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Parthenocarpy in vegetable crops

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Introduction

The process of developing fruit without pollination or fertilization is known as parthenocarpy. It is derived from the Greek words "parthenos" (virgin) and "karpos" (fruit). Noll first used the term "parthenokarpie" in 1902. The definition of parthenocarpy is later given by Winkler c. in1908. Parthenocarpy can develop spontaneously or by artificial means. A fruit is called parthenocarpy if its seeds are tiny, absent, or an embryonic abnormality. Cucumber, eggplant, tomato, watermelon, and other parthenocarpic fruits are desired for improving the quality of both processed and fresh fruits. The idea of substituting edible fruit tissue for seeds and seed cavities is both consumer-friendly and a research challenge. Apomixis and stenospermocarpy are examples of parthenocarpy that is controlled by genes. Pollination and fertilization normally take place in stenospermocarpy, but early embryo abortion causes seedless fruits, such grapes and watermelon. As in the case of oranges, blackberries, walnuts and mangoes, apomixis is the generation of embryos and seeds without fertilization.

Biological Basis of Parthenocarpy

Fruit's primary biological roles are protecting developing embryos and seeds and to aid in the dissemination of mature seeds. Generally, ovule fertilization sets off a series of phytohormone-driven events that synchronize seed and fruit development, hence initiating fruit development.

It has been discovered that parthenocarpic fruit development occurs when the ovary receives phytohormones from sources other than the developing seeds. This suggests that the

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ovary's capacity to synthesize, transport and/or metabolize hormones may be impacted by parthenocarpic genes. This could lead to higher hormone levels or ovary sensitivity, which would encourage fruit formation even in the absence of fertilization and pollination.

Phytohormones control and coordinate the processes involved in the formation of seeds and fruits. Important phytohormones involved in signaling pathways during fertilization and pollination include gibberellins, cytokinins and auxins. The growth and development of seeds and fruits also depend on these phytohormones. Fruit production and quality can be negatively impacted by environmental factors that adversely influence pollen development, germination, and fertilization. Therefore, parthenocarpy is seen to be a useful technique for creating fruits without the need for pollination or fertilization. It is also useful for vegetables whose seeds are unpleasant because of their texture, flavor, or presence of toxic substances Joldersma and Liu, 2018).

Parthenocarpic Vegetable Crops: Benefits and Opportunities

1. **Environmental Stress Resilience:** Parthenocarpic vegetables are resilient to environmental challenges such as high or low temperatures because they may produce fruits even in the absence of fertilization and pollination. This allows for stable development and yield (Upadhyay and Kumar, 2020).
2. **Customer Preference:** Fruits without seeds, such as pickled gherkin, parthenocarpic cucumber and seedless watermelon, have been preferred by customers (Baker *et al.* 1973).
3. **Novel vegetables:** Parthenocarpy makes it possible to create novel vegetables such as parthenocarpic cucumber and tomato without seeds.
4. **Quality and Shelf Life:** In crops like brinjal, where the seeds are thought to be bitter, parthenocarpy improves both quality as well as shelf life (Dalal *et al*. 2006).
5. **Better Taste:** Parthenocarpy makes vegetables like seedless tomatoes taste better overall and have a higher soluble solid content (Falavigna, *et al.* 1978, Lukyanenko 1991).
6. **Processing Profitability:** Fruits without seeds increase processing industry income because there's no need to remove the seeds (Lukyanenko 1991).
7. **Genetic Modification:** Parthenocarpy overcomes transgenic approval issues and safeguards genetically modified crops by preventing horizontal gene transmission (Varoquaux *et al*. 2000).
8. **Early Yielding:** Cucumbers are an example of a parthenocarpic fruit that yields early.
9. **Effective Harvesting:** By growing parthenocarpic cucumbers in greenhouses, fruit can be continuously set on vines, saving off the time and money required for hand pollination and pollen vibrators.

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Types of Parthenocarpy

Parthenocarpy is classified into two types

1. Natural or Genetic parthenocarpy
2. Induced or Artificial parthenocarpy (Varoquaux *et al.* 2002)

Natural or Genetic Parthenocarpy: This can be obligate or facultative.

1. When a characteristic is obligate parthenocarpy, it results in plants that are unable to generate viable seeds because external stimuli have no control over the trait (George *et al.* 1984).
2. Facultative parthenocarpy is triggered by an increase in endogenous hormones in the ovary and only happens when pollination and fertilization are absent (Gillaspy *et al.* 1993).

Single incompletely dominant gene (P) was found to be responsible for parthenocarpy (Pike, L. M. and Peterson, C. E., 1969). In cucumbers, an imperfect dominant gene P is required for parthenocarpy inheritance. Early in the homozygous condition, PP produces parthenocarpic fruits; the first usually develops by the fifth node. Heterozygous Pp plants yield fewer and delayed parthenocarpic fruits compared to homozygous plants. The homozygous recessive pp does not yield any parthenocarpic fruits.

Artificial parthenocarpy: The process of producing fruit by means of techniques like the following that do not require pollination or fertilization:

1. Application of Plant Growth Regulators: Gibberellins, cytokinins and auxins all cause parthenocarpy. Using plant growth regulators on unpollinated pointed gourd blossoms resulted in parthenocarpic fruits instead of hand-pollinated fruits that produced several firm, normal-sized, well-developed seeds. Nevertheless, a few parthenocarpic fruits that were stimulated by 200 ppm of GA3 and NAA, none of the seeds had more than five, which seemed aberrant in terms of morphology and were smaller than typical seeds. The parthenocarpic fruits treated by other plant growth regulators, such as TIBA, CPPU, 2,4-D, etc., have hollow seeds that are coated in a thin, soft coating that is edible (Hassan and Miyajima, 2019).

2. Distant hybridization: Creating a breeding population with parthenocarpic features through the process of distant hybridization. Parthenocarpic watermelon fruit generated using bottle gourd pollen. Watermelon female flowers pollinated with bottle gourd pollen (*Lagenaria siceraria* Standl.) produced seedless watermelons with a fruit set of 57.1 percent (Sugiyama *et al.,* 2014).

There were no normal seeds, except for a few tiny, white, empty ones. According to Gustavson (1941), oblong or triangular-shaped seedless fruits from bottle gourd pollen are regarded to be typical of seedless watermelon. It was thought that the pollen tubes' inability to reach the lowest part of the structure was the reason for the ovary's triangular shape. In other

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words, it was assumed that the lower part of the ovary did not secrete enough hormones because fruit malformation was associated with hormone secretion (Yamane *et al*., 2010).

3. Mutation Breeding: parthenocarpic varieties through mutation induction. These mutations can impact signaling pathways, hormone synthesis, or fruit development processes, which can result in the start and development of parthenocarpic fruits.

4. Use of Irradiated Pollen: The utilization of X- or γ-ray-irradiated pollen to produces seedless fruits. Little empty seeds were the result of pollination in Fujihikari TR using soft X-irradiated pollen at 800 and 1000 Gy. Benikodama, on the other hand, responded best to dosages of 400, 800, and 1000 Gy (Sugiyama and Morishita, 2000). Additionally, watermelon that was diploid and seedless was produced by partially functioning pollen that was exposed to gamma radiation at doses of 600 and 800 Gy.

The findings showed that watermelon cultivars without seeds had much higher levels of carotenoid and total sugar, making them a valuable source of phytonutrients for a diet (Moussa and Salem, 2009).

5. Change in Chromosome Number: Producing triploid plants that yield fruits without seeds. Kihara (1951) used colchicine to generate seedless polyploid (4n) watermelon. Diploid seeds were soaked for 24, 48, and 72 hours in 0.05%, 0.1%, and 0.5% colchicine to produce tetraploid seeds. In both intra- and inter-ploidy crosses, these tetraploides serve as parents. The offspring of 4x X 2x have significantly less seeds than their diploid parent when compatible tetraploid (maternal parent) and diploid (paternal parent) are crossed, but their fruit set rate and morphology are similar to those of the diploid. Vines can be pruned to readily maintain this tetraploid female (Hassan *et al.,* 2020).

6. Gene Transfer and Silencing: The use of genetic engineering methods to induce parthenocarpy. Seedless fruit development, for example, can be achieved by introducing genes related to signaling pathways or auxin production. Parthenocarpic characteristics have been developed into transgenic tobacco, eggplant, and tomato plants. The *iaaM* gene coding region from *Pseudomonas syringae* pv. *savastanoi* has been inserted into these plants and it is regulated by *Anthirrhinum majus dejh9* gene regulator sequences that are specific to placental ovules (Yin *et al.,* 2006).

Phytohormones' Function in Parthenocarpic Fruit Development

Gibberellins, cytokinins and auxins are examples of phytohormones that are necessary for parthenocarpic fruits to form. Gibberellin production is also induced by auxin, which also activates the genes responsible for auxin biosynthesis in ovaries and ovules. Gibberellins are sent to the unpollinated ovary to promote parthenocarpic ovary development and inhibit abscission of

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flowers and fruits. Indole-3-acetic acid (IAA) level can be increased by auxin transport inhibitors, which subsequently response may lead to parthenocarpic fruit formation Fayaz *et al.,* 2021).

Examples of Parthenocarpic Cultivars/ Varieties.

Crop	Institute	Varieties
Cucumber	IARI, New Delhi	Pusa seedless cucumber 6
	GBPUA & T, Pantnagar	Pant parthenocarpic cucumber-1, Pant parthenocarpic cucumber-2, Pant Parthenocarpic cucumber-3, Pant Khira-2 & Pant Khira-3
	KAU, Thrissur	KPCH-1
Watermelon	IIHR, Bengaluru	Arka Madhura
	KAU, Thrissur	Shonima (Red) and Swarna (Yellow)
	IARI, New Delhi	Pusa Bedana
Ivy gourd	CIAH, Bikaner	AHIG-1
Pointed gourd	IIVR, Varanasi	IIVRPG-105

Parthenocarpy exploitation in Vegetable Crops

In many horticultural crops, parthenocarpy is economically advantageous because seedless fruits are more attractive and easier to prepare, consume and process.

Tomato: Higher amounts of gibberellin and auxin in the ovaries are linked to genetic parthenocarpy in tomatoes, which encourages ovary growth without pollination. Compared to seeded varieties, parthenocarpic tomatoes are generally sweeter and have better processing characteristics, such as more dry matter content, higher sugars, less acidity and higher amounts of soluble solids.

Cucumber: Hybrids of parthenocarpic and gynoecious cucumbers have transformed greenhouse farming by offering year-round high yields and high-quality fruit. These hybrids have benefits in terms of consumer preference, yield potential and earliness, and they don't require pollination.

Brinjal (Eggplant): Fruits having without seeds are highly desirable because they have better flesh quality and can be processed more easily. Parthenocarpic brinjal is a development that enables production under protected conditions, providing fruit set even in pollinator-unfriendly situations.

Watermelon: Watermelons without seeds are widely consumed due to their convenience in processing and preparation, and they are generally made with the triploid technique. The application of plant growth regulators has been shown to enhance the size, parthenocarpic development and yield of watermelon fruits.

Summer Squash: To prevent pollination, parthenocarpic cultivars of summer squash, especially zucchini types, have been created. These cultivars are very advantageous in terms of quality and yield, particularly when grown in row covers without pollination

Spine Gourd: Plant growth regulators can be employed to promote parthenocarpy in spine gourds, as they improve fruit set and development. This characteristic helps to improve fruit quality and reduces the need for labour-intensive manual pollination.

Issues pertaining to parthenocarpic fruits

1. In parthenocarpic plants, seed production is a difficult procedure that needs specialized knowledge and occasionally is not economical.
2. The cost of seeds is higher than that of seeded variants.
3. Fruits aren't always perfect for the market and can have defects.
4. Sometimes the texture or taste of the fruit is also unsatisfactory. For instance, Indian consumers dislike the mushy, watery texture of parthenocarpic cucumbers.

Future Prospects for parthenocarpy

1. Combine the parthenocarpic gene with multiple genes.
2. Boost the fruit's quality and character.
3. In high-value crops, parthenocarpy development might result in a larger and earlier yield.
4. To increase production and encourage crossover, combine the parthenocarpy gene with the male sterility gene.
5. Maintain and grow crops with consistent parthenocarpy levels.

Conclusion

Enhancing the productivity, quality, and processing properties of vegetable crops requires parthenocarpy. It is particularly advantageous for cross-pollinated crop growing in greenhouses. Fruit setting is significantly influenced by phytohormones, and the growth of seedless fruits can be further enhanced through genetic engineering. Utilizing biotechnological technologies to identify and use parthenocarpic genes in a variety of crops would ultimately help producers and consumers by supplying higher-quality, seedless fruits.

References

Baker, L. R., Scott, J. W., and Wilson, J. E. (1973). Seedless pickles--a new concept. Res Rep Mich State Univ Agric Exp Stn.

Bose, S., Roy, S., and Karak, C. The Phenomenon of Parthenocarpy in Cucurbitaceous Vegetables: A Overview.

Dalal, M., Dani, R. G., and Kumar, P. A. (2006). Current trends in the genetic engineering of vegetable crops. *Scientia Horticulturae*, **107**(3), 215-225. Volume-1 Issue-3 December 2021 55

Dhatt AS, and Gagandeep Kaur G (2016) Parthenocarpy: potential trait to exploit in vegetable crops: *A review. Agric Rev* **37** (4): 300—308.

Falavigna A, Badino M Soressi GP (1978) Potential of the monomendelian factor pat in the tomato breeding for industry. Genetica Agraria 32 : 159—160.

Fayaz, Z., Nazir, G., Masoodi, U. H., Afroza, B., Wani, A. S., and Rashid, M. (2021). Parthenocarpy: 'a potential trait to exploit in vegetable crops".

George W, Scott J, Spilttstoesser W (1984) Parthenocarpy in tomato. *Hortic Rev* **6**: 65—84.

Gillaspy G, Ben-David H, Gruissem W (1993) Fruits:a developmental perspective. *Pl Cell* **5**: 1439—1451.

Hassan J, and Miyajima I (2019) Induction of Parthenocarpy in Pointed Gourd (*Trichosanthes dioica* Roxb.) by Application of Plant Growth Regulators. Journal of Horticulture and Plant Research Vol. 8, pp 12—21.

Hassan J, Miyajima I, Ozaki Y, Mizunoe Y, Sakai K and Zaland W. (2020) Tetraploid Induction by Colchicine Treatment and Crossing with a Diploid Reveals Less Seeded Fruit Production in Pointed Gourd (*Trichosanthes dioica* Roxb.). Plants.; **9**(3):370.

JM, G., Hathi, H., Ganvit, A. M., Mallikarjuna, K. N., Malviya, A., and Gohil, V. ROLE OF PARTHENOCARPY IN VEGETABLE CROPS.

Joldersma, D., and Liu, Z. (2018). The making of virgin fruit: the molecular and genetic basis of parthenocarpy. *Journal of Experimental Botany*, **69**(5), 955-962.

Kihara, H. (1951). Triploid watermelons. *In Proc. Amer. Soc. Hort. Sci.* (Vol. 58, pp. 217-230).

Lukyanenko AN (1991) Parthenocarpy in tomato. In Monographs on Theoretical and Applied Genetics: Genetics Improvement of Tomato. Springer-Verlag.

Lukyanenko, A. N. (1991). Breeding tomato for mechanized harvesting. In Genetic Improvement of Tomato (pp. 213-230). *Springer*, Berlin, Heidelberg.

Lukyanenko, A. N. (1991). Parthenocarpy in tomato. In Genetic improvement of tomato (pp. 167-177). *Springer*, Berlin, Heidelberg.

Moussa, H., and Salem, A. (2009). Induction of parthenocarpy in watermelon (Citrullus lanatus) cultivars by gamma irradiation. *Acta Agronomica Hungarica*, **57**(2), 137- 148.

Rao, P. G., Prasad, B. V. G., Kumar, T. K. and Lakshmi, T. (2018). Breeding for Climate Resilient Parthenocarpic Vegetables. *Int. J. Curr. Microbiol. App. Sci*, **7**(11), 2473- 2492.

Upadhyay, A., and Kumar, S. (2020). Importance of parthenocarpy in exploitation of vegetable crops. *AGRICULTURE & FOOD e-NEWSLETTER*, 134.

Varoquaux, P., Gouble, B., Ducamp, M. N., and Self, G. (2002). Procedure to optimize modified atmosphere packaging for fruit. Fruits, **57**(5-6), 313-322.

Yin, Z., Malinowski, R., Ziólkowska, A., Sommer, H., Plcader, W., and Malepszy, S. (2006). The DefH9-iaaM-containing construct efficiently induces parthenocarpy in cucumber. *Cellular and Molecular Biology Letters*, **11**(2), 279-290.

Pike, L. M., and Peterson, C. E. (1969). Inheritance of parthenocarpy in the cucumber (*Cucumis sativus* L.). *Euphytica*, **18**(1), 101-105.

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