

# Biodiversity of edible fruit sold at Pasar Gede, Surakarta City, Central Java, Indonesia

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**Abstract.** Sagitarian DGF, Astikasari L, Rahmayani D, Armando MF, Nugroho GD, Himawan W, Mutaqin AZ, Md. Naim D, Setyawan AD. 2023. Biodiversity of edible fruit sold at Pasar Gede, Surakarta City, Central Java, Indonesia. *Asian J Agric* 7: 57-68. The market is a place to purchase numerous varieties of goods. Pasar Gede is a traditional Indonesian marketplace in Surakarta City, Central Java, Indonesia. It is the earliest and the largest fruit market in Surakarta. This study was conducted to ascertain the variety species of fruits sold at Pasar Gede from 12 to 16 December 2022. Direct interviews with Pasar Gede administrators and sellers conducted the sampling. This study uses primary data from interviews and secondary data from literature studies to support the primary data, while descriptive analysis was performed on the collected data. The results revealed that the fruit sold at Pasar Gede comprised 82 species from 25 families, with information on local name, price, seasonality, rarity according to vendors, and conservation status according to the IUCN Red List. In Pasar Gede, fruits with conservation status Least Concern (LC) based on the IUCN Red List were found, namely *juwet* (*Syzygium cumini* (L.) Skeels), *matoa* (*Pometia pinnata* J.R.Forst. & G.Forst.), *jambu biji* (*Psidium guajava* L.), *pir packham* (*Pyrus communis* L.), *srikaya* (*Annona squamosa* L.), *jeruk bali* (*Citrus maxima* (Burm.) Merr.), *delima arab* (*Punica granatum* L.), *sirsak* (*Annona muricata* L.), *sawo* (*Manilkara zapota* (L.) P.Royen), *asam jawa* (*Tamarindus indica* L.) and *kesemek* (*Diospyros kaki* L.f.). *Jeruk* (*Citrus* sp.), *apel/pir* (*Pyrus* sp.), *pisang* (*Musa* sp.), *mangga* (*Mangifera* sp.), and *alpukat* (*Persea* sp.) are the dominant fruits (the most available and frequently sold by every vendor in his stall) in Pasar Gede. *Anggur autumn* (*Vitis vinifera* L. cv. autumn) are the most expensive products at 180,000 IDR per kilogram, while *jambu biji* is the least expensive at 8,000 IDR per kilogram. The production cost, seasonality, and fruit quality determine whether fruit prices are costly. The abundance of fruit indicates that Pasar Gede is a comprehensive fruit market center in Indonesia, particularly in Surakarta.

**Keywords:** Import, local fruit, rare, traditional market

## INTRODUCTION

The fruit is part of the plant, which consists of seeds and the outer part of the fruit/epicarp (Esfahlan et al. 2019). Fruit is a source of minerals, carotene, and energy for the human body (Dhok et al. 2020). The fruit has broad benefits for humans, such as being consumed as food tenacity and functioning in medicine (Suwardi et al. 2020). Every human being needs consumption, especially fruit (Apriliani et al. 2021), which causes the demand continuously. Consuming proper fruit every day is essential for health. Still, according to Komarayanti (2017), the Indonesian population consumes less fruit and has not yet reached a sufficient level (minimum 150 grams/capita/day), which is recommended by WHO (Indonesian Ministry of Agriculture 2021). According to BPS Indonesia (2021), Indonesian consume fruit only around 88.56 grams/capita/day of species of fruit such as *jeruk* (*Citrus* sp.), *rambutan* (*Nephelium* sp.), *duku* (*Lansium* sp.), *durian*

(*Durio* sp.), *apel/pir* (*Pyrus* sp.), *salak* (*Salacca* sp.), *pisang* (*Musa* sp.), and *pepaya* (*Carica* sp.). These amounts are still below the minimum limit recommended by WHO. Indonesia is a country that has a wide variety of fruit species, recording 592 species, with 22 commercial fruit (Kumoro et al. 2020). Several native fruits in Indonesia have high economic value and species diversity, such as *mangga* (*Mangifera* sp.), *durian* (*Durio* sp.), and *rambutan* (*Nephelium* sp.) (Angio and Irawanto 2019). Other fruits that can be easily found in Indonesia are *apel/pir* (*Pyrus* sp.) and *jeruk* (*Citrus* sp.). Almost all species of *apel/pir* (*Pyrus* sp.) are consumed directly or, after processing, as chips or drinks (Safitri et al. 2019). *Jeruk* (*Citrus* sp.) is also a fruit widely consumed by Indonesians and is a superior commodity because of its high consumption rate and ease of cultivation (Astuthi and Antasari 2020).

Several species of local fruit are not widely known and have not been documented (Noverian et al. 2020). Hence, the conservation and sustainable use of these fruit varieties

and the diversity of their consumption are not optimal (Harris et al. 2022). Several factors also influence this condition, including the species of fruit (seasonal or not), land conversion, and imported fruit into the local market (Pratama et al. 2019). Intensive land conversion factors can also cause a loss of fruit biodiversity (Horak et al. 2013). Differences in geographical conditions in each region can influence the diversity of fruit species, thus creating fruit species with characteristics according to their origin (Priyambodo et al. 2019). In addition, the diversity of fruit species can increase because new varieties are created from gene-crossing technology per market demand or other methods (Fitriani et al. 2014). However, the presence of environmental factors such as temperature rise will affect the condition of the fruit. An increase in temperature can trigger changes in taste. It occurs in *anggur* (*Vitis* sp.) and *alpukat* (*Persea* sp.) (Leisner 2020). Therefore, it will affect the quality and quantity of fruit sold. Although the diversity of fruit species in Indonesia is high, the season strongly influences fruit availability.

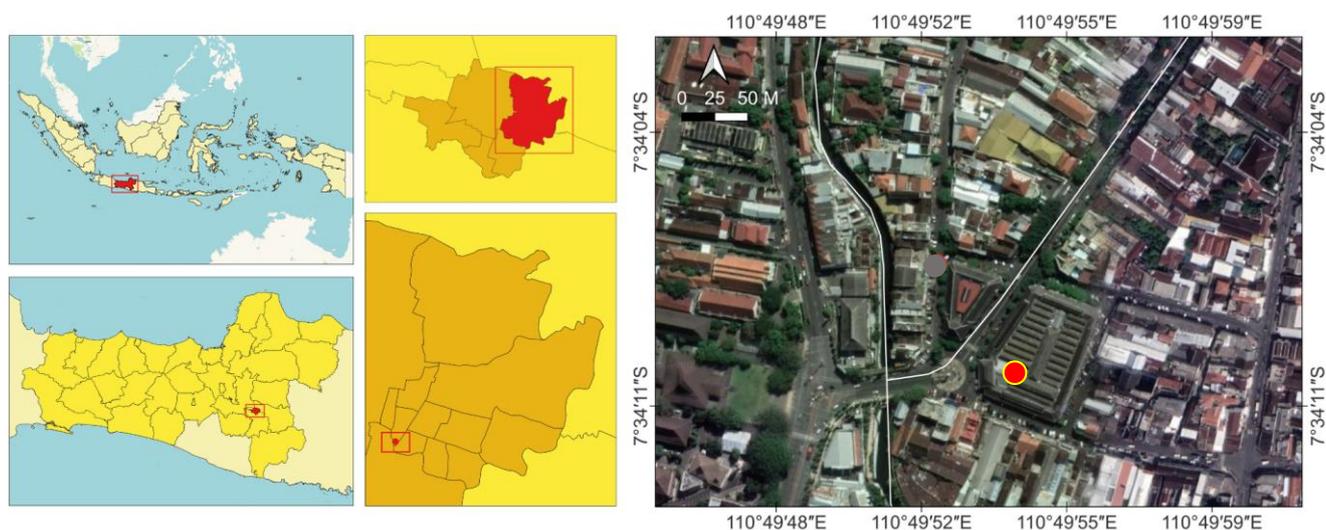
Traditional markets remain influential outlets for fruit sales (Jun et al. 2022). Traditional markets are physically accessible to low-income consumers and consumers who function as wholesalers, serve as entry points for small farmers, and provide job opportunities for sellers (Davies et al. 2022). The fruit market in Indonesia has received a lot of imported fruit inputs. This expansion is because the quality of local fruit has not been able to create superior products (Rahayu et al. 2012). One of the markets with the main selling commodity for fruit in Indonesia is Pasar Gede, one of the leading markets in Surakarta City (Asyfiradayati et al. 2018), a cultural heritage market has attractiveness and competitiveness (Aliyah et al. 2017). In addition, Pasar Gede potentially attracts buyers from outside and within the city due to its strategic middle city location (Aliyah and Aulia 2019). From time to time, the main commodity sold at Pasar Gede varies from local and imported fruits. None of the various species of fruit sold at Pasar Gede come from Surakarta City, but stocks come from Salatiga, Karanganyar, Boyolali, Madiun, and outside Java Island. It is influenced by the condition of Surakarta's

land, an urban area that has increased rapidly and resulted in a loss of agricultural land and fruit cultivation (Rada et al. 2022). Based on the preliminary survey, while Pasar Gede is the largest fruit market in Surakarta, no research discusses the diversity of fruit sold there. Hence, this study aimed to determine the diversity of fruits sold in Pasar Gede, Surakarta, Central Java, Indonesia.

## MATERIALS AND METHODS

### Study area

This research was conducted on 12-16 December 2022 at Pasar Gede Hardjonagoro (traditional market), commonly called Pasar Gede. Pasar Gede is located on Jebres Sub-district, Surakarta City, Central Java, Indonesia, with coordinates 7°34'07" S, 110°49'52" E (Figure 1). Pasar Gede is a fruit market in Surakarta, built from 1925 to 1930 (Herlambang et al. 2017). Based on information from Agus Suharto as the Market Management, it is the largest fruit market in Surakarta. Then, Pasar Gede was a cultural heritage market officially operated in 1935 (Figure 2). Pasar Gede has the full name Pasar Gede Hardjonagoro, derived from the name of a Chinese nobleman who received the title Kanjeng Raden Tumenggung Hardjonagoro. This Chinese nobleman was the one who started Pasar Gede in the form of a *plataran*. In Surakarta, this market is the oldest, and during the golden age of the Surakarta Hadiningrat Palace, it played a role as the center of the economy. In the context of developing Surakarta's economy, Pasar Gede was built and designed by Ir. Herman Thomas Karsten during the time of Pakubuwono X. The Pasar Gede building, consisting of 2 floors, has a unique shape. It is an old Javanese colonial architecture that has maintained its shape until now (Soebiyani et al. 2020). The distinctive shape of the building makes it different from most markets in Surakarta, so it has its charm. Pasar Gede is a traditional Javanese model market that provides staple goods for people outside the palace, such as Chinese Ethnicity, Indigenous Javanese, and Dutch (Harsasto 2018).



**Figure 1.** Location of Pasar Gede in Sudiroprajan Village, Jebres Sub-district, Surakarta City, Central Java, Indonesia



**Figure 2.** Pasar Gede building, Surakarta, Central Java, Indonesia in 1935 (*left*) and 2022 (*right*)

Agus Suharto further informed that with the development of times, this market has also begun to develop in providing various needs for the community. Even so, the goods traded during construction are still the same: necessities (rice, sugar, oil, eggs, onions, salt, meat, milk, kerosene and Liquid Petroleum Gas), vegetables, fish, and pork in the form of meat or processed. For now, there is extra fruit sold in it. As a result of the constantly high demand for fruit, the supply at Pasar Gede is of various species, ranging from local to imported fruits. It resulted in Pasar Gede becoming the most significant fruit market in Surakarta City. Compared to other traditional market, its presence is the oldest and the center of the community's economy and culture. Cultural diversity can enhance traditional culture through various cultural events that attract national and international attention (Ekomadyo 2019).

#### Data collection procedures

The data source of this research is divided into primary and secondary data. Primary data was obtained by conducting interviews with all fruit sellers in Pasar Gede (a total of 48 sellers) to observe whether fruits were sold, local names, prices, scarcity according to the sellers, and seasonal fruit. Interviews with sellers were conducted through a prepared questionnaire (Ruwaida et al. 2022). Meanwhile, secondary data was obtained from literature studies to support data in the field. Secondary data in this study was obtained by family groups, Latin names, and conservation status (IUCN). Various species of fruit sold by sellers in Pasar Gede were recorded in the questionnaire and documented.

#### Data analysis

Data analysis was carried out descriptively and supported by tables, pictures, and graphs as explanations. Tables are presented to explain the characteristics of the respondents and the variety of fruit found in Pasar Gede. Graphs are provided to analyze the family of each fruit found. Apart from being in tabular form, the variety of fruits is also presented in documentation or pictures.

## RESULTS AND DISCUSSION

### Characteristics of respondents from Pasar Gede fruit sellers

The characteristics of fruit sellers in Pasar Gede, based on the interviews with all fruit sellers, are shown in Table 1. This table shows that most fruit sellers in Pasar Gede are women (39), while only nine are men. The most common age of sellers ranges from 51-60 years, while most sellers had high school or elementary school backgrounds. The seller's age can affect their experience, so the seller better understands consumer desires. Several fruit vendors have been selling at Pasar Gede for decades, several respondents even stated that selling fruit at Pasar Gede was a business passed down from their parents. It makes sellers already understand the characteristics of consumers who come. Therefore, sellers are becoming more focused on selecting fruit consumers' requests. On the contrary, being too old will make it difficult for sellers to trade because their increasingly weak physical condition limits their movements. A high educational background shows an individual's knowledge, so sellers with a higher educational background should be more competent in managing their business. However, it is not always accurate because trading requires knowledge and skills. Therefore, good educational background, adequate trading skills, and experience are indispensable for sellers. At Pasar Gede, vendors sell many species of local and imported fruit; some sellers have been selling for over 20 years, and selling fruits was their parents' job. Meanwhile, there was also an elderly merchant who had only graduated from elementary school. She sells only 1 species of fruit, which is usually local fruit and grown by herself.

### Fruit family

Based on Figure 3, it can be seen that there are 25 families of fruit found in Pasar Gede. Most families are represented by only one species: Cactaceae, Oxalidaceae, Bromeliaceae, Chenopodiaceae Actinidiaceae, Lythraceae, Sapotaceae, Fabaceae, Bombacaceae, Clusiaceae, Meliaceae, and Ebenaceae. The fruit family with the most species for sale is Rosaceae, with 15 species; Rutaceae,

with 11 species; and Anacardiaceae and Musaceae, with nine species. This diagram shows that the diversity of families of fruit sold at Pasar Gede is quite diverse compared to those found at Pasar Legi Surakarta, where only 16 families were found for fruits sold at the market (Nurshillah et al. 2022). However, an overview of the species diversity of each family is still lacking because most families only contribute to one species.

**Variety species of fruit in Pasar Gede**

Based on the interviews with sellers, information was obtained that sellers sold as many as 82 species of fruit in stalls or kiosks (Table 2). These fruits are local Indonesian fruits and imported fruits. As much as 75% (36 sellers) mostly sell citrus fruits or jeruk (*Citrus* spp.), apples or apel/pir (*Pyrus* spp.), bananas/pisang (*Musa* spp.), mangoes/mangga (*Mangifera* spp.) and avocados/alpukat (*Persea* spp.). Then, the remaining 25% (12 sellers) are sellers who sell species of fruit that other sellers rarely sell, such as (i) local fruit, namely persimmon/kesemek (*D. kaki*), matoa (*P. pinnata*), siwalan (*B. flabellifer*), srikaya (*A. squamosa*), kedondong (*S. dulcis*), sukun (*A. altilis*), blewah (*C. melo* var. *cantalupensis* naudin), asam jawa (*T. indica*), and juwet (*S. cumini*); (ii) imported fruit, namely plums/plum (*P. domestica*), bit (*B. vulgaris*), lychees/leci (*L. chinensis*), and Arabic pomegranates/delima arab (*P. granatum*). Some pictures of fruit sold at Pasar Gede are shown in Figure 4.

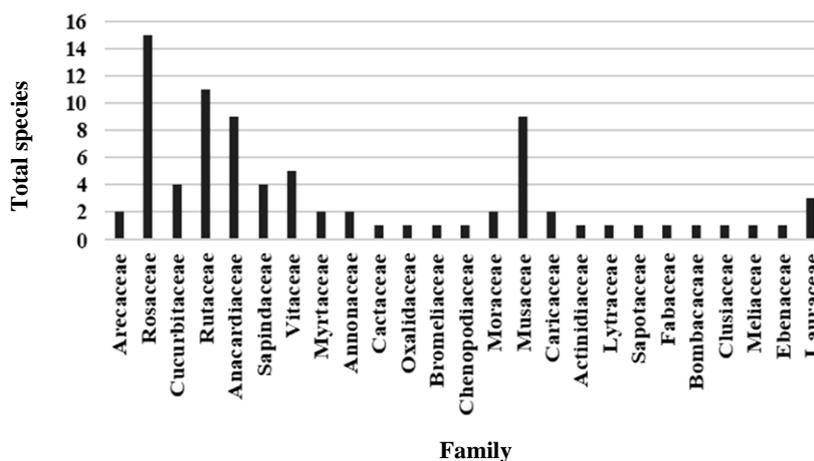
**Rarity and conservation status**

The availability of fruit is seasonal and year-round, with almost the same amount. However, the availability of 5 species of fruit is rare, 4 seasonal fruits (*B. flabellifer*, *S. cumini*, *P. domestica*, and *P. pinnata*) and 1 year-round

fruit (*B. vulgaris*). The fruit with the highest selling price is the autumn grape/anggur autumn (*V. vinifera* var. autumn), with a price of 180,000 IDR per kilogram, which is imported fruit. Then, the fruit with the lowest selling price is *P. guajava* at 8,000 IDR per kilogram. Table 2 shows the fruit species with the Least Concern (LC) conservation status (low risk) based on the IUCN Red List are *S. cumini*, *P. pinnata*, *P. guajava*, *P. communis*, *A. squamosa*, *C. maxima*, *P. granatum*, *A. muricata*, *M. zapota*, *T. indica*, and *D. kaki*. Table 3 also shows that the fruit species sold at Pasar Gede are more diverse and in greater quantity than in other markets. Several species of fruit at Pasar Gede, Surakarta, Indonesia can be seen in Figure 5.

**Table 1.** Characteristics of respondents from fruit sellers at Pasar Gede, Surakarta, Central Java, Indonesia (n= 48)

Variable	Amount	Percentage (%)
<b>Age</b>		
20-30	2	4.2
31-40	4	8.3
41-50	13	27.1
51-60	17	35.4
61-70	9	18.7
71-80	2	4.2
81-90	1	2.1
<b>Gender</b>		
Male	9	18.75
Female	39	81.25
<b>Education</b>		
Elementary School	24	50.00
Junior High School	9	18.75
Senior High School	15	31.25
University	0	0



**Figure 3.** The number of species in the fruit family sold at Pasar Gede, Surakarta, Central Java, Indonesia



**Figure 4.** General conditions inside the market (A and B) and vendor stalls (C) in Pasar Gede, Surakarta, Central Java, Indonesia

**Table 2.** The variety of fruit sold at Pasar Gede, Surakarta, Central Java, Indonesia

Family	Scientific name	Local name	Price (IDR)	Fruit category (Seasonal/ Year-round)	Information (Rare/ Not-Rare)	Status IUCN
Actinidiaceae	<i>Actinidia deliciosa</i> (Chev.) C.F.Liang & A.R.Ferguson	<i>Kiwi</i>	60,000/kg	Seasonal	Not Rare	-
Anacardiaceae	<i>Mangifera indica</i> L. cv. arummanis	<i>Mangga arumanis</i>	15,000/kg	Seasonal	Not Rare	-
Anacardiaceae	<i>Mangifera indica</i> L. cv. gadung	<i>Mangga gadung</i>	25,000/kg	Seasonal	Not Rare	-
Anacardiaceae	<i>Mangifera indica</i> L. cv. gedong gincu	<i>Mangga gedong gincu</i>	55,000/kg	Seasonal	Not Rare	-
Anacardiaceae	<i>Mangifera indica</i> L. cv. indramayu	<i>Mangga indramayu</i>	30,000/kg	Seasonal	Not Rare	-
Anacardiaceae	<i>Mangifera indica</i> L. cv. manalagi	<i>Mangga manalagi</i>	20,000/kg	Seasonal	Not Rare	-
Anacardiaceae	<i>Mangifera indica</i> L. cv. okyong	<i>Mangga okyong</i>	40,000/kg	Seasonal	Not Rare	-
Anacardiaceae	<i>Mangifera indica</i> L. cv. alpukat	<i>Mangga alpukat</i>	35,000/kg	Seasonal	Not Rare	-
Anacardiaceae	<i>Mangifera lalijiwa</i> Kosterm.	<i>Mangga lalijiwo</i>	15,000/kg	Seasonal	Not Rare	-
Anacardiaceae	<i>Spondias dulcis</i> Sol. ex G.Forst.	<i>Kedondong</i>	25,000/kg	Year-round	Not Rare	-
Annonaceae	<i>Annona muricata</i> L.	<i>Sirsak</i>	20,000/kg	Year-round	Not Rare	LC
Annonaceae	<i>Annona squamosa</i> L.	<i>Srikaya</i>	25,000/ kg	Year-round	Not Rare	LC
Arecaceae	<i>Borassus flabellifer</i> L.	<i>Siwalan</i>	15,000/pcs	Seasonal	Rare	-
Arecaceae	<i>Salacca zalacca</i> (Gaertn.) Voss cv. pondoh	<i>Salak pondoh</i>	25,000/kg	Year-round	Not Rare	-
Bombacaceae	<i>Durio zibethinus</i> Murray	<i>Durian</i>	50,000/kg	Seasonal	Not Rare	-
Bromeliaceae	<i>Ananas comosus</i> (L) Merr.	<i>Nanas madu</i>	15,000/pcs	Year-round	Not Rare	-
Cactaceae	<i>Selenicereus undatus</i> (Haw.) D.R.Hunt	<i>Buah naga merah</i>	15,000/kg	Year-round	Not Rare	-
Caricaceae	<i>Carica papaya</i> L. cv. california	<i>Pepaya california</i>	10,000/ kg	Year-round	Not Rare	-
Caricaceae	<i>Carica papaya</i> L. cv. thailand	<i>Pepaya thailand</i>	15,000/kg	Year-round	Not Rare	-
Chenopodiaceae	<i>Beta vulgaris</i> L.	<i>Buah bit</i>	25,000/kg	Year-round	Rare	-
Clusiaceae	<i>Garcinia mangostana</i> L.	<i>Manggis</i>	40,000/kg	Seasonal	Not Rare	-
Cucurbitaceae	<i>Citrullus lanatus</i> (Thunb.) Matsum. & Nakai	<i>Semangka</i>	10,000/kg	Year-round	Not Rare	-
Cucurbitaceae	<i>Cucumis melo</i> L.	<i>Melon</i>	20,000/kg	Seasonal	Not Rare	-
Cucurbitaceae	<i>Cucumis melo</i> L. cv. cantalupensis Naudin	<i>Blewah</i>	20,000/kg	Seasonal	Not Rare	-
Cucurbitaceae	<i>Cucumis melo</i> L. cv. golden	<i>Melon golden</i>	40,000/kg	Seasonal	Not Rare	-
Ebenaceae	<i>Diospyros kaki</i> L.f.	<i>Kesemek</i>	30,000/kg	Seasonal	Not Rare	LC
Fabaceae	<i>Tamarindus indica</i> L.	<i>Asam jawa</i>	25,000/kg	Year-round	Not Rare	LC
Lauraceae	<i>Persea americana</i> Mill.	<i>Alpukat mentega</i>	25,000/kg	Seasonal	Not Rare	-
Lauraceae	<i>Persea americana</i> Mill. cv. aligator	<i>Alpukat aligator</i>	30,000/kg	Seasonal	Not Rare	-
Lauraceae	<i>Persea americana</i> Mill. cv. kendil	<i>Alpukat kendil</i>	40,000/kg	Seasonal	Not Rare	-
Lytraceae	<i>Punica Granatum</i> L.	<i>Delima arab</i>	35,000/kg	Year-round	Not Rare	LC
Meliaceae	<i>Lansium domesticum</i> Corrêa	<i>Duku</i>	45,000/kg	Seasonal	Not Rare	-
Moraceae	<i>Artocarpus altilis</i> (Parkinson) Fosberg	<i>Sukun</i>	15,000/kg	Seasonal	Not Rare	-
Moraceae	<i>Artocarpus heterophyllus</i> Lam.	<i>Nangka</i>	40,000/kg	Year-round	Not Rare	-
Musaceae	<i>Musa acuminata</i> Colla cv. AA	<i>Pisang barlin</i>	15,000/comb	Year-round	Not Rare	-
Musaceae	<i>Musa acuminata</i> Colla cv. cavendish	<i>Pisang cavendish</i>	30,000/comb	Year-round	Not Rare	-
Musaceae	<i>Musa acuminata</i> Colla cv. raja	<i>Pisang raja</i>	30,000/comb	Year-round	Not Rare	-
Musaceae	<i>Musa acuminata</i> Colla cv. susu	<i>Pisang susu</i>	15,000/comb	Year-round	Not Rare	-
Musaceae	<i>Musa acuminata</i> Colla cv. susu merah	<i>Pisang susu merah</i>	40,000/comb	Year-round	Not Rare	-
Musaceae	<i>Musa acuminata</i> x <i>M. balbisiana</i>	<i>Pisang kepok</i>	30,000/comb	Year-round	Not Rare	-

Musaceae	<i>Musa paradisiaca</i> L. cv. bawen	<i>Pisang bawen</i>	20,000/comb	Year-round	Not Rare	-
Musaceae	<i>Musa paradisiaca</i> L. cv. mas	<i>Pisang mas</i>	25,000/comb	Year-round	Not Rare	-
Musaceae	<i>Musa paradisiaca</i> L. cv. sapientum	<i>Pisang ambon</i>	50,000/comb	Year-round	Not Rare	-
Myrtaceae	<i>Psidium guajava</i> L.	<i>Jambu biji</i>	8,000/kg	Year-round	Not Rare	LC
Myrtaceae	<i>Syzygium cumini</i> (L.) Skeels	<i>Juwet</i>	110,000/ kg	Seasonal	Rare	LC
Oxalidaceae	<i>Averrhoa carambola</i> L. cv. demak	<i>Belimbing demak</i>	25,000/kg	Year-round	Not Rare	-
Rosaceae	<i>Fragaria</i> × <i>ananassa</i> (Weston) Rozier	<i>Stroberi</i>	60,000/kg	Year-round	Not Rare	-
Rosaceae	<i>Malus domestica</i> (Suckow) Borkh.	<i>Apel hijau</i>	25,000/kg	Year-round	Not Rare	-
Rosaceae	<i>Malus domestica</i> (Suckow) Borkh. cv. Ambrosia	<i>Apel ambrosia</i>	90,000/kg	Year-round	Not Rare	-
Rosaceae	<i>Malus domestica</i> (Suckow) Borkh. cv. granny smith	<i>Apel granny smith</i>	60,000/kg	Year-round	Not Rare	-
Rosaceae	<i>Prunus domestica</i> L.	<i>Plum</i>	30,000/kg	Seasonal	Rare	-
Rosaceae	<i>Pyrus communis</i> L.	<i>Pir packham</i>	50,000/kg	Seasonal	Not Rare	LC
Rosaceae	<i>Pyrus communis</i> L. cv. century	<i>Pir century</i>	25,000/kg	Seasonal	Not Rare	-
Rosaceae	<i>Pyrus communis</i> L. cv. yali	<i>Pir yali</i>	45,000/kg	Seasonal	Not Rare	-
Rosaceae	<i>Pyrus malus</i> L.	<i>Apel</i>	35,000/kg	Year-round	Not Rare	-
Rosaceae	<i>Pyrus malus</i> L. cv. fuji	<i>Apel fuji</i>	35,000/kg	Year-round	Not Rare	-
Rosaceae	<i>Pyrus malus</i> L. cv. madu	<i>Pir madu</i>	25,000/kg	Seasonal	Not Rare	-
Rosaceae	<i>Pyrus malus</i> L. cv. washington	<i>Apel washington</i>	40,000/kg	Year-round	Not Rare	-
Rosaceae	<i>Pyrus pyrifolia</i> (Burm.fil.) Nakai	<i>Pir asia</i>	50,000/kg	Seasonal	Not Rare	-
Rosaceae	<i>Pyrus pyrifolia</i> (Burm.fil.) Nakai cv. singo	<i>Pir korea singo</i>	80,000/kg	Seasonal	Not Rare	-
Rosaceae	<i>Pyrus pyrifolia</i> (Burm.fil.) Nakai cv. xiang lie	<i>Pir xiang lie</i>	30,000/kg	Seasonal	Not Rare	-
Rutaceae	<i>Citrus</i> × <i>aurantifolia</i> (Christm.) Swingle	<i>Jeruk nipis</i>	20,000/kg	Year-round	Not Rare	-
Rutaceae	<i>Citrus limon</i> (L.) Osbeck	<i>Lemon</i>	30,000/kg	Year-round	Not Rare	-
Rutaceae	<i>Citrus maxima</i> (Burm.) Merr.	<i>Jeruk bali</i>	25,000/kg	Year-round	Not Rare	LC
Rutaceae	<i>Citrus nobilis</i> Andrews	<i>Jeruk medan</i>	25,000/kg	Year-round	Not Rare	-
Rutaceae	<i>Citrus reticulata</i> Blanco	<i>Jeruk mandarin</i>	30,000/kg	Year-round	Not Rare	-
Rutaceae	<i>Citrus reticulata</i> Blanco cv. shiranui	<i>Jeruk dekopon</i>	90,000/kg	Year-round	Not Rare	-
Rutaceae	<i>Citrus sinensis</i> (L) Osbeck cv. sunkist	<i>Jeruk sunkist</i>	40,000/kg	Year-round	Not Rare	-
Rutaceae	<i>Citrus sinensis</i> (Mill.) Pers. cv. baby	<i>Jeruk baby</i>	15,000/kg	Year-round	Not Rare	-
Rutaceae	<i>Citrus sinensis</i> L. Osbeck cv. manis	<i>Jeruk manis</i>	25,000/kg	Year-round	Not Rare	-
Rutaceae	<i>Citrus</i> sp.	<i>Jeruk santang</i>	40,000/kg	Year-round	Not Rare	-
Rutaceae	<i>Triphasia trifolia</i> (Burm.fil.) P.Wilson	<i>Jeruk kimkit</i>	100,000/kg	Year-round	Not Rare	-
Sapindaceae	<i>Dimocarpus longan</i> Lour.	<i>Kelengkeng</i>	40,000/kg	Year-round	Not Rare	-
Sapindaceae	<i>Litchi chinensis</i> Sonn.	<i>Leci</i>	140,000/kg	Seasonal	Not Rare	-
Sapotaceae	<i>Manilkara zapota</i> (L.) P.Royen	<i>Sawo</i>	20,000/kg	Seasonal	Not Rare	LC
Sapindaceae	<i>Nephelium lappaceum</i> L.	<i>Rambutan</i>	30,000/kg	Seasonal	Not Rare	-
Sapindaceae	<i>Pometia pinnata</i> J.R.Forst. & G.Forst.	<i>Matoa</i>	50,000/kg	Seasonal	Rare	LC
Vitaceae	<i>Vitis vinifera</i> L. cv. australia	<i>Anggur australia</i>	50,000/kg	Year-round	Not Rare	-
Vitaceae	<i>Vitis vinifera</i> L. cv. autumn	<i>Anggur autumn</i>	180,000/kg	Year-round	Not Rare	-
Vitaceae	<i>Vitis vinifera</i> L. cv. muscat	<i>Anggur muscat</i>	140,000/kg	Year-round	Not Rare	-
Vitaceae	<i>Vitis vinifera</i> L. cv. red	<i>Anggur merah</i>	50,000/kg	Year-round	Not Rare	-
Vitaceae	<i>Vitis vinifera</i> L. cv. RRC	<i>Anggur RRC</i>	50,000/kg	Year-round	Not Rare	-

Note: LC: Least Concern based on the IUCN Red List, IDR: Indonesian Rupiah

**Table 3.** Several traditional markets in Indonesia and abroad

Traditional market names	Number of species of fruit	References
Ujung Berung traditional market, Bandung (Indonesia)	39	Iskandar et al. (2018)
Sukoharjo traditional market (Indonesia)	32	Deanova et al. (2021)
Beringharjo traditional market, Yogyakarta (Indonesia)	55	Iskandar et al. (2021)
Tabanan traditional market, Bali (Indonesia)	9	Sujarwo et al. (2018)
Karawang village traditional market, Cianjur (Indonesia)	8	Iskandar et al. (2020)
Legi market, Surakarta (Indonesia)	24	Nurshillah et al. (2022)
Traditional market in Bekasi (Indonesia)	24	Gordi et al. (2022)
Tamu Kianggeh Market (Brunei Darussalam)	31	Franco et al. (2020)
Fergana Valley traditional market (Southern Kyrgyzstan)	7	Vlkova et al. (2015)
Batu Pahat traditional market (Malaysia)	22	Sulaini and Sabran (2018)



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**Figure 5.** Several species of fruit at Pasar Gede, Surakarta, Indonesia. 1. Kiwi (*Actinidia deliciosa*), 2. Mangga indramayu (*Mangifera indica* cv. indramayu), 3. Mangga gedong gincu (*Mangifera indica* cv. gedong gincu), 4. Srikaya (*Annona squamosa*), 5. Sirsak (*Annona muricata*), 6. Salak pondoh (*Salacca zalacca* cv. pondoh), 7. Nanas madu (*Ananas comosus*), 8. Buah naga merah (*Selenicereus undatus*), 9. Pepaya california (*Carica papaya* cv. california), 10. Pepaya thailand (*Carica papaya* cv. thailand), 11. Bit (*Beta vulgaris*), 12. Semangka (*Citrullus lanatus*), 13. Melon (*Cucumis melo*), 14. Melon golden (*Cucumis melo* cv. golden), 15. Blewah (*Cucumis melo* cv. cantalupensis), 16. Pisang ambon (*Musa paradisiaca* cv. sapientum), 17. Pisang cavendish (*Musa acuminata* cv. cavendish), 18. Alpukat aligator (*Persea americana* cv. aligator), 19. Alpukat kendil (*Persea americana* cv. kendil), 20. Alpukat mentega (*Persea americana*), 21. Anggur merah (*Vitis vinifera* cv. red), 22. Apel hijau (*Malus domestica* cv. Ambrosia), 23. Apel fuji (*Pyrus malus* cv. fuji), 24. Nangka (*Artocarpus heterophyllus*), 25. Pisang bawen (*Musa paradisiaca* cv. bawen), 26. apel (*Pyrus malus*), 27. Apel washington (*Pyrus malus* cv. washington), 28. Belimbing demak (*Averrhoa carambola* cv. demak), 29. Asam jawa (*Tamarindus indica*), 30. Delima arab (*Punica granatum*), 31. Mangga gadung (*Mangifera indica* cv. gadung), 32. Pir asia (*Pyrus pyrifolia*), 33. Mangga arumanis (*Mangifera indica* cv. arummanis), 34. jambu biji (*Psidium guajava*), 35. Jeruk bali (*Citrus maxima*), 36. Jeruk baby (*Citrus sinensis* cv. baby) 37. Jeruk dekopon (*Citrus reticulata* cv. shiranui), 38. Jeruk mandarin (*Citrus reticulata*), 39. Jeruk manis (*Citrus sinensis* cv. manis), 40. Jeruk nipis (*Citrus × aurantiifolia*), 41. Jeruk sunkist (*Citrus sinensis* cv. sunkist), 42. Kelengkeng (*Dimocarpus longan*), 43. Lemon (*Citrus limon*), 44. Mangga lalijiwo (*Mangifera lalijiwo*), 45. Pir yali (*Pyrus communis* cv. communis), 46. pir packham (*Pyrus communis*), 47. Pir korea singo (*Pyrus pyrifolia* cv. singo), 48. Pir xiang lie (*Pyrus pyrifolia* cv. xiang lie), 49. Pisang barlin (*Musa acuminata* AA), 50. Pisang kepok (*Musa acuminata* x *M. balbisiana*), 51. Pisang susu merah (*Musa acuminata* cv. Susu merah), 52. Plum (*Prunus domestica*), 53. Rambutan (*Nephelium lappaceum*), 54. Jeruk santang (*Citrus* sp.), 55. Sawo (*Manilkara zapota*), 56. Stroberi (*Fragaria ×ananassa*), 57. Sukun (*Artocarpus altilis*), 58. Anggur asutralia (*Vitis vinifera* cv. australia), 59. Anggur autum (*Vitis vinifera* cv. Autumn), 60. Juwet (*Syzygium cumini*), 61. Anggur muscat (*Vitis vinifera* cv. muscat), 62. Jeruk kimkit (*Triphasia trifolia*), 63. Matoa (*Pometia pinnata*), 64. Kedondong (*Spondias dulcis*), 65. Mangga okyong (*Mangifera indica* cv. okyong), 66. Apel granny smith (*Malus domestica* cv. granny smith)

## Discussions

In this study, 82 species of fruit were sold at Pasar Gede, both local and imported. Table 3 shows that Pasar Gede has more fruit sold than other markets from several traditional markets in Indonesia and abroad. Buyers can buy daily needs at this market because of its location (in the middle of the city), complete goods, and best quality goods at affordable prices (Puteri and Fajarwati 2016). The interview with Mr. Agus Suharto (manager of Pasar Gede) shows that the sellers strive for the best quality and maintain the sustainability of the fruit commodity sold by supplying it from out of town and abroad. Furthermore, Mr. Agus Suharto informs that the large number of buyers at Pasar Gede has an impact on increasing demand for fruit so that the species of fruit sold could be more diverse. The

fruits buyers at Pasar Gede seek more after are citrus (*Citrus* spp.) because the community widely uses it for important events, such as the Chinese New Year.

The impact of imports from abroad has resulted in the price of fruit at Pasar Gede tending to be more expensive than at other traditional markets in Surakarta. However, it is still affordable for the community. Fruit sold at higher prices at Pasar Gede is also due to their type as seasonal fruits such as *S. cumini*, *P. pinnata*, *M. indica* cv. *gedong gincu*, *D. zibethinus*, *L. domesticum*, *L. chinensis*, *D. kaki*, *N. lappaceum*, *A. deliciosa*, *G. mangostana*, several species of avocado/alpukat, namely *kendil* (*P. americana* cv. *kendil*) and alligator (*P. americana* cv. *alligator*). Seasonal fruits found in Pasar Gede are generally expensive because they are not sold during their fruiting season, so they are

rarely found. When it sells during their fruiting season, the price will be cheaper; we could also find year-round fruits at a lower price than seasonal fruit. Autumn grapes (*V. vinifera* cv. autumn) are the fruit type with the highest price of 180,000 IDR/kg. Autumn grapes are seedless grapes usually served at banquets. This fruit has high qualities such as higher nutrition, larger diameter, and sweeter than other species because it is produced under strict management and various studies to produce this high-quality fruit (Faci et al. 2014; Fuentes et al. 2018). The overall costs during the fruit production period influence the fruit selling price (Panagos et al. 2018). High quality, being a cultivar, and having high production costs make the price of autumn grapes more expensive. In addition, citrus fruits dominate sales (36 sellers) because they have affordable and very abundant prices (Setiawan et al. 2019). On the contrary, the fruits that people rarely demand, such as *sukun* (*A. altilis*), although it is a seasonal fruit, the price is cheaper than other seasonal fruits.

Seasonal fruits are superior commodities for export and have high economic value. Due to influencing factors, seasonal fruit tends to be more difficult to produce and sustain. One of them is the biennial-bearing characteristic of some plants. Biennial bearing is inconsistent in the stages of fruiting and flowering. A tree will find abundant and maximum fruit yields when it bears fruit but will bear little fruit in the next fruiting time, resulting in erratic crop production (Shivran et al. 2020). The Biennial-bearing properties are caused by the young fruit, which produces the hormone gibberellin. This hormone is then distributed to the vegetative shoots resulting in dense leaves but no flowers in the following year resulting in no fruit (Widiatama et al. 2021). Moreover, seasonal fruit is also influenced by climates, such as rainfall, wind, and dry and wet months. It occurs in *durian* (*Durio* spp.), wherein the flowering and fruiting stages take about 1-2 dry periods/month to encourage the flowering process to bear fruit (Rударmono et al. 2022). High rainfall will result in delays in the flowering process due to many flowers and young fruit falling, reducing the quantity of fruit. La Nina and El Nino can cause high and low rainfall intensity in this area. The existence of La Nina results in high rainfall, which can shed flowers. In contrast, El Nino results in low rainfall, which results in a drought so that flowers are unable to develop and produce fruit which can disrupt fruit production (Sarvina and Sari, 2017). Rainfall that affects the dry/wet months will affect the quality of seasonal fruit, such as the *rambutan* (*Nephelium* sp.), whose flesh will be thin if the dry season is too lengthy (Nugroho et al. 2019). In addition, the wind substantially impacts certain seasonal fruits, such as avocado (*Persea* spp.). In the fruit-producing stage, flowers must be pollinated by wind, so an adequate amount of wind is required. High wind velocities will result in broken branches and impede pollination. On the other hand, temperature and other environmental factors, such as humidity, can also affect a product's nutritional value and flavor (Leisner 2020). Similarly to avocados, the concentration of monounsaturated and polyunsaturated fatty acids increases with temperature (Pedreschi et al. 2016).

Many fruits sold at Pasar Gede are not native to Surakarta; some are brought from other cities and countries. Farmers from Tawangmangu, Karanganyar, Boyolali, Berastagi (Karo), Madiun City, Bali Island, Kalimantan Island, and the Riau Islands sell produce to Pasar Gede's fruit merchants. For example, the stock fruit for *juwet* (*S. cumini*), which is hard to find and only sold by two sellers, comes from Karanganyar District, and *C. reticulata* are sent from Tawangmangu District. In addition to *P. communis* cv. *yali* from China, *V. vinifera* cv. *autumn* from Australia, *C. reticulata* cv. *shiranui* from Japan, and *P. malus* cv. *washington* from the United States.

The fruit utilization for fresh consumption has increased annually; it tends to increase fruit production (Kondo et al. 2020). According to Simchon et al. (2022), this necessitates the supply from other cities, even importation from other countries, to satisfy the need for sustainable food, rising demand, and environmental pressures. Moreover, due to increased urbanization causing changes in land use from previously vegetated areas to built-up land, Surakarta City lacks planting land for fruit cultivation. Consequently, sellers order fruit outside the city and in other countries (Putra et al. 2018). Therefore, to a limited extent, fruits grown in Surakarta cannot meet demand, which only provides a small quantity for personal consumption. On the other hand, due to Surakarta City's rapid growth, changes in land use have reduced the amount of vacant land (Fajar and Taryono 2022). Data from 2020 by Saputra (2021) showed that there had been a change in land use in the City of Surakarta, including vacant land for industry and warehousing, which increased by 1,045; Open space for buildings increased by 5.62; moorland into settlements increased 2.92; and dry land into offices increased by 0.05.

Changes in land use are also influenced by population growth (Agwu et al. 2020). It will cause the structural characteristics of various land use types and land use system types to vary significantly. Consequently, there is insufficient land accessible for farmers to plant fruit trees per regional conditions, despite fruit trees playing an essential role in maintaining the ecological environment and generating enormous economic benefits (Tamang et al. 2019). Urban agriculture contributes to food security and human well-being and has numerous environmental advantages. However, the land allocation has diminished significantly (Dobson et al. 2020). Similarly, the limited land in Surakarta City hinders the community's ability to obtain sufficient quantities of various varieties of fruit. Using fruiting trees as part of urban agriculture in urban landscape planning is a significant challenge (Kazemi et al. 2018). The development of agriculture to meet the fruit demand in urban areas requires planting fruit trees with minimal watering requirements.

Fruit can be used for various purposes, including consumption, as a medicinal constituent, religious rituals, etc. Rare fruit could be defined: as grown in a difficult location, as annual fruit, as fruit that is rarely cultivated, as fruit that grows wild in forest areas and riverbanks, as fruit that is rarely known to the general public, or as fruit that humans dislike due to its flavor (Yuliawati et al. 2016). A fruit's rarity is caused by many factors, including the plant's

slow reproduction rate, the challenging environment to flourish, and its limited distribution. For instance, *T. indica* does not grow well in damp soil and will not flower if grown in wet tropical regions (Agus et al. 2014). In contrast, *S. cumini* is in short supply because there are so few production centers and cultivation (Hesthiati et al. 2019). In addition, many land conversions that result in limited land for fruit cultivation, forest or orchard fires, or changes in environmental conditions are additional causes of fruit scarcity. Increased public interest in imported fruit and the abundance of engineered fruits may also contribute to the scarcity of local fruit. Furthermore, applying genetic engineering to fruit plants can lead to losing local fruit genetic information (Akhmadi and Sumarmiyati 2015). The increase in demand for fruit continues to outpace the increase in supply, making fruit increasingly rare.

Fruits thrive in Indonesia, and many varieties of fruit fall under the rare category, limiting their availability. Even though these rare fruits have great benefits, they are also used as a medicine besides being consumed fresh. Rare or uncommon fruits are typically restricted to a small region. Buyers need rare fruits rich in health benefits; therefore, the fruit sellers in Pasar Gede competed to get those rare fruit stocks. Sellers in Karanganyar District/other areas acquire *S. cumini* from farmers; this fruit is helpful as an anti-infection drug and treats diabetes. Customers wishing for exotic fruits will first order from a selected seller. Then, the seller will place orders and communicate with farmers to get the fruit they want/order. Therefore, the demand for rare fruit will be fulfilled at a higher price due to their special requirements. It's also possible for sellers to try on selling another previously unexploited fruit to acquire as rare stocks. In addition to enforcing laws against rare plants and cultivating rare fruit on a large scale, the government has endeavored to preserve rare fruit.

The IUCN Red List gives global data on all species' conservation status and extinction risk (Brooks et al. 2019). The IUCN Red List is accurate for all plants' conservation, planning, and prioritization actions (Kaky and Gilbert 2019). The IUCN Red List provides adequate demographic information regarding the conservation status of numerous extant organisms based on various criteria (Garner et al. 2020). According to the IUCN Red List, the conservation status is Not Evaluated, Data Deficient, Least Concern, Near Threatened, Vulnerable, Endangered, and Critically Endangered. Several fruits sold at Pasar Gede have a conservation status of LC or Least Concern, according to IUCN Red List records; These fruits are *S. cumini*, *P. pinnata*, *P. guajava*, *P. communis*, *A. squamosa*, *C. maxima*, *P. granatum*, *A. muricata*, *M. zapota*, *T. indica*, and *D. kaki* (Table 2). Least Concern status indicates that a species is of low risk or has a limited range but is not included in a higher IUCN category. Even though most fruits sold at Pasar Gede do not threaten the environment, this issue still requires attention. In addition, fruits with LC status will not necessarily be able to survive continuously, even if it presently has a good conservation status. Therefore, when it comes to extensively consumed and the continued use of large quantities will result in fruit rarity. In contrast, the risk of fruit scarcity can increase for rarely

consumed fruits, as few people are interested in them, and their market availability diminishes (Lestari 2014).

This study concludes that the fruit sold at Pasar Gede comprises 82 species from 25 families, with information on local name, price, seasonality, rarity, and conservation status based on the IUCN Red List. According to the IUCN Red List, Pasar Gede is home to fruits with a conservation status of LC (Least Concern), including *juwet* (*S. cumini*), *matoa* (*P. pinnata*), *jambu biji* (*P. guajava*), *pir packham* (*P. communis*), *srikaya* (*A. squamosa*), *jeruk bali* (*C. maxima*), *delima arab* (*P. granatum*), *sirsak* (*A. muricata*), *sawo* (*M. zapota*), *asam jawa* (*T. indica*), and *kesemek* (*D. kaki*). In Pasar Gede, *jeruk* (*Citrus* sp.), *apel/pir* (*Pyrus* sp.), *pisang* (*Musa* sp.), *mangga* (*Mangifera* sp.), and *alpukat* (*Persea* sp.) predominate (are the most available and frequently sold by every vendor in his kiosk). Autumn grapes (*V. vinifera* cv. *autumn*) are the most expensive products at 180,000 IDR per kilogram, while *jambu biji* is the least expensive at 8,000 IDR per kilogram. The cost of production, seasonality, and fruit quality determine the prices. The abundance of fruit indicates that Pasar Gede is a comprehensive fruit market center in Indonesia, particularly in Surakarta.

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