a black material like tar is produced to stain the camels [32]. Therefore, applying the color meaning to these words on what is mentioned in the verse 'not east and not west' will suggest the fruit color is non-pure reddish or non-pure blackish, but rather a combination of the two colors (reddish and black) within the same fruit. It is interesting to note that the Quran frequently uses this type of description, like when Allah mentioned in the description of the cow belonging to the Bani (children of) Israel, that 'It is a cow not old and not young' (Al-Baqarah - 68). The fact that this color exactly matches the color of fruit in its mature stage is more interesting (Figure 1).

Figure 1. Fruit exocarp colour phenotypes. (a) Individual oil palm fruits of a subspecies of *nigrescens* fruit bunch. Unripe fruits are deep-violet to black at the apex (visible in the bunch), and undergo minimal colour change upon ripening [33].

Fruit colour is an important trait in terms of fruit harvesting and, therefore, oil yield. Most oil palms are producded from the type of *nigrescens* or *virescens* fruit [33]. The *nigrescens* variety of oil palm makes up the majority of oil palm production. Fadilah, *et al*. [12] developed an interesting categorization of the ripeness stage into four groups: unripe purplish black, under-ripe reddish black, ripe red, and overripe reddish orange (table 1).

Table 1. The ripeness stage of palm oil FFB by Malaysian Palm Oil Board [12].

Image	Stage	Color characteristic
	Unripe	Purplish Black
	Under-ripe	Reddish black
	Ripe	Red
	Overripe	Reddish orange

4. Another evidence could support this interpretation

As it has been mentioned above, the Arabic verbs 'sharek' and 'ghareb' have several meanings, including the compass directions east and west. Even if we apply this meaning in the verse, it will also lead to the conclusion that the description of 'not east nor west' may apply to the fruit's color. This exact description describes the color orientation on the individual fruit. Let's suppose you were requested to describe the palm oil fruit colored with two different colors, using just two words. Indeed, it would be a very difficult job to express this situation in two words. Now, if we take into consideration the oblate ellipsoidal rotation of the earth around its minor axis in front of the sun, it has fours directions, two of which are north and south on the minor axis up and down ends, while the other two are east and west. If we divide the ellipsoidal shape of the earth longitudinally along the minor axis, two halves eastern and western hemispheres will be revealed. If we apply this description to the fruit, which has an ellipsoid shape that is almost identical to that of the Earth’s shape, it’s mature ovary has a minor axis capped by the stigma and at the posterior end an ovarian base detached from the receptacle in the inflorescence. So, if we divide this fruit in half along its minor axis, it will give two parts, east and west, comparable to the Earth. As Allah mentioned only the two words 'not east and nor west' that means the orientation of the two colors of the fruit should not be distributed in these two parts. The orientation of the colors - regardless the kind of color must be oriented in these two directions along their minor axes, which are east and west as indicated in figure 2. Therefore, based on the combination of the aforementioned descriptive features, we could suggest that intended blessed tree is the palm oil tree.

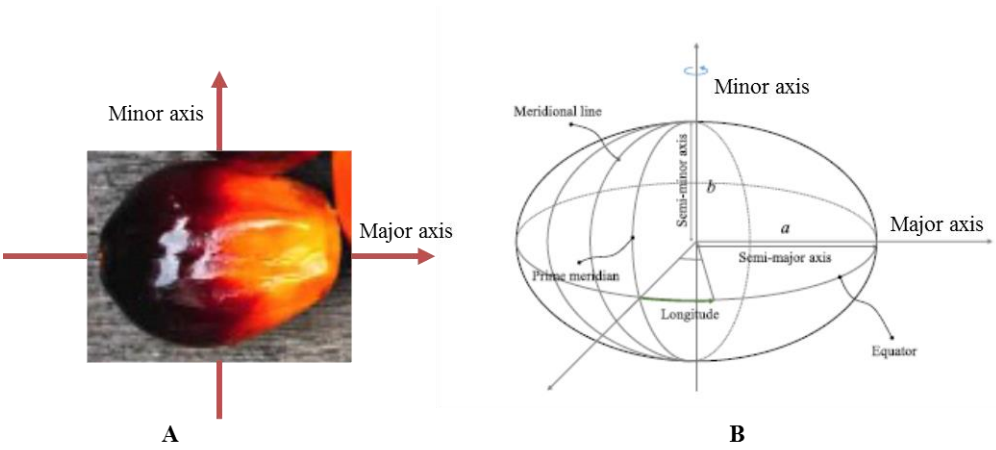

Figure 2. A: Palm oil fruit showing its oval shape with major and minor axes [33], B: Parameters of the ellipsoid model of the earth [34].

5. Correlation between red and black colors in Sunnah and their significance

These two colors, red and black, appeared together several times in the speech of our Prophet. For example, Jabir b. 'Abdullah al-Ansari reported: the Prophet (PBUH) said: 'I have been conferred upon five (things) which were not granted to anyone before me (and these are): Every apostle was sent particularly to his own people, whereas I have been sent to all the red and black'. The red and black people in this hadith refer to all people on the planet Earth, that might refer to the eastern and western people. Again, Abu Nadrah reported: the Messenger of Allah, peace and blessings be upon him, said during the middle of the day at the end of the pilgrimage, 'O people, your Lord is one, and your father Adam is one. There is no favor of an Arab over a foreigner, nor a foreigner over an Arab, nor red skin over black skin, nor black skin over red skin, except by righteousness. Have I not delivered the message?' They said, 'The Messenger of Allah has delivered the message.' This example also emphasizes the strong relationship between the colors, red and black. Generally in the Arabic language, when the expression 'black and red' is used, it often refers to all humanity on the planet. This expression might categorize all people into two groups: red and black. The red group might refer to the eastern people, while the black group might refer to the western one.

6. 'Would almost its oil glow, even if not touched it fire'

In this verse, Allah describes the oil of this blessed tree as an oil that is almost glowing. In Arabic, the verb 'yakādu' means 'it is close to happen', while the verb 'yuḍīu' means 'illuminate or emit radiation'. That means its oil is close to illuminating or emitting radiation, even if it hasn't been touched by fire. The latter phenomenon could be attributable mainly to the presence of carotenoids in crude palm oil. Carotenoids are a diverse class of metabolites belonging to the family of terpenoids. These lipid-soluble compounds include oxygenated xanthophylls and non-oxygenated carotenes [35].

Crude palm oil is a complex mixture consisting of over 99% glycerides, which are the major component of the oil. The minor components include carotenoids, tocopherols, tocotrienols, phytosterols and phosphatides [36]. Red palm oil (RPO) is produced from crude palm oil through a milder refining process that enables the retention of most of the carotenes and vitamin E in the refined oil [37]. RPO is a refined palm oil with a high carotene content of approximately 524-542 mg/kg [38,39]. Moreover, it has been reported that red palm olein (RPOo) is the richest plant source of carotenoids, with a vitamin E content of 810 ppm, mostly in the form of tocotrienol. Vitamin E and β-carotenes play an important role as antioxidants that provide the oil with oxidative stability [40,41]. Interestingly, tocol compounds and β-carotene levels in virgin coconut, virgin olive, sunflower oil, and a mixture of olive and perilla oils are lower than in RPO [42-46].

Carotenoids affect the oil characteristics causing it to emit radiation. After light absorption to their bright S_2 state, carotenoids rapidly decay to the optically dark S_1 state. However, ultrafast spectroscopy experiments have shown the signatures of another dark state, termed S_X [47]. Upon photoexcitation, the generated S_2 state decays into S_1 in a few hundred femtoseconds, which then relaxes back to S_0 over a picosecond time scale [48]. It is difficult to produce the lowest energy triplet state, T1, of a carotenoid by direct absorption of light into that state. Instead, it is usually formed through energy transfer from another triplet species, e.g. triplet chlorophyll, intersystem crossing, the radiation less interconversion of singlet states and triplet states [49]. Triplet states are inefficient producers of luminescence [50].

There are a number of fundamentally sound reports of fluorescence from carotenoids [51-53], although until recently, it was largely believed that carotenoids were non-fluorescent. Indeed, many reports in the literature of carotenoid fluorescence can be attributed to fluorescent impurities in the samples [54]. When sensitive fluorescence spectrometers were used in sample analysis emission from carotenoids which typically have very weak quantum yields

on the range of 10^{-4} to 10^{-5} fluorescence could be observed [54,55]. Most carotenoids exhibit $S_2 \rightarrow S_0$ emission. Fluorescence associated with the $S_1 \rightarrow S_0$ transition is rarer (Figure 4).

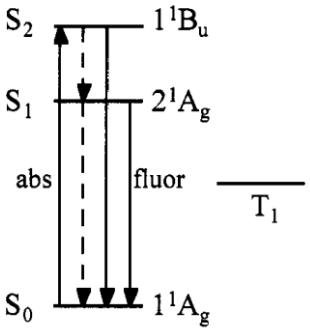

Figure 4. Energy level scheme of carotenoids. S_0, S_1 and S_2 are singlet states, T_1 is the lowest lying triplet state [55].

7. Conclusion

In this article, I tried to give an alternative interpretation for the verse 35 in Surat An-Nur by rethinking the lexical meanings of Arabic words that provide us with some hints that the palm oil tree is the intended blessed tree in the Quran a scenario that is not exclusively restricted to olive tree. This finding was mainly attributed to its possession of highest oil production value in the plant kingdom, as well as to the specific colors of the fruit, the orientation of these colors on the pulp of the fruit, and to the high amount of carotenoids that might be responsible for making its oil almost glow or close to illuminating. Finally, it can be concluded that the intended blessed tree in Surat An-Nur verse 35 is the palm oil tree. Accordingly, the English translation of this part of the verse under investigation should be changed as follows '(which) is lit from a blessed tree– a palm oil, not red and no black, would almost make its oil glow, even if not touched by fire'. Indeed such similes that Allah provided to people through the Quran are very important for mankind and their understanding and knowledge. Therefore Allah mentioned that 'And these (are) the examples, We present them to the people so that they may give thought.(Al-Ankabut - 43). But not all people have the ability to understand these examples, as Allah mentioned in the Quran 'We site these examples for people, but none understand them except the knowledgeable ones (scientists) (Al-Hashr – 21).

Conflict of interest

The authors declare no conflict of interest.

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References

1. Zolfagharnassab, S., Shariff, A.R.B.M., Ehsani, R., Jaafar, H.Z. and Aris, I.B. Classification of Oil Palm Fresh Fruit Bunches Based on Their Maturity Using Thermal Imaging Technique. Agriculture. 2022, **12**, 1779.
2. Raymond, W.D. The oil palm industry. Tropical Science 1961, **3**, 69-89.
3. Bourgis, F., Kilaru, A., Cao, X., Ngando-Ebongue, G.F., Drira, N., Ohlrogge, J.B. and Arondel, V. Comparative transcriptome and metabolite analysis of oil palm and date palm mesocarp that differ dramatically in carbon partitioning. Proc. Natl. Acad. Sci. USA. 2011, **108(30)**, 12527-12532. doi: 10.1073/pnas.1106502108.
Ngando-Ebongue, G.F., Ajambang, W.N., Koona, P., Lalu Firman, B. and Arondel, V. Breeding of the oil palm: Past, present and prospects. Technological Innovations in Major World Oil Crops. 2011, 1, 7.
6. Gorey, N., Ghosh, S., Srivastava, P. and Kumar, V. Characterization of Palm Oil as Biodiesel IOP Conf. Series: Materials Science and Engineering 2017.
7. Al-Qurtubi, 'Al-Jami Li-Ahkam al-Qur'an'. Dar al-Taqwa, London, 2003.
8. Ibn Kathir, '*Tafsīr al-Qurʾān al-ʿaẓīm*', Dar-us-Salam. Riyadh, 2000.
9. Al-Tabari, *Jaami' al-Bayaan fee Ta'weel Ayy al-Qur'an*. Dar al-Ma`arif, Cairo, 1954.
10. Koutb, M. Water breakdown during photosynthesis and transpiration in plants as a scientific miracle in Qur'an. *Journal Interdisciplinary Qur'anic Studies* 2022, **1(2)**, 105-121.

11. Sabri, N., Ibrahim, Z. and Isa, D. Evaluation of color models for palm oil fresh fruit bunch ripeness classification. *Indonesian Journal of Electrical Engineering and Computer Science* 2018; **11(2)**, 549-557. https://doi.org/10.11591/ijeecs.v11.i2.pp549 -557.
12. Fadilah, N., Mohamad-Saleh, J., Halim, Z.A., Ibrahim, H. and Ali S., S.S. Intelligent Color Vision System for Ripeness Classification of Oil Palm Fresh Fruit Bunch. Sensors. 2012, **12**, 14179-14195.
13. Roseleena, J., Nursuriati, J., Ahmed, J. and Low, C. Assessment of palm oil fresh fruit bunches using photogrammetric grading system. *International Food Research Journal*. 2011, **18**, 999-1005.
14. Sabri, N., Ibrahim, Z., Syahlan, S., Jamil, N. and Mangshor, N.N.A. Palm oil fresh fruit bunch ripeness grading identification using color features. *Journal of Fundamental and Applied Sciences*. 2017, **9(4S)**, 563-579.
15. Hambali, A., Siti Hadijah, N. and Rahman, M.A. Application of Integrated AHP and TOPSIS Techniques for Determining the Best Fresh Fruit Bunches (FFB). *Journal of Telecommunincation*, Electronic and Computer Engineering 2017, **9(3)**, 145-149.
16. Junkwon, P., Takigawa, T., Okamoto, H.; Hasegawa, H., Koike, M., Sakai, K., Siruntawineti, J., Chaeychomsri, W., Vanavichit, A., Tittinuchanon, P. and Bahalayodhin, B. Hyperspectral imaging for nondestructive determination of internal qualities for oil palm (*Elaeis guineensis Jacq*. Var. tenera). *Agricultural Information Research*. 2009, **18**, 130-141.
17. Osama, M.B., Shariff, A.R.M., Shafri, H.Z.M., Mahmud, A.R. and Alfatni, M.S.M. Hyperspectral Technique System for Fruit Quality Determination. Map Asia and ISG. 2010, Kuala Lumpur, Malaysia.
18. Hazir, M.H.M. Ripeness Detection of Oil Palm Fresh Fruit Bunches Using Fluorescence Sensor. Ph.D. Thesis, 2011, University Putra Malaysia, Selangor, Malaysia.
19. Hazir, M.H.M., Shariff, A.R.M. and Amiruddin, M.D. Determination of oil palm fresh fruit bunch ripeness-Based on flavonoids and anthocyanin content. Industrial Crops and Products 2012, **36**, 466-475.
20. Alfatni, M.S.M., Shariff, A.R.M., Abdullah, M.Z., Marhaban, M.H., Shafie, S.B., Bamiruddin, M.D. and Saaed, O.M.B. Oil palm fresh fruit bunch ripeness classification based on rule-based expert system of ROI image processing technique results. IOP Conference Series: Earth and Environmental Science 2014.
21. Makky, M., Sony, P. and Salokhe, V.M. Automatic Non-destructive Quality Inspection System for Oil Palm Fruits. *International Agrophysics*. 2014, **28**, 319-329.
22. Harun, N.H., Mirson, N., Sidek, R.M., Aris, I., Wakiwaka, H. and Tashiro, K. Resonant Frequencies Effects on an Induction-Based Oil Palm Fruit Sensor. Sensors. 2014, **14(11)**, 21923-21940.
23. Mirson, N., Harun, .N.H., Lee, Y.K., Sidek, R.M., Aris, I., Wakiwaka, H. and Tashiro, K. Improvement in Sensitivity of an Inductive Oil Palm Fruit Sensor. Sensors, 2014, **14**, 2431-2448.
24. Silalahi, D.D., Reaño, C.E., Lansigan, F.P., Panopio, R.G., Bantayan, N.C., Caliman, J.P., Davrieux, F., Sudarno, S. and Yuan, Y.Y. Near-infraredspectroscopy: A rapid and non-destructive technique to assess the ripeness of oil palm (*Elaeis guineensis Jacq*) fresh fruit. *Journal of Near Infrared Spectroscopy.* 2016, **24**, 179-190.
25. Shiddiq, M., Salambue, R., Yasmin, N.Z., Lismayeni, F., Fitridhani, S. and Adzani, H. Laser based imaging method to discriminate Riau Province pure honeys. *Journal of Physics: Conference Series,* 2018.
26. Zuhaira, Z.M., Hashim F. H., Raj, T. and Huddin, A. B. A Rapid and Non-Destructive Technique in Determining the Ripeness of Oil Palm Fresh Fruit Bunch (FFB). *Journal Kejuruteraan* 2018, **30**, 93-101.
27. Alfatni, M.S.M., Shariff, A.R.M., Shafri, H.Z.M., Saaed, O.B. and Eshanta, O.M. Oil palm fruit bunch grading system using red, green and blue digital numbers. *Journal of Applied. Sciences.* 2008, **8**, 1444-1452.
28. Wan Ishak, W.I., Mohd Zohadie, B. and Abdul Malik, A.H. Optical Properties for Mechanical Harvesting of Oil Palm FFB. *Journal of Oil Palm Research* 2000, **12(2)**, 38-45.
29. Hong, T.S., Hashim, F.H., Raj, T. and Huddin, A.B. Classification of Oil Palm fruit ripeness Using Artificial Neural Network. IEEE International Conference on Automatic Control and Intelligent Systems (I2CACIS). 2021, 358-363.
30. Tzuan. G.T.H., Hashim, F.H., Raj., T., Baseri Huddin, A. and Sajab, M.S. Oil Palm Fruits Ripe-ness Classification Based on the Characteristics of Protein, Lipid, Carotene, and Guanine/Cytosine from the Raman Spectra. Plants. 2022, **11(15)**, 1936.
31. Robi, S.N.A.B.M., Izhar, M.A.B.M. and Ahmad, N.B. Image Detection and Classification of Oil Palm Fruit Bunches. In Proceedings of the 4th International Conference on Smart Sensors and Application (ICSSA), Kuala Lumpur, Malaysia, 2022, **26(28)**, 108-113.
32. Ibn Manẓūr, Muhammad ibn Mukarram, Lisān al-ʿArab, ed. Mīrdāmādī J. Beirut: Dār al-Fikr/ Dār Ṣādir, 1993.
33. Singh, R., Low, E.T.L., Ooi, L.C.L. Ong-Abdullah, M., Nookiah, R., Ting, N.C., Marjuni, M., Chan, P.L., Ithnin, M., Manaf, M.A., Nagappan, J., Chan, K.L., Rosli, R., Halim, M.A., Aziz, N., Budiman, M.A., Lakey, N., Bacher, B., Van Brunt, A., Wang, C., Hogan, M., He, D., MacDonald, J.D., Smith, S.W., Ordway, J.M., Martienssen, R.A. and Sambanthamurthi, R. The oil palm *VIRESCENS* gene controls fruit colour and encodes a R2R3-MYB. Nature Communications 2014, **5**, 4106.
34. Jo, K., Lee, M. and Sunwoo, M. Fast GPS-DR Sensor Fusion Framework: Removing the Geodetic Coordinate Conversion Process. IEEE Transactions on Intelligent Transportation Systems 2015, 17, **7**, 2008-2013. doi: 10.1109/TITS.2015.2475620.
35. Badmus, U.O., Crestani, G., Cunningham, N., Havaux, M., Urban, O. and Jansen, M.A. UV Radiation Induces Specific Changes in the Carotenoid Profile of *Arabidopsis thaliana*. Biomolecules 2022, **12(2)**, 1879.

36. O'Holohan, D.R. Malaysian Palm Oil: The Story of a Major Edible Vegetable Oil and its Rule in Human Nutrition. Kuala Lumpur: Malaysian Palm Oil Council. 1997, 47-64.
37. Ooi, C.K., Choo, Y.M., Yap, S.C., Basiron, Y. and Ong, A.S.H. Recovery of carotenoids from palm oil. *Journal of the American Oil Chemists Society*. 1994, **71(4)**, 423-426.
38. Yi, J., Andersen, M.L. and Skibsted, L.H. Interactions between tocopherols, tocotrienol and carotenoids during autooxidation of mixed palm olein and fish oil. *Food Chemistry*. 2011, **127**, 1792-1797.
39. Top, A.G., Muhamad, H., Abdullah, A., Sani, H.A. and Dauqan, E. Vitamin, E. and beta, carotene. Composition in four different vegetable oils. *American Journal of Applied Sciences.* 2011, **8**, 407-412.
40. Alyas, S. A., Abdulah, A. and Idris, N.A. Changes of β-carotene content during heating of red palm olein. *Journal of Oil Palm Research*. 2006, 99- 102.
41. Nagendran, B., Unnithan, U.R., Choo, Y.M. and Sundram, K. Characteristics of red palm oil, a carotene and vitamin E–rich refined oil for food uses. *Food and Nutrition Bulletin*. 2000, **21(2)**, 189-194.
42. Choe, E. Interaction of light and temperature on tocopherols during oxidation of sunflower oil. *Journal of the American Oil Chemists Society.* 2013, **90**, 1851-1857.
43. Rukmini, A. and Raharjo, S. Pattern of peroxide value changes in virgin coconut oil (VCO) due to photo-oxidation sensitized by chlorophyll. *Journal of American Oil Chemists Society*. 2010, **87(12)**, 1407-1412.
44. Poulli, K.I., Mousdis, G.A. and Georgiou, C.A. Monitoring olive oil oxidation under thermal and UV stress through synchronous fluorescence spectroscopy and classical assays. *Food Chemistry*. 2009, **117**, 499-503.
45. Kim, N. and Choe, E. Singlet oxygen-related photooxidative stability and antioxidant changes of diacylglycerol-rich oil derived from mixture of olive and perilla oil. *Journal of Food Science*. 2012, **77(11)**, C1185-C1191.
46. Kim, N. and Choe, E. Contribution of minor compound to the singlet oxygenated photooxidation of olive and perilla oil blend. *Food Science and Biotechnology*. 2013, **22**, 315-321.
47. Accomasso, D., Arslancan, S., Cupellini, L., Granucci, G. and Mennucci, B. Ultrafast Excited-State Dynamics of Carotenoids and the Role of the SX State. *The Journal of Physical Chemistry Letters.* 2022, **13**, 6762-6769.
48. Polívka, T. and Sundström, V. Ultrafast Dynamics of Carotenoid Excited States-From Solution to Natural and Artificial Systems. Chemical Reviews: 2004, **104**, 2021-2072.
49. Britton, G., and Helliwell, J. R. Carotenoid-protein interactions. *Carotenoids:* Natural Functions. 2008, **(4)**, 99-118.
50. Angelé-Martínez, C., Goncalves, L.C.P., Premi, S., Augusto, F.A., Palmatier, M.A., Amar, S.K. and Brash, D.E. Triplet-Energy Quenching Functions of Antioxidant Molecules. Antioxidants, 2022, **11(2)**, 357.
51. Cherry, R.J., Chapman, D. and Langelaar, J. Fluorescence and phosphorescence of β-carotene, Transaction of the Faraday Society. 1968, **64**, 2304-2307.
52. Haley, L.V. and Koningstein, J.A. Space- and time-resolved resonance-enhanced vibrational raman spectroscopy from a femtosecond-lived singlet excited state of β-carotene. Chemical Physics, 1983, **77(1)**, 1-9.
53. Bondarev, S.L., Bachilo, S.M., Dvornikov, S.S. and Tikhomirov, S.A. $S_2 \rightarrow S_0$ fluorescence and transient $S_n \leftarrow S_1$ absorption of all-*trans*-β-carotene in solid and liquid solutions. *Journal of Photochemistry and Photobiology A: Chemistry*. 1989, **46(3)**, 315-322.
54. Frank, H.A., Chynwat, V., Desamero, R.Z., Farhoosh, R., Erickson, J. and Bautista, J. On the photophysics and photochemical properties of carotenoids and their role as light-harvesting pigments in photosynthesis. *Pure and Applied Chemistry*. 1997, **69(10)**, 2117-2124.
55. Gillbro, T. and Cogdell, R.J. Carotenoid fluorescence. *Chemical Physics Letters.* 1989, **158 (3-4)**, 312-316.

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