

Standardization of Maturity Indices for Harvesting of Punjab Nectarine [*Prunus persica* (L.) Batsch] Fruit

Kirandeep Kaur¹, Dr. Sukhdev Singh²

¹M.Sc. Agri Horticulture (Fruit Science), Khalsa College, Amritsar, Punjab, India.

²Former Professor cum HOD of Horticulture, Khalsa College, Amritsar, Punjab, India

ABSTRACT

An investigation entitled "Standardization of maturity indices for harvesting of Punjab Nectarine fruit" was carried out during 2020-2021 at the Department of Horticulture, Khalsa College, Amritsar. The objective was to study physico-chemical changes during growth and development and to standardize optimum harvest maturity.

Full bloom was recorded on 22nd February, 2021. Thirty fruits were harvested at weekly intervals from 27 Days After Full Bloom (DAFB) to 76 DAFB and then at 2-day intervals from 76 to 86 DAFB. Fruits were analyzed for physical parameters - fruit weight, length, diameter, skin colour, stone weight, length, diameter, pulp:stone ratio, specific gravity, dry matter, firmness and biochemical parameters - TSS, titratable acidity, TSS:TA, total, reducing and non-reducing sugars, ascorbic acid and juice pH.

Fruit growth followed a double sigmoid curve with three distinct phases: Phase I rapid growth 10-41 DAFB, Phase II slow growth 41-62 DAFB due to pit hardening, and Phase III final swell 62-83 DAFB. Optimum harvest maturity was attained at 83 DAFB i.e. 17th May, when fruits exhibited 59.97 g weight, 52.55 mm length, 47.55 mm diameter, orange-yellow ground colour with 80-90% red blush, pulp:stone ratio 9.33, specific gravity 0.92 g/cc, TSS

13.51 °Brix, titratable acidity 0.82%, TSS:TA 16.48 and total sugars 11.51%. Dry matter and ascorbic acid showed erratic and continuous declining trends respectively and were not found suitable as maturity indices.

How to cite this paper: Kirandeep Kaur | Dr. Sukhdev Singh "Standardization of Maturity Indices for Harvesting of Punjab Nectarine [*Prunus persica* (L.) Batsch] Fruit" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-10 | Issue-4, August 2026, pp.1158-1163, URL: www.ijtsrd.com/papers/ijtsrd141964.pdf



Copyright © 2026 by author (s) and International Journal of Trend in Scientific Research and Development Journal. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0) (<http://creativecommons.org/licenses/by/4.0>)



KEYWORDS: Punjab Nectarine, DAFB, Double sigmoid growth, Maturity indices, TSS, Harvest maturity.

1. INTRODUCTION

Nectarine (*Prunus persica* L. Batsch) is a smooth-skinned genetic variant of peach belonging to the family Rosaceae. The cultivated peach is diploid with a chromosome number of $2n = 16$. Peach is believed to have originated in China, while the nectarine was probably domesticated there more than 4,000 years ago. The major distinguishing characteristic between peach and nectarine is the smooth and fuzzless skin of nectarine fruit, which is associated with the expression of a recessive allele.

Nectarines are grown successfully in temperate as well as subtropical regions, particularly with the availability of low-chilling cultivars. In India, peach and nectarine production is distributed across temperate regions such as Jammu and Kashmir, Himachal Pradesh and Uttarakhand and subtropical

regions including Punjab, Haryana and Uttar Pradesh. In Punjab, peach cultivation is reported from several districts including Amritsar, Gurdaspur, Hoshiarpur, Jalandhar, Ludhiana and Moga.

Nectarine is a climacteric fruit whose ripening is associated with ethylene production. Fruit development follows a characteristic double-sigmoid growth curve comprising different phases of cell division, stone development, fruit enlargement and ripening.

Fruit maturity is an important determinant of final quality, storage life, transportability and consumer acceptability. Nectarines are generally harvested at the firm-mature stage and allowed to ripen before consumption. Harvesting too early can result in poor eating quality and inadequate development of

desirable sugars and flavour, whereas delayed harvesting can result in over-ripening, mechanical damage, deterioration and increased decay.

Several physical and biochemical characteristics have been proposed as maturity indicators in peach and nectarine, including days from full bloom, fruit weight, fruit dimensions, skin colour, firmness, total soluble solids (TSS), titratable acidity, TSS:TA ratio and sugars. The suitability of these indices, however, varies according to cultivar and growing conditions.

Therefore, the present study was undertaken to characterize the changes occurring during growth and development of Punjab Nectarine and to identify suitable physical and biochemical parameters for determining its optimum harvest maturity.

Objectives

The study was undertaken with the following objectives:

1. To study the physical and biochemical changes occurring during growth and development of Punjab Nectarine.
2. To identify suitable maturity indices for Punjab Nectarine.
3. To standardize the optimum stage of harvesting of Punjab Nectarine under Punjab conditions.

2. Materials and Methods

2.1. Experimental Site

The investigation entitled “Standardization of maturity indices for harvesting of Punjab Nectarine fruit” was conducted during 2020–2021 in the orchard and laboratory of the Department of Horticulture, Khalsa College, Amritsar, Punjab. The experimental site was located at approximately 31°N latitude and 74°E longitude at an elevation of about 234 m above mean sea level. The area represents the subtropical humid agro-climatic conditions of Punjab. The orchard soil was well drained, fertile and sandy loam in texture, with a pH ranging from 7.3 to 7.9.

2.2. Plant Material

Fresh fruits of Punjab Nectarine were obtained from plants maintained in the peach orchard of the Department of Horticulture, Khalsa College, Amritsar. The experimental trees were eight years old and raised on Sharbati peach rootstock. Healthy trees of uniform size, vigour and appearance were selected. Uniform cultural practices, fertilization and plant protection measures were followed throughout the experiment.

2.3. Fruit Sampling

Pea-sized fruits were tagged with labels indicating the date of flowering. Fruits of uniform size, shape and colour and free from defects were selected. Diseased

and damaged fruits were discarded. Thirty fruits from nine trees were harvested at weekly intervals from 27 DAFB to 76 DAFB and subsequently at two-day intervals from 76 to 86 DAFB. Fruits were randomly handpicked from different portions of the trees and immediately transported to the laboratory for analysis.

Full bloom was considered to have occurred when more than 60% of flowers had opened on randomly selected limbs. In the experimental observations, February 22 was considered the full-bloom date because more than 70% of flowers had opened on selected branches.

2.4. Physical Parameters

The following physical parameters were recorded:

- Days from full bloom to harvest
- Fruit weight
- Fruit length
- Fruit diameter
- Fruit skin colour
- Stone weight
- Stone length and diameter
- Pulp-to-stone ratio
- Specific gravity
- Dry matter
- Fruit firmness

Fruit weight was determined using a digital balance. Fruit length and diameter were measured using a digital Vernier caliper. Skin colour was assessed visually using a panel of five judges and compared with a standard colour chart. Stone characteristics were recorded after separating the stones from the pulp. Pulp-to-stone ratio was calculated by dividing fruit pulp weight by stone weight.

Specific gravity was determined by the water-displacement method and calculated as fruit weight divided by fruit volume. Dry matter was estimated after drying fruit samples in a hot-air oven at 55°C to constant weight. Fruit firmness was measured using a penetrometer and expressed in pounds-force (lbf).

2.5. Biochemical Parameters

The biochemical parameters evaluated were:

- Total soluble solids (TSS)
- Titratable acidity
- TSS:TA ratio
- Reducing sugars
- Total sugars
- Non-reducing sugars
- Ascorbic acid
- Juice pH

TSS was measured using an Erma hand refractometer and expressed as °Brix. Titratable acidity was determined by titration against N/10 NaOH using

phenolphthalein as indicator and expressed as percentage anhydrous malic acid. TSS:TA was calculated by dividing TSS by titratable acidity.

Reducing and total sugars were estimated by the Lane and Eynon method, while non-reducing sugars were calculated from the difference between total and reducing sugars using the appropriate correction factor. Ascorbic acid was determined by the indophenol dye method. Juice pH was determined using a calibrated digital pH meter.

2.6. Statistical Analysis

The experimental data were statistically analysed using R-Studio software following a Randomized Block Design (RBD).

3. Results and Discussion

3.1. Fruit Growth Pattern

The growth and development of Punjab Nectarine followed a characteristic double-sigmoid pattern. The growth period was broadly divided into three phases: rapid growth from approximately 10–41 DAFB, slower growth from 41–62 DAFB and a second period of rapid growth from 62–83 DAFB.

This pattern is characteristic of stone fruits and is associated initially with active cell division, followed by stone hardening and subsequently by renewed fruit enlargement.

3.2. Fruit Weight

Fruit weight increased progressively throughout fruit development. The average fruit weight was 10.30 g at 27 DAFB and increased to 17.75 g at 34 DAFB and 29.13 g at 41 DAFB. Growth subsequently became slower before increasing again during the final phase. Maximum fruit weight of approximately 59.97 g was recorded at 83 DAFB, after which a slight reduction was observed.

The slight reduction after maximum fruit weight may be associated with moisture loss and the onset of post-maturity changes. Thus, fruit weight can serve as a useful supplementary indicator of maturity.

3.3. Fruit Size

Fruit length and diameter increased with advancement of fruit development and reached maximum values around the optimum maturity stage. At 83 DAFB, the fruit attained a length of approximately 52.55 mm and diameter of approximately 47.55 mm. A slight reduction in fruit size was observed after the optimum stage.

The increase in fruit dimensions reflects progressive cell enlargement and accumulation of photosynthates during fruit development.

3.4. Fruit Skin Colour

A distinct change in skin colour was observed during maturation. Young fruits were brownish-crimson and green. With advancement of maturity, the background colour changed towards orange-yellow with increasing red blush. At approximately 83 DAFB, fruits developed an orange-yellow ground colour with about 80–90% red blush, which was considered an acceptable mature appearance. By 86 DAFB, the colour became darker orange-yellow with extensive red blush, indicating further maturation.

Therefore, skin colour was identified as a practical visual maturity index for Punjab Nectarine.

3.5. Stone Characteristics

Stone weight, length and diameter increased rapidly during the early stages, particularly around the period of stone hardening. Later, stone growth slowed considerably and remained relatively stable near maturity. This indicates that stone characteristics are primarily associated with early fruit development and are less useful as independent indicators of harvest maturity.

3.6. Pulp-to-Stone Ratio

Pulp-to-stone ratio increased progressively with fruit maturation and reached its highest value at 83 DAFB, after which a slight decline was observed.

The increase in pulp proportion represents the accumulation of edible fruit tissue relative to the relatively stable stone and therefore provides a useful indication of fruit maturity.

3.7. Specific Gravity

Specific gravity showed a decreasing trend during fruit development. At full maturity, the fruit recorded a specific gravity of approximately 0.92 g cc⁻¹.

The consistent trend observed during development suggests that specific gravity can be used as a supplementary maturity index.

3.8. Dry Matter

Dry matter percentage increased during the intermediate phase of fruit development but declined with the onset of the final development stage. Considerable variation was observed near maturity. Because of its erratic pattern, dry matter was not considered an ideal independent index for determining harvest maturity of Punjab Nectarine.

3.9. Fruit Firmness

Fruit firmness declined progressively with advancing maturity. The decrease was associated with softening of the fruit flesh during ripening. Because excessive softening reduces resistance to mechanical injury and transportation, firmness is an important practical parameter for deciding the appropriate harvest stage.

3.10. Total Soluble Solids

TSS increased rapidly during fruit maturation. The minimum value recorded at the initial sampling stage was 6.73 °Brix, while the maximum value of 13.51 °Brix was observed at 83 DAFB. A slight decline occurred after this stage.

The increase in TSS is associated with accumulation of soluble sugars and other soluble constituents during maturation. The maximum TSS at 83 DAFB supports the use of TSS as an important maturity index.

3.11. Titratable Acidity

Titrate acidity increased during the initial and intermediate phases and reached a maximum of approximately 1.29%. Thereafter, acidity declined during the final phase of fruit development. At the optimum harvest stage, acidity was approximately 0.82%.

The decline in acidity during maturation contributes to the development of a sweeter and more acceptable flavour profile.

3.12. TSS:TA Ratio

The TSS:TA ratio increased substantially during the final phase of fruit development. The maximum value of 16.48 was recorded at 83 DAFB and was associated with acceptable eating quality. Further delay in harvesting resulted in deterioration of eating quality due to over-maturation.

Thus, the TSS:TA ratio is a particularly useful combined index because it reflects the balance between sweetness and acidity.

3.13. Sugars

Reducing sugars increased markedly during the intermediate stage and subsequently remained relatively stable during the final phase. Total sugars and non-reducing sugars continued to increase during fruit development. Maximum total sugar content of 11.51% and non-reducing sugar content of 6.68% were recorded during the final sampling period.

The increase in sugar concentration contributes directly to improved sweetness and consumer acceptance.

3.14. Ascorbic Acid

Ascorbic acid content was highest in young fruit, with a maximum value of approximately 9.66 mg/100 g at the first sampling date. It gradually decreased with fruit development and reached approximately 4.92 mg/100 g at the final sampling stage. The variation did not show a consistent relationship with maturity phases. Consequently, ascorbic acid was not considered a reliable maturity index for Punjab Nectarine.

4. Optimum Harvest Maturity

The combined evaluation of physical and biochemical characteristics indicated that Punjab Nectarine reached optimum harvest maturity approximately **83 days after full bloom (DAFB)**.

At this stage, the fruit exhibited:

Maturity Characteristic	Optimal observation
Days after full bloom	83 days
Harvest date	May 17
Fruit weight	59.97 g
Fruit Length	52.55 mm
Fruit diameter	47.55mm
Ground color	Orange-yellow
Red blush	Approximately 80-90%
TSS	13.51 °Brix
Titrate acidity	0.82%
TSS:TA ratio	16.48
Specific gravity	Approximately 0.92 g cc ⁻¹
Fruit firmness	Reduced to mature-stage level

The original study identified May 17, corresponding to 83 DAFB, as the peak maturity stage, with desirable fruit size, colour, TSS, acidity and TSS:TA ratio.

5. Practical Harvest Maturity Indices

The findings indicate that no single parameter should be used in isolation. A combination of visual, physical and biochemical characteristics provides a more reliable assessment of maturity.

The most useful maturity indicators for Punjab Nectarine were:

- Days from full bloom:** approximately 83 days.
- Fruit size:** approximately 59.97 g weight, 52.55 mm length and 47.55 mm diameter.
- Skin colour:** orange-yellow ground colour with approximately 80–90% red blush.
- Fruit firmness:** progressive reduction indicating physiological maturity.
- TSS:** approximately 13.51 °Brix.
- Titrate acidity:** approximately 0.82%.
- TSS:TA ratio:** approximately 16.48.
- Pulp-to-stone ratio:** maximum around 83 DAFB.
- Specific gravity:** approximately 0.92 g cc⁻¹.

Dry matter and ascorbic acid were less suitable as independent maturity indices because their patterns did not show a sufficiently consistent relationship with maturity.

6. Conclusion

The present investigation demonstrated that Punjab Nectarine undergoes distinct physical and biochemical changes during fruit growth and maturation. Fruit development followed a double-sigmoid growth pattern, with rapid growth during the initial and final phases and relatively slow growth during the intermediate phase.

Fruit weight and size increased progressively and reached maximum values around 83 DAFB. Fruit colour changed from green/brownish-crimson at early stages to orange-yellow with approximately 80–90% red blush at optimum maturity. Fruit firmness decreased with maturity, while pulp-to-stone ratio increased up to the optimum stage. Specific gravity showed a decreasing trend and could also be used as a supplementary maturity indicator.

Among biochemical characteristics, TSS increased substantially and reached 13.51 °Brix at 83 DAFB, while titratable acidity declined to approximately 0.82%. The TSS:TA ratio reached 16.48 and corresponded with satisfactory eating quality. Total and non-reducing sugars increased with maturity. In contrast, ascorbic acid declined throughout fruit development and did not provide a reliable maturity signal.

Overall, **Punjab Nectarine attained optimum harvest maturity approximately 83 days after full bloom, corresponding to May 17 under the environmental conditions of the study.** At this stage, fruits had desirable size and colour and favourable TSS, acidity and TSS:TA ratio.

For commercial harvesting, a combination of **days after full bloom, fruit colour, fruit firmness, TSS and TSS:TA ratio** is recommended rather than relying on a single maturity parameter. Correct identification of harvest maturity can help minimize immature and over-mature fruit, improve market quality and reduce postharvest losses.

7. Recommendations

Based on the findings of the investigation, the following recommendations can be made:

- Punjab Nectarine should preferably be harvested around **83 DAFB** under conditions similar to those of the experimental site.
- Fruit should possess an **orange-yellow ground colour with approximately 80–90% red blush.**
- TSS should be approximately **13.5 °Brix** at optimum maturity.
- Titratable acidity should be around **0.82%.**
- A TSS:TA ratio close to **16.48** may be used as an indicator of acceptable eating quality.

- Fruit firmness should be assessed along with colour and soluble solids to avoid harvesting over-ripe fruit.
- Days after full bloom should be combined with objective quality measurements because climatic conditions and orchard management can influence fruit development.
- Further multi-year and multi-location studies are desirable before establishing a universal maturity standard for all Punjab Nectarine orchards.

8. Acknowledgements

The authors acknowledge the Department of Horticulture, Khalsa College, Amritsar, Punjab, for providing the experimental orchard, laboratory facilities and other necessary support for conducting the investigation.

9. Conflict of Interest

The authors declare that there is no conflict of interest associated with the present research work.

10. Data Availability

The experimental observations and analytical data generated during the study are contained in the research thesis from which the present article has been prepared.

References

- [1] Abidi W, Jimenez S, Moreno MA and Gogorcena Y (2011). Evaluation of antioxidant compounds and total sugar content in a nectarine (*Prunus persica* [L.] Batsch) progeny. *International Journal of Molecular Sciences* 12(10): 6919–6935.
- [2] Abrol GS, Thakur KS, Thakur NS and Rana N (2015). Standardization of maturity at harvest for nectarine cultivars May Fire, Snow Queen, Silver King and Red Gold. *International Journal of Bio-resource and Stress Management* 6(3): 366–374.
- [3] AOAC (1990). *Official Methods of Analysis*. 15th ed. Association of Official Analytical Chemists, Washington, DC.
- [4] AOAC (2000). *Official Methods of Analysis*. 17th ed. Association of Official Analytical Chemists, Gaithersburg, MD.
- [5] Babu KD and Yadav DS (2002). Growth and development studies in peach cv. Shan-i-Punjab under Meghalaya conditions.
- [6] Babu KD, et al. (2011). Standardization of harvest maturity of low-chilling peach cultivars under Indian conditions.
- [7] Bassi D, Corelli G L, Ravaglia G and Giusti I (1995). Evoluzione della maturazione in due

nettarine. *Atti XXII Convegno Peschicolo*, Cesena, Italy.

- [8] Bhatnagar P and Kaul MK (2002). Growth and development studies in peach (*Prunus persica* Batsch) cvs. Pratap, Flordasun and Shan-i-Punjab. *Journal of Eco-Physiology* 5(3/4): 93–95.
- [9] Borsani J, Budde CO, Porrini L, et al. (2009). Carbon metabolism of peach fruit after harvest: changes in enzymes involved in organic acid and sugar level modifications. *Journal of Experimental Botany* 60: 1823–1837.
- [10] Brovelli EA, Brecht JK, Sherman WB and Sims CA (1998). Potential maturity indices and developmental aspects of melting-flesh and nonmelting-flesh peach accessions for the fresh market. *Journal of the American Society for Horticultural Science* 123(3): 438–444.
- [11] Byrne DH, Nikolic AN and Burns EE (1991). Variability in sugars, acids, firmness and color characteristics of 12 peach genotypes. *Journal of the American Society for Horticultural Science* 116: 1004–1006.
- [12] Cantin CM, Gogorcena Y and Moreno MA (2010). Phenotypic diversity and relationships of fruit quality traits in peach and nectarine breeding progenies. *Euphytica* 171: 211–226.
- [13] Cascales AI, Costell E and Romojaro F (2005). Effects of the degree of maturity on the chemical composition, physical characteristics and sensory attributes of peach cv. Caterin. *Food Science and Technology International* 11(5): 345–352.
- [14] Crisosto CH (1994). Stone fruit maturity indices: a review. *Postharvest News and Information*.
- [15] Crisosto et al. (2003). Studies on maturity and quality characteristics of nectarine and peach fruit.
- [16] Iglesias I and Echeverria G (2009). Differential effect of cultivar and harvest date on nectarine colour, quality and consumer acceptance. *Scientia Horticulturae* 120: 41–50.
- [17] Infante R, Meneses C and Predieri S (2008). Sensory quality performance of two nectarine flesh typologies exposed to distant market conditions. *Journal of Food Quality* 31: 526–535.
- [18] Janick J (2003). History of Asian horticultural technology. *Acta Horticulturae* 620: 19–32.
- [19] Kader AA (1999). Fruit maturity, ripening, and quality relationships. *Acta Horticulturae* 485: 203–208.
- [20] Kader AA and Mitchell FG (1989). Maturity and quality. In: *Peaches, Plums and Nectarines: Growing and Handling for Fresh Market*. University of California.