Prototype of automatic line sorting of mango

R. Pornprasit,[a] P. Theanjumpol,[a] S. Pattana,[b] W. Klongpanich[b] and J. Natwichai[b]

[a]*Postharvest Technology Research Institute, Chiang Mai University/Postharvest Technology Innovation Center, Chiang Mai 50200 Thailand.*
E-mail: ratt.pornprasit@gmail.com
[b]*Faculty of Engineering, Chiang Mai University/Postharvest Technology Innovation Center, Chiang Mai 50200 Thailand*

Introduction

Mangoes are one of the most important economic fruits in Thailand. Every year, mangoes can produce revenue of up to 600 million baht approximately (about US$18 million). One approach to improve the market value of the mangoes is to improve the eating quality, because the quality can affect the market price. Near-infrared (NIR) spectroscopy can be used to predict the eating quality.[1,2] In this paper, we propose to build a prototype of a mango line-sorting system, by applying the prediction technique described in reference 1. Our proposed prototype uses an FT-20, a portable type NIR spectrometer to measure the mangoes. Subsequently, after the optimum wavelengths for quality measurement are selected, the wavelengths will be used to compute the eating quality by software that we have developed. Finally the software will alert the NIRS line-sorting system to convey the mango to the correct-quality receptacle.

Materials and methods

The main components of the proposed prototype are a conveyer system, an NIR spectroscopy measurement unit (FT-20), and a spectral analytical software tool. The main functionalities of the developed spectral analytical software tool are to read the reflectance values from the FT-20, and to subsequently compute the quality measurement as described in Reference 1. This information will be transmitted to the conveyer system to sort the mangoes to the correct receptacle.

The main functionalities of the conveyer system are as follows. First, it will move each mango to be measured to the FT-20 probe position. The subcomponent to perform this task will be the conveyer belt control unit (CBCU). Secondly, it will acquire the reflectance from the FT-20, which is needed to control the movement of the NIR probe. This task is controlled by the probe movement control unit (PMCU). The conveyer system will need to sort the quality-assessed mangoes into the correct receptacle. The subcomponent for this part is the line sorting control unit (LSCU).

The last functionality of the system is the overall control unit, referred to as the main control unit (MCU).

The details of the conveyer system are presented as follows.

CBCU

The CBCU main task is to move each mango to the position where it can be measured by the FT-20 probe. It is composed of a conveyer belt that is driven by a speed-reducer-motor, and a speed-adjustment-equipment. The sides of the belt are fitted with a rim to prevent the mangoes from falling off the belt. The size of the rim can be adjusted to work with various sizes of mangoes. When the line sorting is started, the mango will be conveyed until reaches the sensor point. Subsequently, the sensor will notify the MCU to stop the belt and start the PMCU.

PMCU

This unit is designed to be able to move the FT-20 probe to the correct position to scan the mango properly. In the idle state, the probe is set at the top position. When the unit is notified, the probe will be moved down until it touches the mango. The correct-touch position is determined by a sensor. When the probe is in the ready position, the sensor will notify the software to begin the analysing process. When the process is finished, the software will notify the LSCU to sort the mango into the correct receptacle, and the probe will return to the idle position. Figure 1 shows the reflectance measuring system, including the FT-20 probe, and conveyor belt.

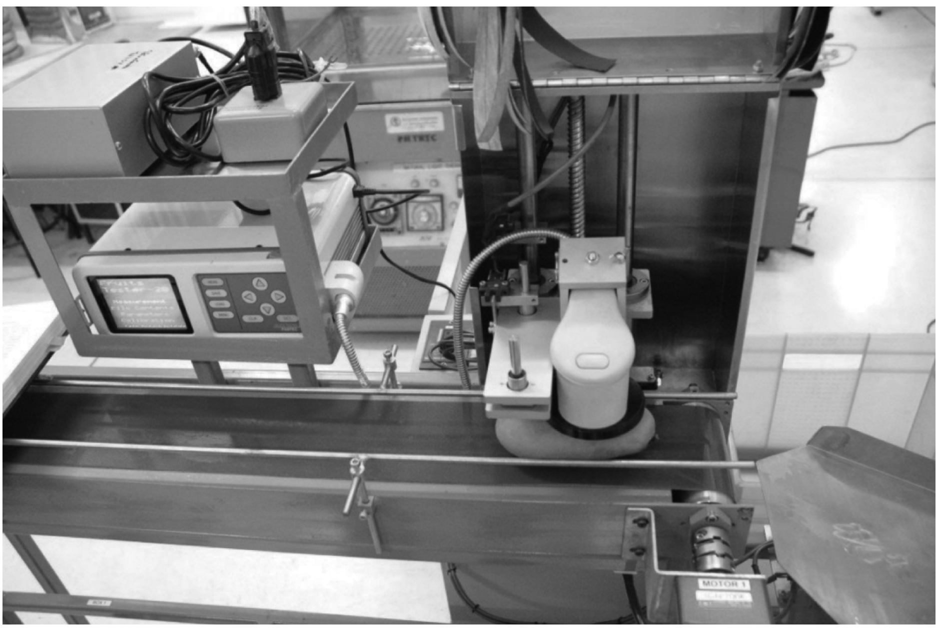

Figure 1. Reflectance measuring by the prototype.

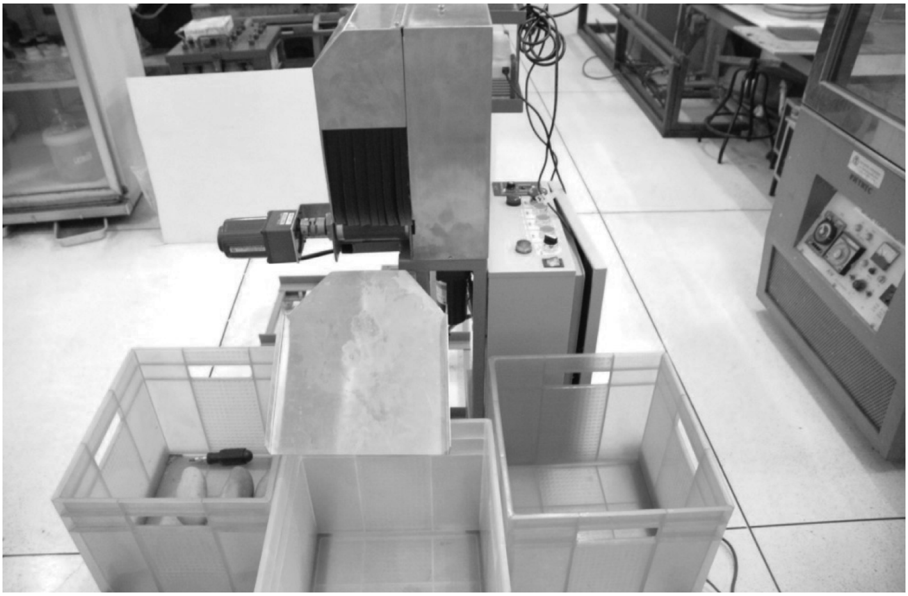

Figure 2. The LSCU and its tray.

LSCU

To convey the mango to the correct receptacle, the LSCU will rotate the tray (shown in Figure 2) to the direction of the receptacle.

The rotation will be guided by the data from the LSCU-sensor. Note here that in this prototype, the quality has been divided into three levels, excellent, average, and unacceptable.

MCU

The MCU task is to coordinate all units. It consists of a Programmable Logic Controller (PLC) (Keyence - KV-24AR), a current filter circuit, control switches, and relays. The PLC, the main component of the MCU, cannot communicate with computers while operating, unless it receives proprietary software from the vendors. Therefore, a micro-controller (Sila Research– V-C2051M) is used to facilitate the communication between the PLC and the software tool.

Results and discussion

We conducted experiments to determine the performance of our prototype. The manual quality assessment by humans is used as the basic system to compare with our prototype. Manual measurement allows more adjustment when measuring e.g., the probe contact-point of the mangoes, or the angle of the contact-point. However, the manual method takes more time than our prototype, when the number of the mangoes to be evaluated is large.

Table 1. Performance of the prototype comparing with the manual measurement.

	R	Bias
Predicted Brix	0.91	0.44

In these experiments, one hundred mangoes were used. Both our prototype and the manual measurement use Equation 1 to predict the quality. Note here that the Brix value in the equation is the Brix as predicted from the predicted DM and starch.

$$\text{Quality} = \begin{cases} 3, \text{ if Brix} < 14.15 \\ 2, \text{ if } 14.15 \le \text{Brix} < 15.67 \\ 1, \text{ if Brix} \ge 15.67 \end{cases} \tag{1}$$

Table 1 shows the performance of our prototype compared with the manual measurement in terms of R and bias. From the results, it can be seen that the predicted Brix from the two methods are in the same trends, though the bias is noteworthy.

In Table 2, the results of the line sorting between the two methods are reported. The first column reports the amount of sorted mangoes by the manual method. The second column reports the results by our proposed work, which has identical performance. Last, the third column reports the difference between the compared methods categorized by the quality. From the results, we can see that the prototype can line-sort the mangoes into the same quality as the manual measurement 76% of the mangoes.

Conclusion

In this paper, we have introduced an automatic line-sorting prototype for mango. The details and concepts of the prototype design are described. We have also reported the experiment results of our proposed prototype in which the sorting accuracy is up to 76%. Future work will focus on

Table 2. Performance of the prototype comparing with the manual method in sorting mango quality.

Manual Method Prediction	Prototype Prediction	
	Identical Result	Different Result
Excellent – 20	10	Sorted to Average – 10
		Sorted to Unacceptable – 0
Average – 80	66	Sorted to Excellent – 14
		Sorted to Unacceptable – 0
Unacceptable – 0	–	–
		–

improving the prototype in the following areas. First, the smoothness of the conveyer belt should be improved and it should be able to adjust automatically. Also, the prediction mechanism should be improved, with regards to the reliability and accuracy e.g. k-nearest neighbours[2] or Associative Classification[3] might be applied. Finally, the flexibility, and the robustness of the analytical software should be considered.

Acknowledgement

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