

‘Arisoo’, a Midseason Apple

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‘Arisoo’ is a red apple (*Malus × domestica* Borkh.) that ripens in early September. It was selected from a hybrid population of a cross between ‘Yoko’ (Cummins, 1991) and ‘Senshu’ (Soejima et al., 1998) in 2010 at the Apple Research Institute, National Institute of Horticultural and Herbal Science, Rural Development Administration, Republic of Korea, and commercially registered in 2013. The ‘Arisoo’ apple is of relatively premium fruit quality in terms of taste, fruit shape, and high red blush peel, even under high summer temperatures. The incidence of flesh browning was negligible in ‘Arisoo’ during cold storage and shelf life; therefore, ‘Arisoo’ apple is a highly important variety not only for fresh consumption but also for processing into products, such as juice and fresh-cut fruit. Overall, ‘Arisoo’ apple is a promising cultivar owing to its numerous potential applications, as well as its higher peel blushness.

Origin

The apple cultivar Arisoo originated from a cross between ‘Yoko’ and ‘Senshu’ apple cultivars in 1994. The objective of the cross was to breed a midseason cultivar with red blush apple fruit of high quality (Fig. 1). The seedling, from which ‘Arisoo’ originated, was selected in 2010 and was registered in 2013 in the Republic of Korea. The selection was grafted onto Malling 9 (‘M.9’) clonal rootstocks of 7-year-old trees and then evaluated for four consecutive years in Gunwi in the southern region of the Republic of Korea (lat. 36°16’ N, long. 128°27’ E, altitude 71 m). In the experimental field, the soil characteristics at depth of 0 to 50 cm were clay

loam, pH 6.5, and 2.21% of organic matter content. Irrigation was applied whenever the soil moisture tension was close to –30–40 kPa using an automatic irrigation system equipped with a tensiometer (Irrometer SR; Irrometer Company Inc., Riverside, CA). Data from the nearest meteorological station showed that the daily mean, maximum, and minimum air temperatures of the experimental area in the last decade were 26.2, 31.2, and 22.2 °C in August, and –1, 4.2, and –5.8 °C in January, respectively. The average annual rainfall was 1200 mm. We investigated characteristics of this new cultivar, according to the standard protocol of the

International Union for the Protection of New Varieties of Plants (UPOV, 1994).

The seed parent ‘Yoko’ was selected from an open pollinated seedling of ‘Golden Delicious’ by the Gunma Horticultural Experiment Station, Japan, in 1973 (Cummins, 1991). It has a fruit weight of 282 g, red skin color with a slight stripe and a tendency toward a russet tinge, white flesh color, high fruit storability, and ripens in early October. The pollen parent ‘Senshu’ originated from the cross between ‘Toko’ and ‘Fuji’ at the Akita Fruit Tree Experiment Station, Japan, in 1974 (Soejima et al., 1998). It has a fruit weight of 265 g; a bright, striped, red skin color; yellowish-white juicy flesh; and ripens from early- to mid-October. Characteristics of ‘Arisoo’ fruit are more similar to those of ‘Yoko’, including its white flesh, shape, and slight russet skin color.

‘Hongro’, which is harvested in early September (Shin et al., 1989), is similar to ‘Arisoo’ and has the largest midseason market sharing among Korean apple cultivars (Korea Rural Economic Institute, 2017). The demand for ‘Arisoo’ and its cultivation area are both increasing recently in Korea, due to its superior taste and fruit shape, compared with ‘Hongro’ (KREI, 2018).

Description

Trees, flowers, and leaves. ‘Arisoo’ trees show low vigor, compared with ‘Fuji’ and ‘Gala’ when planted at the same orchard with

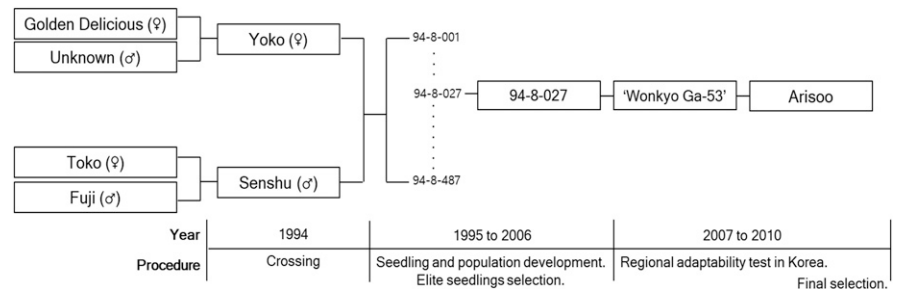


Fig. 1. Pedigree and timeline of breeding procedure used in the development of the apple cultivar Arisoo.



Fig. 2. Tree, flower, and fruit of the apple cultivar Arisoo.

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Table 1. Characteristics of trees, flowers, and leaves of apple cultivars Arisoo, Yoko, and Senshu grown in Gunwi, Republic of Korea.

Characteristics	Arisoo	Yoko (♀)	Senshu (♂)
<i>Tree</i>			
Tree vigor	Weak	Medium	Medium
Tree type	Ramified	Ramified	Ramified
Bearing type	On spurs and long shoots	On spurs and long shoots	On spurs and long shoots
<i>Flower</i>			
Predominant color at balloon stage	Light pink	Light pink	Light pink
Diameter with petals (mm)	42.5 ± 0.2 ^z	45.3 ± 0.2	46.2 ± 0.2
<i>Leaf</i>			
Leaf blade length (mm)	105.3 ± 0.8	125.7 ± 1.1	112.3 ± 0.9
Leaf blade width (mm)	70.2 ± 0.5	83.5 ± 0.5	77.4 ± 0.5
Petal arrangement	Overlapping	Overlapping	Intermediate
First flowering time	Early (18 Apr.)	Early (19 Apr.)	Early (20 Apr.)
Harvest time	Intermediate (early-Sept.)	Late (early-Oct.)	Late (mid-Oct.)

^zValues are means ± SD (n = 30). Data represent the mean of 3 years of experiments (2008–10).

Table 2. Fruit characteristics of apple cultivars Arisoo, Yoko, and Senshu grown in Gunwi, Republic of Korea.

Characteristics	Arisoo	Yoko (♀)	Senshu (♂)
Fruit size (g)	Large (260 ± 18) ^z	Large (282 ± 14)	Large (265 ± 13)
Fruit shape	Globose	Globose	Flat-globose
Ribbing	Absent or weak	Absent or weak	Absent or weak
Crowning at calyx end	Absent or weak	Absent or weak	Absent or weak
Fruit ground color	Yellowish green	Yellowish green	Yellowish green
Relative area of over color	Very large	Very large	Large
Hue of over color	Red	Red	Red
Pattern of over color	Only solid flush	Only solid flush	Solid flush with weakly defined stripes
Intensity of over color	Medium	Medium	Dark
Area of russet around stalk attachment	Absent	Absent	Medium
Relative area of over color	Large	Large	Medium
Area of russet around calyx	Medium	Large	Absent or small
Color of flesh	White	White	Cream
Soluble solids content (%)	14.3 ± 0.2	14.4 ± 0.2	14.8 ± 0.2
Titrate acidity (%)	0.35 ± 0.02	0.37 ± 0.01	0.50 ± 0.01

^zValues are means ± SD (n = 30). Data represent the mean of 3 years of experiments (2008–10).

same rootstock, ‘M.9’ (Fig. 2). There should be adequate numbers of branches during the young plant stage and dwarf rootstocks

should be exposed at 5 cm from the ground when the ‘Arisoo’ scion is grafted with ‘M.9’ (Rural Development Administration, 2018).

Table 4. Responses of fruit quality attributes of ‘Arisoo’ apples harvested on 3 Sept. 2018 at Moonkyong Apple Research Institute and then stored at 0.5 °C for up to 5 months in air.

Storage duration (mo.)	Wt loss ^z (g)	Firmness ^y (N)	SSC ^x (%)	TA ^w (%)	Skin color variables ^v			Cortex color variables ^v		
					Lightness (L*)	Chroma (C*)	Hue angle (h°)	Lightness (L*)	Chroma (C*)	Hue angle (h°)
0	0.0 ^u d ⁱ	84.3 a	15.4 a	0.35 a	58.6 a	40.1 ^{NS}	61.9 a	79.1 c	19.6 b	97.6 a
1	2.1 c	75.5 b	14.8 b	0.33 a	51.0 b	39.2	46.5 b	82.0 b	19.3 b	97.4 a
3	4.4 b	67.6 c	14.9 ab	0.25 b	49.2 b	39.8	41.6 b	81.4 b	20.9 a	96.0 b
5	11.4 a	64.1 c	15.0 ab	0.19 c	51.2 b	39.8	41.0 b	83.7 a	20.5 a	96.0 b
LSD	1.1	7.0	0.6	0.03	4.1	1.4	6.3	1.4	0.8	0.8
Linearity	*	****	NS	**	NS	NS	NS	NS	NS	NS

^zWeight loss was the difference of fruit fresh weight between at harvest and at the corresponding storage time point.

^yFirmness was determined from a texture analyzer (TAHDI/500; Texture Technologies Corp. and Stable Micro Systems, Ltd., Hamilton, MA) with 11 mm probe.

^xSSC (soluble solids content) was determined by squeezing flesh sample to make juice and then used a refractometer (PR-201a, Atago Co. Ltd., Tokyo, Japan) to assess SSC.

^wTA (titrate acidity) was determined by titrating 5 mL juice to pH 8.1 with 0.1 N NaOH.

^vColor variables of peel and cortex tissues were measured at the equator region using a chromameter (Minolta CR-200, Minolta Co., Osaka, Japan). In terms of color coordinates, chroma (C*) indicates relative saturation and hue angle (h°) means the angle of the hue in the CIELab color wheel, while lightness (L*) was mentioned in Table 3.

^uValues are means of 15 fruit (n = 15).

ⁱNS, *, **, ***, ****Nonsignificant or significant at P < 0.05, 0.01, 0.001, or 0.0001, respectively.

Table 3. Fruit skin color variables (L*, a*, and b*) of apple cultivars Arisoo, Yoko, and Senshu grafted on M.9 rootstocks.

Cultivars	L* ^z	a* ^y	b* ^x
Arisoo	40.1 b ^w	23.8 a	15.3 b
Yoko	45.5 a	21.0 b	17.3 ab
Senshu	48.6 a	14.3 c	19.2 a

^zLightness of the color (L*): L* = 100 (white) and L* = 0 (black).

^ya*: One of three coordinates of CIELAB, which position is between red/magenta and green (a*, negative values indicate green, but positive values indicates magenta).

^xb*: One of three color coordinate of CIELAB, which position is between yellow and blue (b*, negative values indicate blue and positive values indicate yellow).

^wMeans in the same column with different letters indicate significant differences (P < 0.05).

‘Arisoo’ begins bearing fruit during the second year after planting. ‘Arisoo’ flowers bloomed from 1 to 2 d earlier than those of ‘Yoko’ and ‘Senshu’ in Gunwi, the Republic of Korea (Table 1). The predominant flower color at the balloon stage is light pink (Fig. 2); the petal diameter is 42.5 mm for ‘Arisoo’, 45.3 mm for ‘Yoko’, and 46.2 mm for ‘Senshu’; and the arrangement of petals is overlapping (Table 1). The self-incompatible genotype of ‘Arisoo’ is S₃S₇ (Cho et al., 2014). ‘Arisoo’ has pollen compatibility with ‘Fuji’ (S₁S₉), ‘Gala’ (S₂S₅), and ‘Golden Delicious’ (S₂S₃), but not with ‘Tsugaru’ (S₃S₇) (Broothaerts et al., 2004). The length and width of the leaf are 105.3 and 70.2 mm for ‘Arisoo’, 125.7 mm and 83.5 mm for ‘Yoko’, and 112.3 and 77.4 mm for ‘Senshu’, respectively (Table 1).

Fruit. The ‘Arisoo’ fruit is large (260 g); has a medium height (67.7 mm) to diameter (79.1 mm) ratio (Table 2); globose shape; yellowish-green ground color; smooth, shiny, and medium thickness skin, with an average number of small lenticels; and 80% to 100% is covered with a red, flushed blush (Fig. 2). Russet

incidence is also detected on the fruit peel. Ribbing and crowning at the calyx end of the fruit are absent. The flesh is white in color, crunchy, and firm. Soluble solids content (SSC) is 14.3% and titratable acidity (TA) is 0.35% (Table 2). ‘Arisoo’ fruit shows hardly any pre-harvest drop. The redness response of ‘Arisoo’ fruit, based on a^* values, is higher than that of ‘Yoko’ and ‘Senshu’ (Table 3). ‘Arisoo’ fruit are more attractive on peel color than ‘Yoko’ and ‘Senshu’ based on these traits.

Storability. The fruit quality characteristics and storability of ‘Arisoo’ apples are shown in Table 4. As storage duration was progressed, fresh weight loss rate gradually increased but flesh firmness decreased during cold storage. SSC remained relatively unchanged but TA gradually decreased during cold storage. Peel lightness (L^*) and hue angle (h°) values were significantly lower during cold storage than those at harvest, regardless of how long the fruit were placed in cold storage. By contrast, cortex L^* was higher during cold storage than that at harvest. Cortex C^* increased during the second half of cold storage but was lower in cortex h° .

Flesh browning incidence. The incidence and severity of flesh browning were negligible in ‘Arisoo’. The change of lightness and color in ‘Arisoo’ showed lower than other cultivars (Fuji, Pink Lady, and Arkansas Black). ‘Arisoo’ is suitable for fresh cutting and requires minimal processing (Hong et al., 2018).

Availability

Plant variety protection of ‘Arisoo’ was obtained by Korean Seed Industry Law in 2013. It is available for commercial and research use with permission from the RDA. The breeder of this variety can be contacted via the RDA (e-mail: topapple@korea.kr).

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