CROP BREEDING AND APPLIED BIOTECHNOLOGY

CULTIVAR RELEASE

‘KU Gold’: a new yellow-fruit papaya cultivar in Thailand

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Crop Breeding and Applied Biotechnology
22(4): e438622412, 2022
Brazilian Society of Plant Breeding.
Printed in Brazil
http://dx.doi.org/10.1590/1984-70332022v22n4c47

Abstract: *‘KU Gold’ is a papaya cultivar with attractive yellow fruit and pale-yellow pulp during its immature stage. It can produce year-round sweet fruit containing a high amount of ascorbic acid during its ripe stage. It also has great potential as an ornamental plant due to its pale-yellow petioles and flowers.*

Keywords: *Papaya breeding, golden papaya, ornamental papaya*

INTRODUCTION

Papaya (*Carica papaya* L.) is a popular and economically important tropical fruit crop that originated across Central America in countries from Mexico to Costa Rica (Fuentes and Santamaría 2014). It was then distributed and is now widely grown in other tropical and subtropical parts of the world, such as the Philippines, India, Australia, and Thailand. The total papaya production from 68 countries in 2020 was more than 13.8 million tons (Food and Agriculture Statistics 2022) and was mainly used for fruit consumption. In addition to consuming the ripened fruit, papaya pulp, particularly during the external color break stage, can be processed into various types of products, such as canned papaya in syrup, dried papaya, and cereal flakes (Rajarathnam 2010). Unripe papaya in the green-fruit stage is used as a vegetable to make a variety of meals in several countries, including traditional papaya salad and sour soup in Thailand. Most commercial cultivars available in the world, including Thai cultivars such as ‘Khaek Dam’, ‘Khaek Nuan’, and ‘Pluk Mai Lai’, have green fruit with greenish-white pulp at the unripe stage. Growing fruit crops in backyards for both consumption and decorative purposes is a growing area of interest for Thai people. Although several research teams, including researchers from universities (Iamjud et al. 2016, Srimat et al. 2017, Janthasri et al. 2018), the Department of Agriculture (Somsri 2018), and a private company (East-West Seed 2018), have been operating papaya breeding projects for years, no selections or cultivars of papaya have been released for ornamental use in Thailand.

In 2009, the Department of Horticulture, Faculty of Agriculture at Kamphaeng Saen, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom, Thailand (HortKUKPS) started a papaya breeding program emphasizing the development of cultivars, both for pulp consumption and ornamental uses. As a result, a new yellow-fruit papaya cultivar with high ascorbic acid content and attractive fruit and vegetative characteristics was developed and named ‘KU Gold’. This study explored the main characteristics of the cultivar as presented here.

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Received: 02 November 2022
Accepted: 23 November 2022
Published: 20 December 2022

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ORIGIN AND BREEDING METHOD

The 'KU Gold' papaya is a yellow-fruit cultivar selected from an open-pollinated population collected from a villager in the northeast part of Thailand in 2015 by HortKUKPS. From 2016 to 2019, the pure line selection method was used for four generations under field conditions at a breeding station (lat 14° 02' 08" N, long 99° 58' 59" E, alt 7.05 m asl). Planting distance was 2.5 × 2.5 m. Based on the Kamphaeng Saen soil series, the soil morphology was a non-calcic brown soil type, the pH was 7.0-8.0, and the soil texture was sandy loam (Land Development Department 2022). In each generation, selfed seeds from selected hermaphrodite plants were collected and grown for the next generation of selection. In 2020, one breeding line of the fourth generation was selected based on its consistency in both plant and fruit characteristics, including high-quality fruit performance for fresh consumption at the ripe stage. The selection was also based on the attractiveness of both vegetative and reproductive characteristics for decorative use. The selfed seeds from all hermaphrodite plants of the selected line were collected and mixed. The selected line was later named 'KU Gold'. An application was submitted to the Plant Varieties Protection Office, The Department of Agriculture, Thailand, on August 16, 2022, for registration of 'KU Gold' as a new papaya cultivar in Thailand.

CHARACTERISTICS AND PERFORMANCE

'KU Gold' is a yellow-fruit papaya selected for both fresh consumption and ornamental bedding plant production. The leaf, flower, and fruit characteristics presented in this study were evaluated from hermaphrodite plants under field conditions. There is not a commercial yellow-fruit papaya cultivar registered in Thailand, so the characteristics of the 'KU Gold' were compared with those of the 'Pluk Mai Lai' cultivar, which is the most widely grown commercial cultivar for fresh consumption in Thailand. The colors were described using the RHS Colour Chart (The Royal Horticultural Society 2001). Fruit weight (kg), fruit length (cm), fruit width (cm), pulp thickness (cm), pulp firmness (N), total soluble solids (TSS, %Brix), and ascorbic acid content (mg 100 g^{-1} fresh weight) were evaluated at the ripe stage. Pulp thickness, color, firmness, and TSS were measured at the midpoint of the fruit. Pulp firmness was measured using a fruit hardness tester (N.O.W., Japan) with a 1.2 cm diameter cylinder probe; the data were converted to Newton (N) values by multiplying them by 9.807. TSS was measured in the juice extract from the pulp samples using a digital pocket refractometer (PAL-1, Atago, Japan). Ascorbic acid content was measured using the 2,6-dichlorophenolindophenol titration method, as described by the Association of Official Analytical Chemists (1990). The distinguishing characteristics of 'KU Gold' are yellow-skinned fruit and pale-yellow pulp at the immature stage, with pale-yellow petioles and flowers (Table 1). The morphological descriptions are as follows:

Table 1. Comparison of 'KU Gold' and 'Pluk Mai Lai' papaya cultivars

Characteristics	Means ± SD	
	'KU Gold No. 1'	'Pluk Mai Lai'
Petiole color	Pale yellow, 2C	Pale green, 146D
Flower color	Pale yellow, 4D	Pale yellow-green, 150D
Fruit skin color at immature stage	Yellow, 7C	Green, 137A
Fruit skin color at ripe stage	Orange-red, 34C	Yellow-orange, 23A
Pulp color at immature stage	Pale yellow, 4D	Green-white, 157B
Pulp color at ripe stage	Orange-red, 32A	Orange-red, N30C
Fruit weight (kg)	1.2 ± 0.1 a	1.0 ± 0.1 b
Fruit length (cm)	29.5 ± 0.9 a	19.5 ± 0.6 b
Fruit width (cm)	9.3 ± 0.6	9.2 ± 0.5
Pulp thickness (cm)	2.5 ± 0.2	2.7 ± 0.1
Pulp firmness (N)	8.9 ± 1.0	9.9 ± 1.5
Total soluble solids (%Brix)	12.0 ± 0.6	12.6 ± 0.6
Ascorbic acid (mg 100 g^{-1} fresh weight)	95.4 ± 14.1	112.9 ± 10.9

Means followed by different letters in the same row are significantly different (t-test, $P < 0.05$).

The 'KU Gold' tree is vigorous, with an upright single-stemmed growth habit. It grows to approximately 5 m tall in its second year, with a canopy diameter of approximately 2 m. The stem has a slightly rough surface at the base, and it is yellow-green (N144D) with irregularly shaped, unequally sized, and horizontal grayed-orange (165A) stripes when young and through the first year of age. The stripes gradually disappear according to plant age, and the stem becomes grayed-white (156B) with a knobby surface at the base.

The leaves are light green (138A) with 11 lobes arranged in a spiral pattern on nearly horizontal petioles. The leaf has a long, pale yellow (2C; Figure 1A) petiole that is an average of 72.5 cm long and 2.1 cm in diameter at the base. Some leaves have secondary leaves. The leaf blade is large (an average of 75.9 cm in width and 64.6 cm in length) and has prominent pale-yellow rips and veins. The color of the rips and veins is a lighter yellow than that of the petioles.

'KU Gold' blooms throughout the year and the mild fragrance generally found in this species was observed in our study. The flowers are borne on inflorescences with three to five flowers each, of which only one is an elongata or pentandria that can set fruit, whereas the others are mostly reduced elongata that cannot set fruit. The elongata flower at the anthesis stage is approximately 3.29 cm long and 1.46 cm wide. The five sepals are pale yellow with a small size of 3.95 mm in width at the base and 3.52 mm in length. The five petals are a lighter pale yellow (4D) than the sepals and fused at the base for one-third of the flower length. The 10 filaments are pale yellow and topped with yellow-orange anthers. The pollen is white and abundant. The style and the five fan-shaped stigmas are pale yellow, similar to the petals.

The fruits developed from the elongata flower are cylindrical, have smooth skin, and are attractive in color (Figure 1A). The skin color of immature fruit is primarily green-yellow (1A) to yellow (7C; Figure 1B) and gradually changes to orange-red (34C; Figure 1C) when ripe. The color of the fruit pulp when immature is pale yellow (4D; Figure 1B) and gradually changes to orange-red (32A; Figure 1C) when ripe. The fruits are moderately large, averaging 1.2 kg in weight, 25.9 cm in length, and 9.3 cm in width. The fruit pulp is thick (2.5 cm on average), juicy, soft (average firmness of 8.9 N), and categorized as moderately sweet, with an average TSS content of 12.0 %Brix. The ascorbic acid content in the ripe pulp is an average of 95.4 mg 100 g^{-1} fresh weight (Table 1). Because the recommended dietary allowance of ascorbic

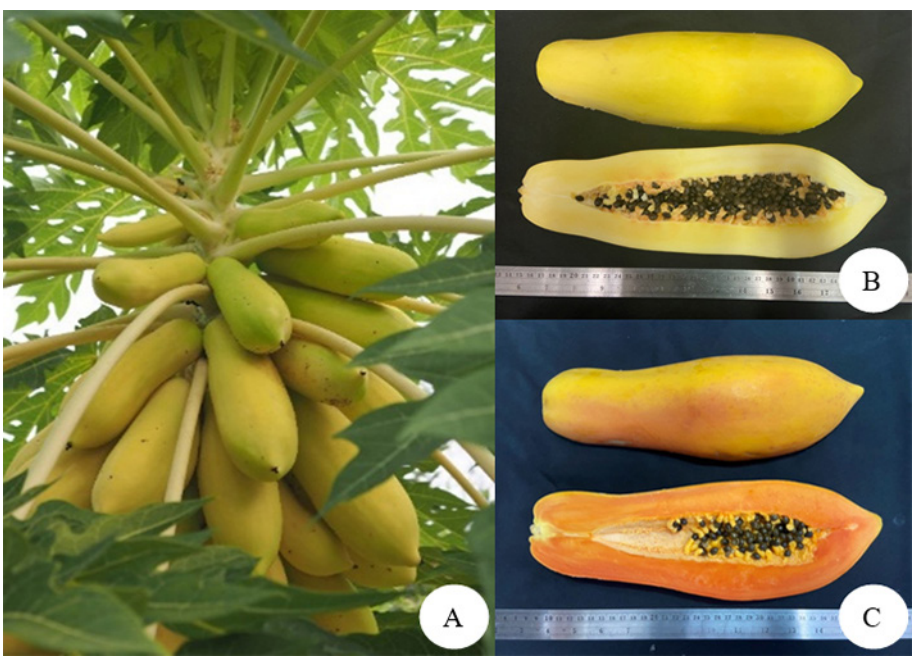

Figure 1. Phenotypic characteristics of 'KU Gold' papaya (A) fruits and petioles, (B) fruit and pulp at immature stage, and (C) fruit and pulp at ripe stage. All photographs were taken from June to August 2022 at an experimental field of the Department of Horticulture, Faculty of Agriculture at Kamphaeng Saen, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom, Thailand.

acid is 75 and 90 mg day^{-1} for adult females and males ages 15-50 years, respectively (Institute of Medicine 2000), the consumption of 100 g/day of 'KU Gold' would be sufficient to meet these requirements.

The fruits contain numerous ellipsoid-shaped, wrinkled, dark brown seeds (200A). The seed quantity ranges widely from 27-364 seeds per fruit and has an average weight of 1.7 g per 100 seeds, with average dimensions of 6.61 mm in length and 4.02 mm in width.

PROPAGATION AND CULTIVATION

'KU Gold' propagation methods and production problems are like other papaya cultivars in Thailand. The primary propagation method is by seed, and the seeds can be stored for six months at 5-10 °C without affecting the germination rate. Grafting and air layering are also practical papaya propagation methods, and the use of these two techniques is increasing in Thailand. 'KU Gold' prefers full sunlight and grows best in well-drained and fertile loamy soil in field and container conditions. However, growing 'KU Gold' in containers is recommended only for decorative purposes because it is likely to produce very little to no fruit. The plant can bloom and set fruit throughout the year; however, a temperature of 34 °C or higher will reduce the elongata-type flowers, resulting in a decreased fruit set. High temperatures also reduce pollen viability (Srimat et al. 2014), resulting in a lessened seed set. Hot and highly humid conditions promote the occurrence of pentandria and carpelloid flower types, and vivipary can develop in hot and dry conditions. No solutions are available for these cultivation problems. In addition, papaya ring spot virus is a major disease of concern. Protected cultivation, such as growing papayas in net houses, is a way to reduce the likelihood of disease (Fongthep and Thaipong 2017).

SEED PRODUCTION AND DISTRIBUTION

HortKUKPS is responsible for seed production. Requests for 'KU Gold' seeds for research purposes can be acquired under a material transfer agreement with HortKUKPS.

ACKNOWLEDGEMENT

This research was financially supported by the Kasetsart University Research and Development Institute (KURDI), FF(KU)1.64, Thailand.

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