

# Evaluation of carambola cultivars in the Canary Islands

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## Evaluation of carambola cultivars in the Canary Islands.

**Abstract — Introduction.** A study was set up in 1995 in the Canary Islands to determine the commercial crop potential of the carambola tree (*Averrhoa carambola* L.) in the warmest areas of the islands. **Materials and methods.** Twelve carambola cultivars were planted in three blocks, at the rate of two plants per cultivar and block, under drip irrigation at a planting distance of 5 m × 4 m. For each cultivar, morphological and organoleptic data of the fruit were measured. **Results.** Results to date appear promising, with high yields and good quality fruit for all cultivars, although some have proved susceptible to fruit fly; harvesting lasts 6 to 7 months, throughout autumn and winter. **Conclusion.** The cultivars recommended under the Canary Island warm climatic conditions are B-17 and Sri Kembangan (short style types), and Arkin (long style type).

**Spain / Canary Islands / *Averrhoa carambola* / variety trials / agronomic characters / crop performance / quality / fruits**

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## Évaluation de cultivars de carambolier dans les îles Canaries.

**Résumé — Introduction.** Une étude a été lancée en 1995 aux Canaries pour déterminer les potentialités commerciales du carambolier (*Averrhoa carambola* L.) dans les régions les plus chaudes de ces îles. **Matériel et méthodes.** Douze cultivars de carambolier ont été plantés dans trois blocs, à raison de deux plants par cultivar et par bloc. L'irrigation a été faite au goutte-à-goutte et les distances de plantation ont été de 5 m × 4 m. Des caractéristiques morphologiques et organoleptiques du fruit ont été évaluées pour chaque cultivar. **Résultats.** Les résultats semblent jusqu'ici prometteurs ; les rendements ont été élevés et le fruit a été de bonne qualité pour tous les cultivars bien que certains se soient révélés sensibles à la mouche des fruits ; la récolte, qui s'est étalée de l'automne à l'hiver, a duré 6 à 7 mois. **Conclusion.** Les cultivars recommandés dans le contexte des conditions climatiques chaudes des îles Canaries sont B-17 et Sri Kembangan (types à styles courts), et Arkin (type à style long).

**Espagne / Canaries (îles) / *Averrhoa carambola* / essai de variété / caractère agronomique / performance de culture / qualité / fruits**

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## 1. Introduction

The first carambola cultivars were introduced in the Canary Islands from Florida early in the 1980s [1]. Limited evaluation trials over the following years were successful [2], encouraging small commercial plantings and the introduction of new plant material for further evaluation. Due to this recent introduction, right now there are only 10 ha of carambola cultivation in the Islands but prospects for small expansion are good. After the Instituto Canario de Investigaciones Agrarias (ICIA) established a new experimental station in a different locality on the island of Tenerife in 1994, a research line was established to evaluate carambola cultivars suitable for commercial planting in the Canary Islands.

As this crop is of recent introduction and no standards for cultivars appropriate for the Islands have already been established, evaluation criteria took into consideration general worldwide recommendations for this species [3–5], such as: early bearing, abundant and regular production, acceptable

fruit weight (> 100 g), attractive shape (five-angled shape), appropriate [acid / sugar] ratio (total soluble solids higher than 10 °Brix, acidity less than 3.2 mg·g<sup>-1</sup>), resistance to harvesting (thick ribs with wide angles and rounded edges), attractive color (yellow or orange), resistance to pests (mainly to fruit fly).

## 2. Materials and methods

In June 1995, an experimental trial was established at the Cueva del Polvo experimental station located at 50 m altitude and at 28°13' N and 16°50' W in the southwest of the island of Tenerife (*table I*). Twelve carambola cultivars (*table II*) side-grafted on 1-year-old sour carambola seedlings from seeds originally brought from Guyana were planted in three blocks, two plants per cultivar and block, at a planting distance of 5 m × 4 m. As is customary in the Canaries, the soil of the plot was artificially built up (0.80 m of andic soil over an artificial drainage layer) and the plot was

**Table I.**

Meteorological data at the Cueva del Polvo experimental station of ICIA in the southwest of the island of Tenerife (Canary Islands) (average 1997–2000).

Month	Temperature (°C)			Relative humidity (%)			Rainfall (mm)
	Maximum	Minimum	Average	Maximum	Minimum	Average	
January	20.3	14.8	17.2	82.7	52.6	67.8	39.6
February	21.7	15.5	18.3	80.6	46.8	63.1	0
March	22.4	15.9	18.6	79.7	46.8	62.7	2.6
April	21.8	15.7	18.5	81.9	52.6	67.3	11
May	22.3	16.6	19.4	81.7	54.9	68.5	0
June	23.9	18.5	21.1	89.0	63.6	76.8	0
July	25.1	19.6	22.0	91.2	64.2	79.0	0
August	26.1	20.4	22.9	93.3	65.1	82.0	0
September	25.7	20.3	22.6	89.8	63.0	78.8	1.1
October	25.7	20.2	22.5	89.4	62.6	77.8	2.8
November	24.3	18.5	21.0	84.1	52.0	67.7	1.9
December	21.6	15.9	18.7	81.4	49.8	65.6	4.1

**Table II.**

Source of introduction and general characteristics of twelve different carambola cultivars evaluated in the Canary Islands from 1995.

Cultivar	Source	Year of introduction	Canopy shape	Style type
Arkin	Florida	1982	Upright	Long
B-6	Australia	1987	Spreading	Long
B-10	Malaysia	1989	Not defined	Short
B-16	Malaysia	1989	Not defined	Long
B-17	Malaysia	1989	Upright	Short
Fwang Tung	Florida	1991	Not defined	Short
Hart	Florida	1991	Not defined	Long
Jungle Gold	Florida	1991	Rounded	Short
Kary	Florida	1991	Spreading	Long
Maha	Australia	1989	Not defined	Long
Sri Kembangan	Florida	1991	Upright	Short
Thai Knight	Australia	1989	Spreading	Short

surrounded with 2.5-m-high windbreaks of perforated cinderblocks. Six months before planting, the soil was amended with 1.5 kg of calcium superphosphate per tree and, 3 months before planting, a further amendment of 0.25 m<sup>3</sup> of goat manure per tree was dug in.

Drip irrigation was applied in increasing quantities, reaching 9500 m<sup>3</sup> ·ha<sup>-1</sup> for the year 1999: 672 L per plant per week during the summer, 280 L per plant per week during the spring and autumn and 224 L per plant per week during the winter. Fertilization, through a drip irrigation system, was also applied in increasing quantities, reaching 1.32 g N, 0.82 g P and 1.32 g K per plant per day in 1999, evenly distributed during the whole year. Iron chelates were applied at the beginning of the spring at the rate of a half teaspoon slightly buried under two of the drips of the irrigation system in each tree.

At the end of the harvesting season of 1997–1998, due to the excessive vigor of the trees and to damage produced by strong winds, a severe pruning was done, leaving only the main branches of the trees.

Morphological, phenological and production data were currently recorded, but only the following parameters will be discussed in this paper: the tree canopy shape (upright, spreading, rounded or not defined) observed from six non-pruned trees per cultivar; the flowering period; the type of style which can be either longer than stamens (long) or shorter than stamens (short); the harvesting period; the yield in kg per tree and per harvesting season; the fruit characteristics obtained from analysis of 60 fruits per cultivar: fruit weight (g) and length (mm); rib length (mm), assessed by the distance from the center of the fruit to the outside tip and rib width (mm), measured by the distance of the base of the rib; rib slope (straight or curved); rib edge shape (rounded or sharp); skin and flesh color; shape of the fruit cross-section; preliminary panel quality from flavor of fruit slices of about 1 cm thickness: bad, normal, good or excellent; titrable acidity assessed with NaOH 0.1 N given as mg of citric acid per g of fruit, and total soluble solids measured with a hand refractometer in °Brix. The fruit fly incidence (high, moderate or low) was studied too.

A Tukey's mean separation test ( $p < 0.05$ ) was done for the evaluation of yield; for the morphological fruit characteristics the parameters mean and standard deviation are given. All parameters were taken with a minimum of 20 observations.

### 3. Results and discussion

#### 3.1. Tree canopy shape

All cultivars showed a great vigor, needing heavy pruning to maintain a well structured canopy, as is usual in other countries [3, 5]. Arkin, B-17 and Sri Kembangan showed an upright growth habit while B-6, Kary and Thai Knight were spreading. Jungle Gold had a rounded canopy. The remainder did not exhibit a defined growing habit (*table II*).

#### 3.2. Flowering observations

Practically all cultivars started flowering in the second year, according with the precocity of this species. Continued flowering was observed in all cultivars during most of the year and no alternance seemed to exist. While flowers emitted between April and January normally set fruits, those produced outside these months only occasionally led to fruit set, as expected for the cooler conditions of the winter months. This agrees with observations in a similar subtropical location in Southern Queensland [6].

Under the conditions of this experiment, long style cultivars included Arkin, B-6, B-16, Hart, Kary and Maha. Short style was exhibited by B-10, B-17, Fwang Tung, Jungle Gold, Sri Kembangan and Thai Knight. Our observations agree with those reported in the literature [4, 5].

#### 3.3. Harvesting period and yield

In the 1997–1998 and 1999–2000 seasons, the harvesting period extended from August till February (both included) for most cultivars, except for Thai Knight which started to be cropped one month

later. Due to the severe pruning done in 1998, the harvesting period for the 1998–1999 season was delayed until the beginning of December and lasted until the end of March.

Broadly speaking, the most productive cultivars included Arkin, B-6, B-17 and Thai Knight. The lowest producing cultivars were B-16, Maha, Fwang Tung and Hart, the other cultivars being intermediate. However, yields were high but comparable with those reported for other carambola producing countries [5], with average yields in the 1999–2000 season not lower than 84 kg per tree (*table III*).

#### 3.4. Fruit characteristics

##### 3.4.1. Fruit weight and length

Weights ranged from 84 g (B-6) to 190 g (Fwang Tung). With the exception of B-6, Hart, Jungle Gold and Thai Knight, all the cultivars exceeded 130 g per fruit (*table IV*). Since the appropriate range for a carambola cultivar has been indicated to be between (100 and 300) g [5], all the cultivars except B-6 and Hart meet this requirement.

Only Hart had an average length shorter than 100 mm, Fwang Tung and B-17 bearing the largest fruits. However, a big variation was observed within each cultivar. These observations, broadly speaking, do not differ from data reported for the same cultivars at the Hilo repository [7].

##### 3.4.2. Organoleptic characteristics

All cultivars exhibited yellow or orange skin colors when ripe, but Maha showed a typical whitish-yellow color completely different from any other (*table V*). Flesh color ranked from whitish yellow to orange.

There were differences between cultivars regarding total soluble solids and total titrable acids, with higher total soluble solids for B-10, B-17, Kary, Fwang Tung and Sri Kembangan, exceeding favorably the ideal values for commercial cultivars. Acidity for all cultivars was lower than the maximum values recommended for commercial cultivars ( $< 3.2 \text{ mg}\cdot\text{g}^{-1}$ ) [5]. B17 and Sri Kembangan showed the highest and both

**Table III.**

Average yield of twelve different carambola cultivars evaluated in the Canary Islands for three harvest seasons (kg per tree per harvest season).

Cultivar	1997–1998	1998–1999	1999–2000
Arkin	103 a	105 ab	198 a
B–6	86 a	117 a	185 ab
B–10	72 abc	93 bc	146 bc
B–16	29 d	42 e	84 d
B–17	76 ab	73 cd	164 ab
Fwang Tung	45 cd	46 e	100 d
Hart	46 cd	39 e	100 d
Jungle Gold	92 a	92 bc	132 bcd
Kary	49 bcd	44 e	108 bcd
Maha	39 d	38 e	89 d
Sri Kembangan	48 bc	73 cd	105 cd
Thai Knight	79 ab	64 de	160 abc

Figures differ significantly ( $p < 0.05$ ) when followed by different letters. Comparisons are always made within the same harvest season.

**Table IV.**

Morphological fruit characteristics measured for twelve different carambola cultivars evaluated in the Canary Islands for three harvest seasons (1997 to 2000).

Cultivar	Fruit weight (g)	Fruit length (mm)	Rib length (mm)	Rib width (mm)	Rib length / width	Rib slope / edge shape
Arkin	131 ± 22	124 ± 40	20.1 ± 1.1	17.6 ± 0.7	1.1	Straight / rounded
B–6	84 ± 30	120 ± 26	20.8 ± 3.9	14.7 ± 1.0	1.4	Curved / sharp
B–10	157 ± 40	122 ± 29	23.0 ± 2.1	16.8 ± 0.1	1.4	Curved / sharp
B–16	140 ± 53	112 ± 36	20.2 ± 1.1	17.3 ± 0.9	1.2	Straight / sharp
B–17	139 ± 44	136 ± 33	18.7 ± 1.8	16.9 ± 0.8	1.1	Curved / rounded
Fwang Tung	190 ± 56	132 ± 44	26.4 ± 2.0	19.4 ± 0.9	1.4	Curved / rounded
Hart	86 ± 22	88 ± 29	19.7 ± 2.2	14.6 ± 0.9	1.3	Straight / sharp
Jungle Gold	119 ± 38	107 ± 45	22.6 ± 3.0	17.8 ± 0.8	1.3	Curved / rounded
Kary	148 ± 35	107 ± 52	21.4 ± 0.8	16.8 ± 0.8	1.3	Curved / sharp
Maha	140 ± 24	116 ± 29	20.7 ± 1.4	18.2 ± 1.0	1.1	Straight / sharp
Sri Kembangan	139 ± 25	128 ± 43	20.4 ± 2.9	18.1 ± 1.8	1.1	Curved / rounded
Thai Knight	110 ± 13	110 ± 30	21.7 ± 2.6	14.9 ± 0.5	1.5	Curved / sharp

**Table V.**

Organoleptic fruit characteristics for twelve different carambola cultivars evaluated in the Canary Islands for three harvest seasons (1997 to 2000).

Cultivar	Skin color	Flesh color	Fruit shape	Flavor	Acidity (mg citric acid·g <sup>-1</sup> )	Total soluble sugars (°Brix)	[Total soluble sugars / acidity] ratio
Arkin	Yellow-orange, green borders	Yellow- orange	Ellipsoidal	Normal	2.54	8.6	3.39
B-6	Orange	Orange	Ellipsoidal	Normal	2.64	8.6	3.27
B-10	Yellow-orange	Yellow- orange	Elongated	Normal	2.39	10.3	4.28
B-16	Yellow-orange	Yellow- orange	Ellipsoidal	Normal	3.03	7.0	2.31
B-17	Yellow-orange	Yellow- orange	Ellipsoidal	Excellent	2.61	10.7	4.08
Fwang Tung	Yellow	Yellow	Ovoid	Normal	2.72	10.1	3.72
Hart	Greenish yellow	Whitish yellow	Ellipsoidal	Bad	2.27	9.0	3.97
Jungle Gold	Greenish yellow	Whitish yellow	Ovoid	Good	3.06	8.5	2.78
Kary	Yellow-orange	Yellow- orange	Ellipsoidal	Normal	2.95	10.8	3.65
Maha	Whitish yellow	Yellow	Ovoid	Normal	3.02	8.0	2.65
Sri Kembangan	Yellow	Yellow	Elongated	Excellent	2.58	10.5	4.07
Thai Knight	Yellow-orange, green borders	Orange	Ellipsoidal	Good	2.55	9.9	3.88

very similar [total soluble solids/ acidity] ratio, only surpassed by B-10 due to its lower acidity, which makes them more suitable for fresh consumption. In fact, the preliminary panel survey done with fruit slices indicated clearly an excellent taste for the cultivars B-17 and Sri Kembangan. Although B-17 did not have the highest total soluble solids values (15–18 °Brix) reported for Malaysia, all the others are on the normal rank obtained elsewhere for these cultivars [5].

### 3.4.3. Other characteristics

The cultivars Arkin, B-17, Maha and Sri Kembangan exhibited the smallest rib [length / width] ratio which, in principle, would favor their marketing. On the other

hand, the sharply pointed rib shape of Maha is a serious defect for postharvest handling, also reported in other countries [8] (*table IV, figure 1*).

### 3.5. Pest and disease incidences

The main pest observed was the Mediterranean fruit fly (*Ceratitidis capitata* Wied.), controlled with regular applications of fenthion at early fruit stages and pyrethrins. All cultivars were susceptible to this pest, but Sri Kembangan and Fwang Tung showed the highest susceptibility and B-10 and Hart the least (*table VI*). Attacks of *Polyphagotarsonemus latus* Banks (broad mite) and aphids sporadically occurred.

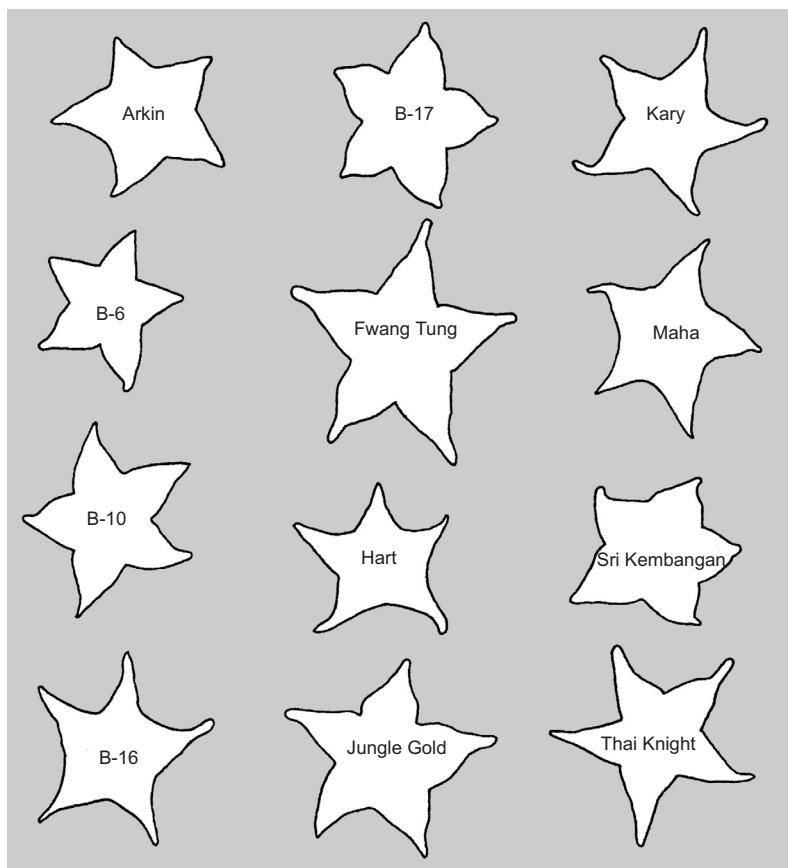
#### 4. Conclusion

For all the trees, the vigor was very high, needing strong pruning to avoid branch breaking due to the load of the fruit and to sporadic winds.

The trees showed a short juvenile period, as normal in this species, with very good yields from the second year of planting and, during the following years, yields similar to other producing countries [6]. The harvesting period is long for a sub-tropical location.

The fruit characteristics seemed to be similar to the standard for the different cultivars [6, 7], with good fruit size, appearance and flavor for various cultivars, adapted to the market requirements of western consumers.

Within the short style cultivars, B-17 and Sri Kembangan (*figure 2*) produced fruit of the best quality. B-17 was also a cultivar with high yields. The long style cultivar Arkin (*figure 2*) was also high yielding although its flavor was not as sweet as B-17 and Sri Kembangan. These three cultivars are currently recommended for cultivation under the Canary Islands' warm climatic conditions.



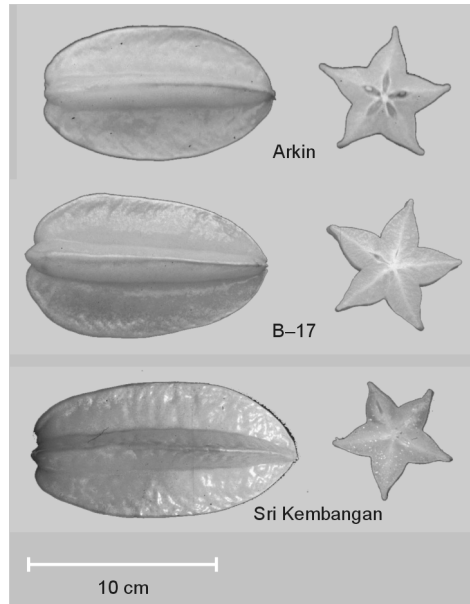
**Figure 1.** Representative cross-sections of twelve different carambola cultivars evaluated in the Canary Islands.

**Table VI.** Mediterranean fruit fly incidence on twelve different carambola cultivars studied in the Canary Islands for three harvest seasons (1997 to 2000).

Cultivar	Incidence
Arkin	Moderate
B-6	Moderate
B-10	Low
B-16	Moderate
B-17	Moderate-high
Fwang Tung	High
Hart	Low
Jungle Gold	Moderate
Kary	Moderate
Maha	Moderate
Sri Kembangan	High
Thai Knight	Moderate

**Figure 2.**

Fruit of the three cultivars recommended under the Canary Islands' warm climatic conditions: B-17 and Sri Kembangan (short style types); Arkin (long style type).



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## Evaluación de cultivares de carambola en las Islas Canarias.

**Resumen — Introducción.** En 1995 se inició un estudio de doce cultivares de carambola (*Averrhoa carambola* L.) con el fin de determinar su potencial como cultivo comercial en las zonas más cálidas de las Islas. **Material y métodos.** Se plantaron doce cultivares de carambola en tres bloques con dos plantas por cultivar y bloque, con riego por goteo y a un marco de plantación de 5 m × 4 m. Para cada cultivar se tomaron datos tanto de características morfológicas como organolépticas de los frutos. **Resultados.** Los resultados hasta la fecha parecen prometedores, con rendimientos altos y buena calidad de fruto para todos los cultivares, aunque algunos han mostrado susceptibilidad a la mosca de la fruta, la recolección se realiza durante 6–7 meses en otoño–invierno. **Conclusión.** Los cultivares recomendados para las zonas de clima cálido de Canarias son B-17 y Sri Kembangan (estilo corto) y Arkin (estilo largo).

**España / Canarias / *Averrhoa carambola* / ensayos de variedades / características agronómicas / productividad / calidad / frutas**