ADVANCES IN AGRICULTURAL AND FOOD RESEARCH JOURNAL

Original Research Article

Analysis for the Estimation of Harumanis Mango Ripeness Guide

Noor Umairah Mohd Nasir[1], Muhammad Izzuddin Azman[1], Zainal Abidin Arsat[1]*

[1]School of Bioprocess Engineering, Universiti Malaysia Perlis, 02600 Arau, Perlis, Malaysia

*Corresponding author: Zainal Abidin Arsat, School of Bioprocess Engineering, Universiti Malaysia Perlis, 02600 Arau, Perlis, Malaysia; zainalabidin@unimap.edu.my

Abstract: In such artificial intelligence technology era commencing, the Harumanis mango ripeness guide scarcely reaches for predicting its ripening stages. The use of digital support tools for selective fruits in predicting the ripening stages should not be subdued. Instead, the tool is exercising to be accessible by directive users, local farmers, and consumers. Due to these lacks, this preliminary project is a first step to analyse the ripeness stages of Harumanis mango, referring to its firmness, pulp colours, and total soluble sugar (TSS) for digitalization purposes. Twenty-five Harumanis mangoes harvested at week tenth after bloom were used, which had an average mass of 417.96 ± 163.24 g. Five samples were randomly selected and sorted in five stages by settling them under room temperature and a two-day interval. Findings showed the lowest TSS content uncovered at stage 2 for 6.94 Brix and the highest found at stage 5 for 15.02 Brix. The highest firmness unfolded in stage 2 with the value of 28.468 N and the lowest discovered in stage 5 with 7.946 N. In the RGB value scheme, the pulp colours showed a reduction of blue values for 70, activated at stage 3. The results suggested that the Harumanis mango started deteriorating after six days of room temperature storing, followed by rapid firmness degradation and increasing TSS value. Moreover, combinations of RGB colour values, which are red, green, and blue, composed constructive predictive yellowish variants as recorded in the five stages. Positively, the respective RGB values incorporated are useable to develop digital decision-supporting tools such as smartphones.

Keywords: Harumanis; mango; RGB; ripeness: total soluble sugar

Received: 20th May 2020

Received in revised form: 2nd December 2020

Accepted: 12th January 2021

Available Online: 2nd February 2021

Citation: Nasir NUM, Azman MI, Arsat ZA. Analysis for the estimation of harumanis mango ripeness guide. Adv Agri Food Res J 2021; 2(1): a0000190. https://doi.org/10.36877/aafrj.a0000190

1. Introduction

Several techniques have been deployed to turn the Harumanis mango to yellowish skin colour as its entered ripening stages, and this included using different wrapping bag materials and storing methods (Islam *et al.*, 2017; Gupta & Jain, 2014; Srinivasa *et al.*, 2002). As far as Harumanis mango concerns, the mangoes are hardly recognized when ripen stage is reached without the interference of those methods mentioned above. This behaviour leads to a lot of local assumptions growing on the best ready-to-eat timeframe for Harumanis mango. Differently on the established mangoes variants, the peels and the pulps essentially show a synchronous signature between them, either in terms of colour changes, lenticels, and shapes (Sudheeran *et al.*, 2019; Schulze *et al.*, 2015; Ketsa *et al.*, 1999). As of that concern, locals often remotely proceed for an artificial ripening process, which is an absolute deterioration of one health by having an open exposure to carcinogenic substances such as calcium carbide (Bafor *et al.*, 2019).

The use of artificial intelligence from the manifestation of pulp colour is one of many components that lean against the realization of digitalizing transition for fruit ripening guide. Harumanis mango, in specific, the asking retail price by local farmers during the harvesting period is quite demanding. Regardless of maturity, local farmers are toning down to advice to consumers for a week of ripening period in practice. This fact on the generalization of ripening period should be put to the rest as of existing digital decision support tools such as colorimetric device or conventional easy guide card, as they are essentially helping retailers as a front-tier (Kasampalis *et al.*, 2020; Gené-Mola *et al.*, 2019a; Gan *et al.*, 2018; Barnea *et al.*, 2016). However, none have pursued those techniques which secondarily suggested demoting practicality of merchants and costly to exercise.

It is fully agreed that those destructive methods are outdated. Thus, to lead the locals to use as such mobile application for a directive suggestion for consumers would be a progressing improvement. Having a first step towards the mass users of practical mobile applications, this study aimed to analyse the pulp color, total soluble sugar (TSS), and the Harumanis mango's firmness under five ripeness stages.

2. Materials and Methods

2.1. Sample Preparation

The research started during the flowering season of the harumanis mango by tagging and labelling 40 branches of the harumanis trees that happened to flower in a private land at Beseri, Perlis. Having the greenhouse mango production scheduler (Patent No. AR2017004577, 2017), this first essential stage was to prepare the area secured against wild animals for over ten weeks of a growth period. During the third week after the flowering stage, the fruits were covered using double-lay brown-carbon paper bags to prevent the fruit from pests. During the tenth week, twenty-five Harumanis mangoes were selected on the trees and harvested based on their physical weight with an average of 417.96 ± 163.24 gram, while the rest of the tagged fruits were left uninvolved in this research. All of the 25 fruits were then numerically labelled on the callout notes prepared. Five sets of random numbers were generated at once by MATLAB version 2018a software for every interval of two full days during fruit selections. This measure was taken to randomly pick the fruits and completed the following procedures; firmness, TSS, and pulp colour for a total unbiased exercise. For the second stage, another five mangoes were tested strictly, repeating the first procedure cycle, and remained to standardize for the subsequent third to fifth stages. The mangoes' storage condition was set to lay a room temperature at the Institute of Sustainable Agrotechnology (INSAT) laboratory.

Figure 1. The numeric labels of Harumanis inside a red basket that used for random selection were still intact, in which, to avoid erroneousness during the procedure, and they were peeled off right before the samples were put onto the test table of TexturePro CT V1.2 to allow the probe to penetrate the samples at a rate of 2 mm/s.

2.2. Determination of Mangoes Firmness

A firmness test was carried out in order to determine the hardness varies through five stages. The tests began as soon as the mango was harvested; the firmness test took place for stage 1 by using the textural analyser. The equipment used was a destructive type of textural analyzer with a specific TexturePro CT V1.2 Build 9 (Figure 1). The Harumanis mangoes were marked in three sections: top, middle and bottom. They were punctured by using a textural analyzer with a probe TA39 to get the average data. The probe's depth penetrated the harumanis mango was set to have a consistent depth of 0.6 cm, while the probe's constant velocity entered the mango at two mm/s. The data setup used for the textural analyser was persistent for all stages. The readings were labelled and recorded accordingly.

2.3. Determination of Pulp Colour

Pulp colour was determined on the middle of the fruits' cheek using the image processing technique. The high-definition digital camera was used to capture the samples in 90 degrees setup over a constant focal length of 50 mm (Figure 2). Three measurements were collected per sample for three colours: red, green, and blue using MATLAB version 2018a software. The digital images uploaded to be read by the m-file of the algorithm were constructed to capture adjacent three pixels of pointed locations. The marks of appointed pixels were visible and remained highlighted for not selecting the same coordinate degree for the other two locations. The coding line of calculating the pixels was set to appear for the average of those selected pixels. All the data were labelled and recoded accordingly.

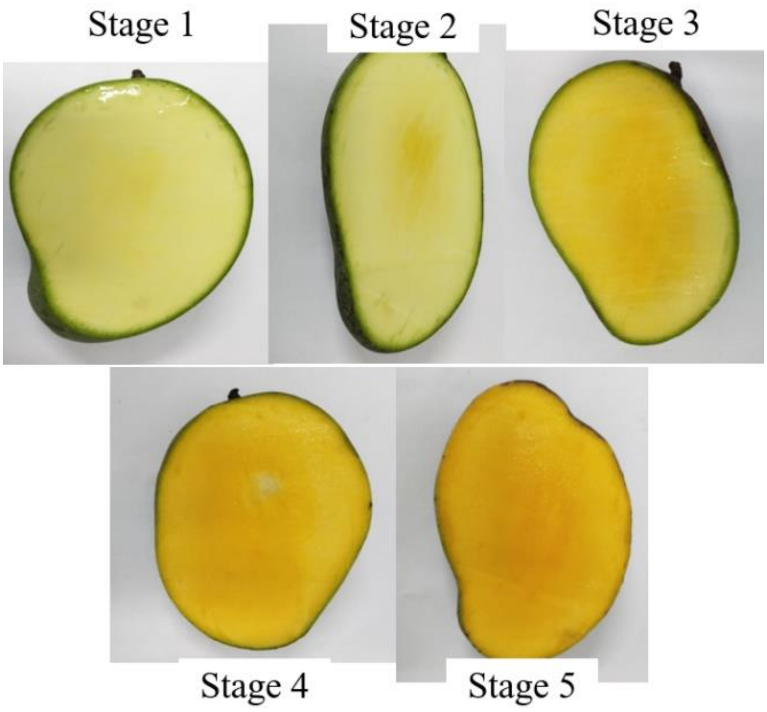

Figure 2. Digital images of the Harumanis mango samples were classified according to stages within two days upon harvesting period at week tenths.

2.4. Determination of Total Soluble Sugar Content

The TSS content experiment took place after the firmness test for each stage was completed. The five peeled mangoes were cut into cube shape and were homogenized in 10 mL distilled water. The solution was then filtered, and the residue was directly measured for Brix number by using a refractometer. The refractometer was calibrated by testing the device using distilled water to get a 0 reading on every measurement. The process of measuring the Brix number was standardized for all of the samples. All the readings were recorded according to the label given.

3. Results

3.1. Firmness

Based on Figure 3, the highest average load was unsurprisingly fell for the second stage for 26.467 N. This followed by an average load of 24.702 N for the first stage, where a little of 1.765 N difference between the first and the second stages. The average load has seen a slight reduction for 20.071 N for the third stage after four consecutive days of storing. For the fourth stage, the average load plummeted to 12.213 N where the samples lost their firmness for almost half compared to the second stage. In the final stage, the samples have shown a complete ripen through their skin texture; the average load that was remained on the samples was the lowest at 7.946 N after eight days of storing period.

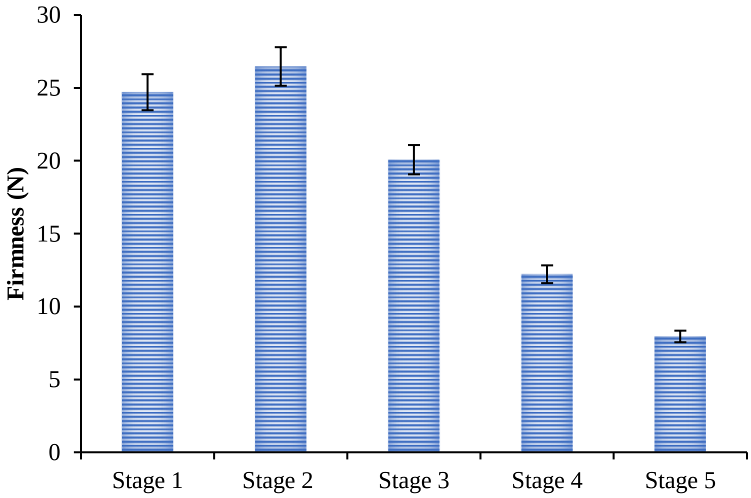

Figure 3. The samples tested on the first stage were freshly tested from a harvest day at a week tenth after blooming season. The firmness of the samples shows five stages with an interval storing two days.

3.2. Pulp Colour

The average red, green and blue (RGB) values for stage 1 were 208, 200, and 112, respectively (Figure 4). For stage 2, the most dominating colour was the red value with 209. While the green colour in stage 2 had a slightly low to red with 197 and 102 for blue. The average RGB value for stage 3 were 204, 161, and 31, respectively. The data also showed that the blue value slightly decreased as the stages climbed. This RGB values in stage 4 suggested the regression of blue value for an overall of 210, 165, and 26, respectively. In the last stage, the green color's value starts to decrease even more while the blue value continued to fall. The average RGB value for stage 5 was obtained at 208, 155, and 20, respectively.

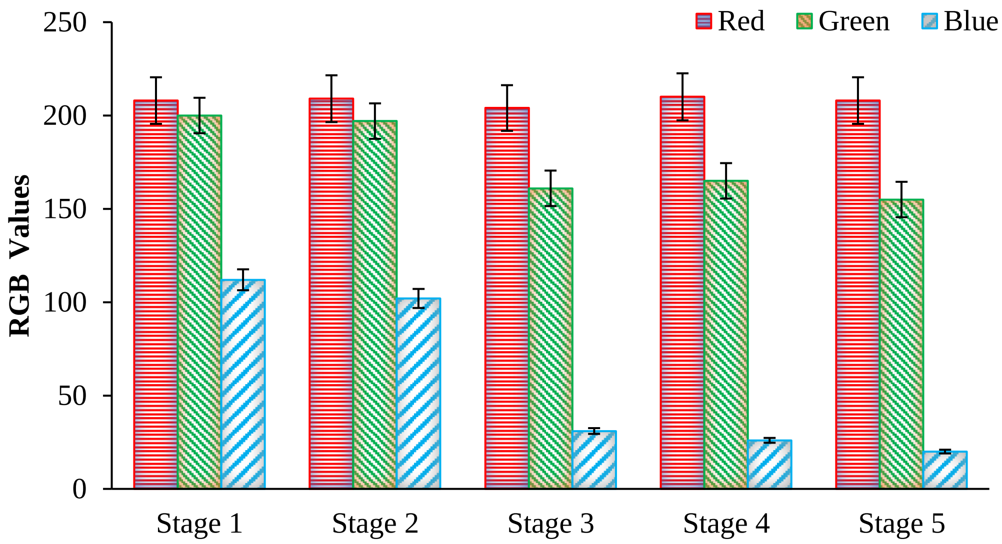

Figure 4. The RGB values of Harumanis mangoes from stage 1 to stage 5.

3.2. TSS Content

In stage 1(Figure 5), the average Brix content is 6.36 Brix that was slightly lower than stage 2. On the first TSS test, it was suspected that one of the five mangoes in stage 1 is already starting to ripen so that the average reading for stage 1 influenced the reading. The average Brix content for stage 2 was 7.52 Brix that was slightly high compared to stage 1. For the average Brix content in stage 3, the sugar content increases drastically, 11.42 Brix due to the ripening process. The data showed that the mangoes had a higher sugar content for all the mango in stage 3. For stage 4, the average reading was 13.44 Brix which slightly higher than stage 3. Lastly, the average Brix content in stage 5 is 15.02, which is the highest sugar content compared to other stages. Positively, the trendline showed that the data keep increasing at each stage.

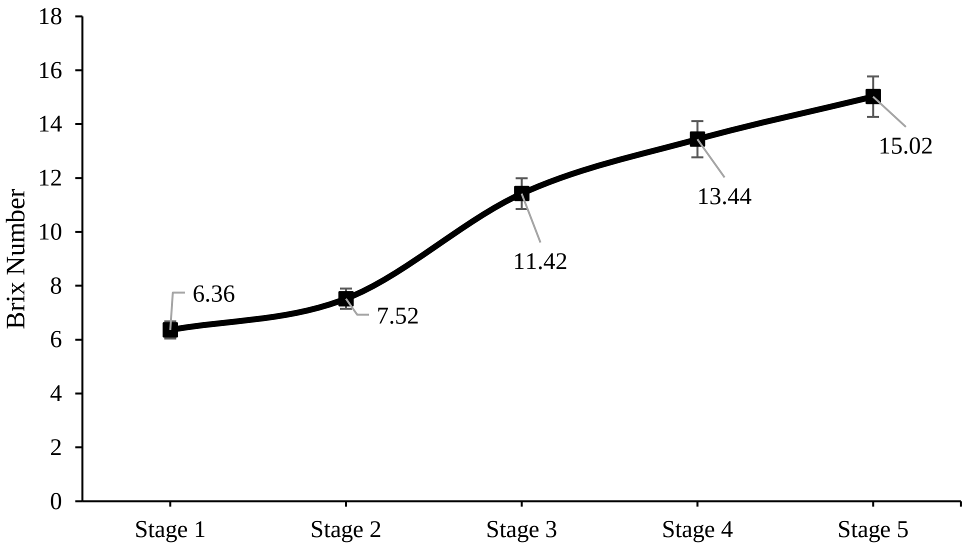

Figure 5. The samples' total soluble sugar content for stage 1 and stage 5 had a minimum of 6.36 Brix and a maximum of 15.02 Brix, respectively.

4. Discussion

In Figure 3, the first stage's load data was lower than the second stage, as it was due to one of the mangoes was expected starting to ripen during the testing day. However, the difference between the first and the second stages not as significant to the whole concept, where the samples were not ripened nor ready to be eaten at the current stage. The third stage test took place in the day four, in which, the average load started to decrease as the samples began to naturally release a small compound of acetylene gas, which helped the samples for the ripening process. This imperceptible phenomenon often suggests its behaviour can be monitored as most flesh parts of the samples still having a rigid composure. In contrast, small flesh portion areas of the samples showed a slight tenderness. After a full six days of storing, the samples started to show evenly ripe in every three segments: top, middle and bottom. This behaviour confirmed through the firmness numbers dropped to half compared to the first and the second stages. At stage 4, the samples had reached a stage where the samples were ready to be eaten.

Moreover, on the last stage, the samples went an over ripen stage where the firmness numbers showed the lowest, this trailed by black spots appeared all over on the flesh samples. At this stage, the samples had been suspended for eight days in a room temperature storage period. Texture-wise, the samples lost the pectin polymers' structure on their cell wall, which later stabilized, indicating completion of the ripening process.

Based on Figure 4, the red value maintains as the dominating colour while the green value slightly decreased as the stages build up. The blue value showed a drastic decrease at stage 3. This sign indicated that the ripening exercise progressing the colour of the mangoes started transforming into yellow. This parallel to mango peel, as from observation, contained several pigments of which chlorophyll was most noticeable when the samples were still unripe (Fukuda *et al.*, 2014). However, when ripening commenced, chlorophyll slowly breaks down into segments then the other pigments become visible to red and yellow (Gené-Mola *et al.*, 2019b). Having those RGB colours attained, using any RGB calculator available on the internet (Figure 6), the combination of those colours may be possible to digitize the composure colours in a specific stage.

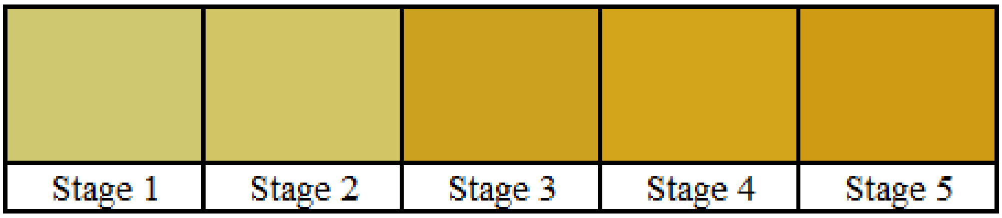

Figure 6. The combination of red, green, and blue values composes five yellow colors from stage 1 to stage 5.

Based on Figure 5, the result showed that the higher the mango's time to ripen, the higher the Brix content reading. The duration of the five stages was eight days included the day that the samples harvested. As soon as it was harvested, the experiment took place for stage 1. The gradient for the linear equation was 2.324, which means it is increasing slowly. The coefficient of determination for this graph was 0.971, which means the graph was almost perfect linear because close to 1. As the stages increase, the moisture content increases due to the ripening process. It affects the increase of sugar content in the mango, which changes the osmotic pressure and forces water movement from the peel to the pulp (Liang *et al.*, 2020; Liu *et al.*, 2020). The change of starch to the sugar by hydrolysis also affected the reading of sugar content.

5. Conclusions

The results suggested that the firmness in degrading fashion equivalent to the whole concept of fruit ripening stages. Parallel to the positively ascending of TSS values and the threshold of yellowish pulps colour as the stage levels hiked. Also, the results ascertained the generalization of ripening stage perception is an impractical resolution for consumers. Moreover, gradients of the yellowish colour sorted the pulp colour of the Harumanis mango in distinctive stages for digital decision support tool development.

Author Contributions: formal analysis, NU. M. Nasir.; writing—original draft preparation, MI. Azman.; writing—review and editing, ZA Arsat

Funding: No external funding was provided for this research

Acknowledgments: The researchers would like to thank the Institute of Sustainable Agrotechnology and the School of Bioprocess Engineering staff for their technical assistance and support to this project.

Conflicts of Interest: The authors have no conflict of interest to declare.

References

Bafor, E. E., Greg-Egor, E., Omoruyi, O., *et al*. (2019). Disruptions in the female reproductive system on consumption of calcium carbide ripened fruit in mouse models. *Heliyon*, *5*(9), e02397. doi:https://doi.org/10.1016/j.heliyon.2019.e02397

Barnea, E., Mairon, R., & Ben-Shahar, O. (2016). Colour-agnostic shape-based 3D fruit detection for crop harvesting robots. *Biosystems Engineering*, *146*, 57–70. doi:https://doi.org/10.1016/j.biosystemseng.2016.01.013

Fukuda, S., Yasunaga, E., Nagle, M., *et al*. (2014). Modelling the relationship between peel colour and the quality of fresh mango fruit using random forests. *Journal of Food Engineering, 131*, 7–17. doi:https://doi.org/10.1016/j.jfoodeng.2014.01.007

Gan, H., Lee, W. S., Alchanatis, V., *et al*. (2018). Immature green citrus fruit detection using color and thermal images. *Computers and Electronics in Agriculture, 152,* 117–125. doi:https://doi.org/10.1016/j.compag.2018.07.011

Gené-Mola, J., Vilaplana, V., Rosell-Polo, J. R., *et al*. (2019a). KFuji RGB-DS database: Fuji apple multi-modal images for fruit detection with color, depth and range-corrected IR data. *Data in Brief, 25*, 104289. doi:https://doi.org/10.1016/j.dib.2019.104289

Gené-Mola, J., Vilaplana, V., Rosell-Polo, J. R., *et al*. (2019b). Multi-modal deep learning for Fuji apple detection using RGB-D cameras and their radiometric capabilities. *Computers and Electronics in Agriculture*, *162*, 689–698. doi:https://doi.org/10.1016/j.compag.2019.05.016

Gupta, N., & Jain, S. K. (2014). Storage behavior of mango as affected by post harvest application of plant extracts and storage conditions. *Journal of Food Science and Technology, 51*(10), 2499–2507. doi:10.1007/s13197-012-0774-0

Islam, M. T., Shamsuzzoha, M., Rahman, M. S., *et al*. (2017). Influence of pre-harvest bagging on fruit quality of mango (*Mangifera indica* L.) cv. Molika. *Journal of Bioscience and Agriculture Research, 15*(01), 1246–1254.

Kasampalis, D. S., Tsouvaltzis, P. & Siomos, A. S. (2020). Chlorophyll fluorescence, non-photochemical quenching and light harvesting complex as alternatives to color measurement, in classifying tomato fruit according to their maturity stage at harvest and in monitoring postharvest ripening during storage. *Postharvest Biology and Technology, 161*, 111036. doi:https://doi.org/10.1016/j.postharvbio.2019.111036

Ketsa, S., Phakawatmongkol, W. & Subhadrabhandhu, S. (1999). Peel enzymatic activity and colour changes in ripening mango fruit. *Journal of Plant Physiology, 154*(3), 363–366. doi:https://doi.org/10.1016/S0176-1617(99)80181-3

Liang, M., Su, X., Yang, Z., *et al*. (2020). Carotenoid composition and expression of carotenogenic genes in the peel and pulp of commercial mango fruit cultivars. *Scientia Horticulturae, 263*, 109072. doi:https://doi.org/10.1016/j.scienta.2019.109072

Liu, S., Huang, H., Huber, D. J., *et al*. (2020). Delay of ripening and softening in 'Guifei' mango fruit by postharvest application of melatonin. *Postharvest Biology and Technology, 163*, 111136. doi:https://doi.org/10.1016/j.postharvbio.2020.111136

Schulze, K., Nagle, M., Spreer, W., *et al*. (2015). Development and assessment of different modeling approaches for size-mass estimation of mango fruits (*Mangifera indica* L., cv. 'Nam Dokmai').

Computers and Electronics in Agriculture, 114, 269–276. doi:https://doi.org/10.1016/j.compag.2015.04.013

Srinivasa, P., Baskaran, R., Ramesh, M., *et al*. (2002). Storage studies of mango packed using biodegradable chitosan film. *European Food Research and Technology, 215*(6), 504–508. doi:10.1007/s00217-002-0591-1

Sudheeran, P. K., Love, C., Feygenberg, O., *et al*. (2019). Induction of red skin and improvement of fruit quality in 'Kent', 'Shelly' and 'Maya' mangoes by preharvest spraying of prohydrojasmon at the orchard. *Postharvest Biology and Technology*, *149*, 18–26. doi:https://doi.org/10.1016/j.postharvbio.2018.11.014