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CHAPTER 1

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INTRODUCTION

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1.1 Introduction to the Research Problem and Related Technologies in Fresh-Cut Mango

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The global production of major tropical fruits such as mango, mangosteen, guava, pineapple, avocado and papaya was estimated at about 100 million tonnes in 2018**.** The world production of mango accounted for 52**%** of total global major tropical fruit production (Altendorf, 2019)**.** Mango (*Mangifera indica* L.) is one of the most consumed tropical fresh fruits globally. Asia is the largest mango producing zone, especially India, China, Thailand, Pakistan, Indonesia, Bangladesh and the Philippines are world-leading mango production countries (Evans et al., 2017). Thailand has more than 60 mango varieties but the major varieties such as 'Nam Dok Mai', 'Khiao Sawoei', 'Chok Anan', 'Nang Klang Wan', 'Pim Sen Dang', 'Maha Chanok' and 'Rad' are popular in foreign markets. 'Nam Dok Mai' mango is the most popular variety for export to Japan and the global markets (Yasunaga et al., 2018). 'Nam Dok Mai' mango is one of Thailand's most significant mangoes for both local and export markets due to its characteristics of great flavor and bright yellow flesh (Matulaprungsan et al., 2019). Mango possesses a unique flavor, aroma, texture and color and a high amount of bioactive compounds that attract consumers (Salinas-Roca et al., 2017).

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The variation in pre- and postharvest factors affect the quality and contribute to providing potent heterogeneous batches of mangoes in terms of fruit size, gustatory quality, essential nutrients, vitamins, and minerals, in the supply chain and affect the postharvest management (Jacobi et al., 1995; Lalel et al., 2003; Nunes et al., 2007). A study on postharvest losses of mango at different stages from harvesting to consumption revealed that these losses accounted for about 34.49 % in India.

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Sab et al. (2017) reported that the losses were 8.44 % at farm level, 4.93 % at the wholesale market level, 5.46 % at the retail market level, 5.65 % at the storage level, 3.19 % at processing and 6.82 % at the consumer level. Yusuf et al. (2019) also reported that the overall postharvest losses of mango from harvesting to consumption were accounted for about 25.51 % in Bangladesh, including 7.04 % losses at farm level, 4.7 % at wholesale market, 3.66 % at retail market, 3.5 % at storage, 3.5 % at consumer level, and 3.11 % at processing. Over-ripening, withering, and spoilage are the main postharvest losses at the retail and consumer level.

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References

If use Name-Year citation
Example: Sort A to Z in references list
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Altendorf, S. (2019). *Major tropical fruits market review 2018*. FAO.

Evans, E. A., Ballen, F. H., & Siddiq, M. (2017). Mango production, global trade, consumption trends, and postharvest processing and nutrition. In M. Siddiq, J. K. Brecht, & J. S. Sidhu (Eds.), *Handbook of Mango Fruit* (pp. 1-16). John Wiley & Sons.

References

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[1] Altendorf, S. (2019). *Major tropical fruits market review 2018*. FAO.

[2] Evans, E. A., Ballen, F. H., & Siddiq, M. (2017). Mango production, global trade, consumption trends, and postharvest processing and nutrition. In M. Siddiq, J. K. Brecht, & J. S. Sidhu (Eds.), *Handbook of Mango Fruit* (pp. 1-16). John Wiley & Sons.

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CHAPTER 2

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LITERATURE REVIEW

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2.1 Mango

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-0.5 inch- Mango (*Mangifera indica* L.) belongs to the family *Anacardiaceae,* and it is originated in the Indo-Burma region. *Mangifera indica* can be distinguished into two groups, a subtropical group with mono-embryonic seed (Indian type) and a tropical group with poly-embryonic seed, depending on their manner of reproduction as well as their specific diversity areas (South-east Asian) (Litz, 2008). Mangoes are cultivated in tropical and subtropical locations under a variety of environmental conditions. Asia is the biggest mango production zone, and production was about 77.17 % of total world's mango production (Evans et al., 2017; FAOSTAT, 2015). It is one of the most important tropical fruit crops. More than a thousand mango varieties can be classified depending on shapes, sizes, colors, textures, and nutritional properties (Evans et al., 2017).

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-0.5 inch- The mango fruits possess a massive, fleshy drupe with a varied thickness edible mesocarp. The mesocarp is resinous and has a wide range of structure, size, color, fiber content, and flavor. Fruits vary in shape, forming elongate, oblong, and ovate or intermediate shapes combining two of these types. The length of fruits ranges from 2.5 to greater than 30 cm, depending on the varieties (Mukherjee & Litz, 2009). The most popular varieties of mango traded are Tommy Atkins, Kent, Keitt, Haden, Francis, Ataulfo, Alphonso, Kesar, Edward and Manila. Other varieties gaining importance in the trade include Sindhri, Badami, Glenn, Valencia Pride and Nam Dok Mai (Evans et al., 2017). In Thailand, one of the well-known kinds of mango is 'Nam Dok Mai Si-Thong (golden variety) which is highly produced in Thailand for domestic and export (Figure 2.1). The mangoes are majorly produced in Chiang Mai, Phitsanulok, Loei, Nakhon Ratchasima and Prachuap Khiri Khan provinces. The on-season production befalls from April to May, early off-season production is from January to March, and late off-season is from August to December (Statistics, 2015).

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2.2 Problems of Fresh-Cut Mango Production

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-0.5 inch- Fruit and vegetable processing is readily perishable and has a reduced shelf life than whole fruit because peeling, trimming, chopping, and shredding put them under a lot of physical stress (Kim, 2008). Many physiological changes can occur during the processing, including increased respiration rate, oxidation process, changing in color, and loss of nutrients because of several biochemical and enzymatic processes. Several enzymatic processes induce color and texture deterioration (Kong & Singh, 2016). The raw material quality is closely related to fresh-cut quality, so the raw mango attributes must be monitored before processing (Siddiq et al., 2017).

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-0.5 inch- Physiological changes in wounded tissues tend to degrade cell integrity and subcellular compartmentation during fresh-cut processing, which contributes to endogenous enzyme and its substrates interact in a variety of ways. Wounding accelerates cell wall enzyme activity (Karakurt & Huber, 2002), inducing a great of tissues softening in fresh-cuts. These changes are responses to plant tissue injury during processing. Certain reactions to wounding include changes in chemical or physical properties, such as increased ion leakage or partial loss, turgor reduction and flux subsequent changes. These physiological changes bring declining texture and undesired essence, fresh-cut surface mottling, subsequent nutrient reduction, and excessive leaching moisture at the cut surface, that speeds up water depletion (Temiz & Kütük Ayhan, 2017).

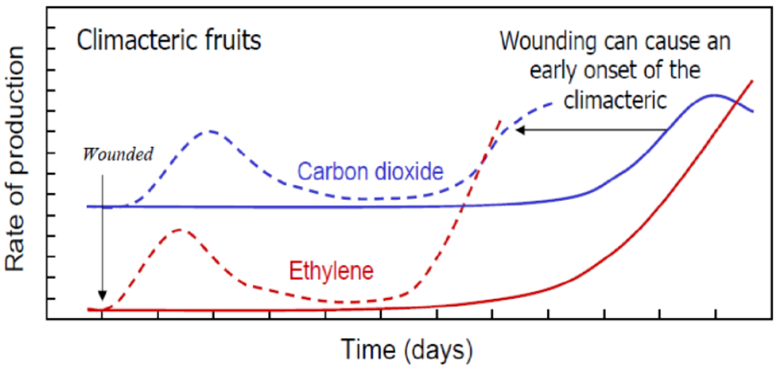

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Figure 2.1 Effect of wounding on the respiration and ethylene production rate of climacteric fruits

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References

Altendorf, S. (2019). *Major tropical fruits market review 2018*. FAO.

Litz, R. E. (2008). Mango. In C. Kole & T. C. Hall (Eds.), *Compendium of transgenic crop plants: Transgenic tropical and subtropical fruits and nuts* (pp. 163-174). Blackwell.

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[1] Litz, R. E. (2008). Mango. In C. Kole & T. C. Hall (Eds.), *Compendium of transgenic crop plants: Transgenic tropical and subtropical fruits and nuts* (pp. 163-174). Blackwell.

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CHAPTER 3

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INVESTIGATION AND EVALUATION OF IMPACT BRUISING IN GUAVA USING IMAGE PROCESSING AND RESPONSE SURFACE METHODOLOGY[1]

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Abstract

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Simulated impact damage testing was investigated by fractal image analysis using response surface methodology (RSM) with a central composite design (CCF) on quality of ‘Glom Sali’ guava for drop heights (0.2, 0.4, and 0.6 m), number of drops (1, 3, and 5) and storage temperature conditions (10, 20, and 30 °C). After 48 h, impacted fruit were determined and analyzed for bruise area (BA), bruise volume (BV), browning index (BI), total color difference (ΔE), image analysis for bruise area (BAI), and fractal dimension (FD) at the bruising region on peeled guava. Results showed that the correlation coefficient (r = −0.6055) between ΔE and FD value was higher than ΔE and either BA (r = 0.3132) or BV (r = 0.2095). The FD variable was determined as a better indicator than conventional measurement (BA or BV) for pulp browning and impact bruising susceptibility. The FD variable also exhibited highest R2adj value (81.69%) among the other five variables, as the highest precision model with high determination coefficient value (R2adj) (> 0.8) for impact bruising prediction. Recommended condition of the FD variable to minimize impact bruising was drop height of 0.53 m for five drops under storage at 30 °C. FD variable assessed by image analysis was shown to be a highly capable measurement to determine impact bruising susceptibility in guava fruit.

Keywords: Bruise Susceptibility, Impact Bruise, Mechanical Injury, Transportation

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[1]This paper has been published in *Horticulturae Journal*, 2021, *7*(10), 411. https://doi.org/10.3390/horticulturae7100411

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3.1 Introduction

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Guava (Psidium guajava L.) is one of the most famous and economically important fruits in Thailand, with an export value in 2020 worth 5.50 million USD [1]. Guava is a climacteric fruit with a round shape and thin skin that bruises easily. To maintain fruit quality and shelf life and minimize losses, guava fruit needs proper postharvest handling practices [2]. Thai agriculture and ASEAN standards of guava require slight defects on the skin not exceeding 10% of the total surface area of guava fruit [3,4]. Bruising effects can be distinguished from quality changes in guava such as browning, softening of the fruit peel, cell destruction, and reduction in intercellular air spaces resulting in the bruised tissue losing moisture and becoming desiccated [5]. Impact damage to fruit is more severe than vibration and compression damages. When a fruit falls with sufficient force against a surface, impact damage occurs, while dynamic damage of a single fruit occurs through fruit-to-fruit impact between packaging. Fruit dropping from trees to the ground during harvesting, dynamic impact between single fruit, and between the fruit and packaging or containers are all causes of impact damage [6].

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3.1.1 Quality Measurements

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2.2.2.1 Bruise Determination of the Guava Fruit

2.2.2.2 Pulp Color at Bruise Area

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Table 3.1 Bruise Assessment Parameters of Guava Fruit Stored at 25 °C Under 70% RH for Four Days

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	BA	**BV**	**BI**	**Δ*E***	**BAI**	**FD**
BA	1.0000					
BV	0.2363					
BI	−0.1871	0.1332				
Δ*E*	0.3132	0.2095	0.4332			
BAI	0.9975 *	0.2372	−0.1837	0.3116		
FD	−0.3854	−0.2366	−0.0448	−0.6055 *	−0.3992	1.0000

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Note * Significant at $p < 0.05$: BA = bruise area; BV = bruise volume; BI = browning index; Δ*E* = total color difference, BAI = bruise area by image analysis; FD = fractal dimension.

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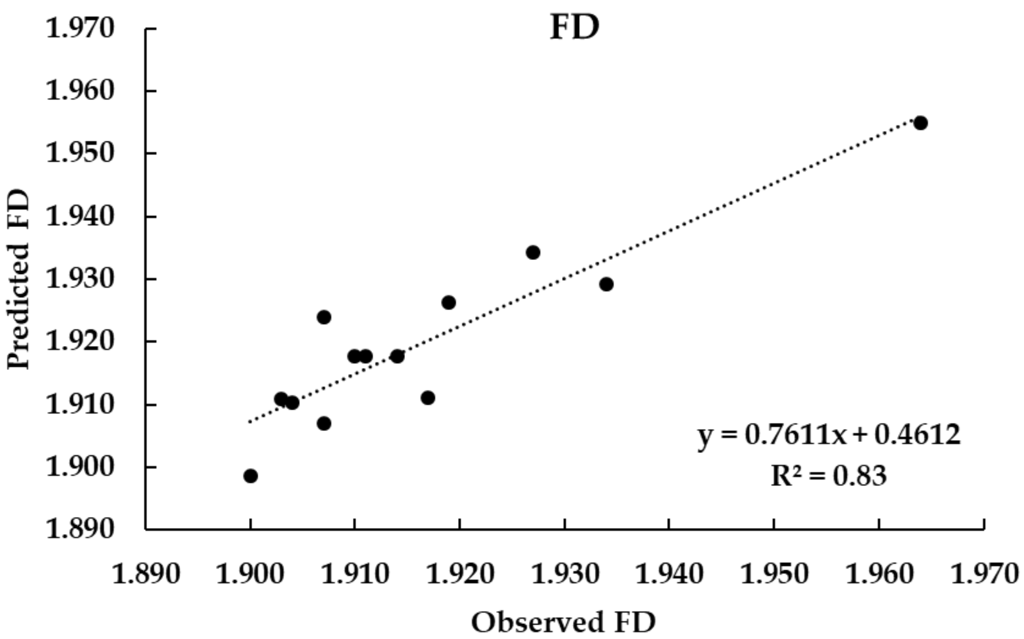

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Figure 3.1 Verification of Predictive Model Equations for Fractal Dimension (FD) Values in ‘Glom Sali’ Bruised Guava by Impact Testing for 48 h

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Acknowledgments

The authors gratefully acknowledge the Thailand International Cooperation Agency (TICA) and the Integrated AgriTech Ecosystem Research Group (IATE), Scientific and Technological Instruments Center, Mae Fah Luang University for financial and equipment sup-port.

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If use Numerical citation
Example: Sort [1] to [last number] in references list
Follow APA style

[1] Thai Customs. (2021). *The exported guava from Thailand from 2015–2019*. http://www.customs.go.th/statistic_report.php?lang=en&ini_content = statistics _report&fbclid=IwAR3fgvhby1iB4O9LUuMedqNtqYNS_Z fyBOOqjPJnBGQlXT6zEWd18v577YQ

[2] Shafie, M., Rajabipour, A., & Mobli, H. (2017). Determination of bruise incidence of pomegranate fruit under drop case. *International Journal of Fruit Sciences*, *17*, 1–14.

[3] Li, Z., & Thomas, C. (2014). Quantitative evaluation of mechanical damage to fresh fruits. *Trends Food Science & Technology*, *35*, 138–150.

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Thai Customs. (2021). *The exported guava from Thailand from 2015–2019*. http://www.customs.go.th/statistic_report.php?lang=en&ini_content = statistics _report&fbclid=IwAR3fgvhby1iB4O9LUuMedqNtqYNS_Z fyBOOqjPJnBGQlXT6zEWd18v577YQ