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Enhancing Fruit Affordability for Nutritional Security: Production and Postharvest Strategies for a Growing Population

Sushank[1], Vinita Rajput[2], Saksham[3] and *Garima[1]
[1]Department of Horticulture, CCS Haryana Agricultural University, Hisar, India
[2]Krishi Vigyan Kendra (Sirsa), CCS Haryana Agricultural University, Hisar, India
[3]Maharana Pratap Horticulture University, Karnal, Haryana, India
*Corresponding Author's email: garima19march@gmail.com

Fruits help to keep people healthy, but many poor households cannot afford to buy them. Studies carried out around the world have shown that fruit and vegetable consumption is lowest among those who have the least access to them in terms of affordability while in many countries the supply of fruits and vegetables is below the required level. In this paper, using information from high-impact publications, an attempt is made to identify ways of making fruit production more productive, profitable and affordable for the consumer. The author sees the improvement of fruit orchard productivities as an urgent challenge because every fruit lost during the pre-sales period increases the price of the remaining fruits and reducing postharvest losses is seen as a lever of equal weight. Native research, low-cost technologies and progressive policies are needed with small-hold farmers at the center.

Keywords: Fruit affordability; Nutritional security; Orchard productivity; Climate-smart horticulture; Underutilized fruits; Postharvest loss

Introduction

The demand for healthy food is growing due to urbanization, population growth and increased income. A meta-analysis of 95 prospective studies found that the risk of cardiovascular disease and early death decreased as fruit and vegetable consumption increased up to 800 grams per day for most outcomes and up to 600 grams per day for cancer (Aune et al., 2017). The availability of fruit and vegetables has historically been inadequate to meet recommended intakes according to an integrated modeling study that extended to more than 150 countries. Only 81 countries or 55% of the world's population had availability above the WHO minimum requirement by 2015 (Mason-D'Croz et al., 2019). Fruit growers today are confronted to produce more fruit under the constraints of less land, water and other factors while ensuring that the prices are affordable to the common people. The author of this article tries to address this issue by identifying the reasons behind the high rates and discussing the strategies used in production and post-harvesting that can help increase the supply of fruits while reducing the prices.

The affordability problem

Fruits and vegetables are the most expensive part of a healthy diet. In a study of 159 countries they made up the largest share (31.2%) of the cost of the cheapest EAT–Lancet diet which had a global median cost of US$2.84 per day in 2011. The authors estimated that this diet cost more than the per capita household income of at least 1.58 billion people (Hirvonen et al., 2020). In the PURE study, which covered 18 countries mean daily intake was 2.14 servings in low-income countries and 5.42 servings in high-income countries. Within this gradient consumption fell as the relative cost of fruit and vegetables rose (Miller et al., 2016). Higher incomes will help, but they will not close the gap alone. Many countries remain below the estimated minimum necessary levels, even if the situation is favorable in terms of social

and economic indicators. In 2050, between 0.8 and 1.9 billion people in Sub-Saharan Africa will live in countries where the average person consumes less than 400 g of fruit and vegetables a day (Mason-D'Croz et al., 2019).

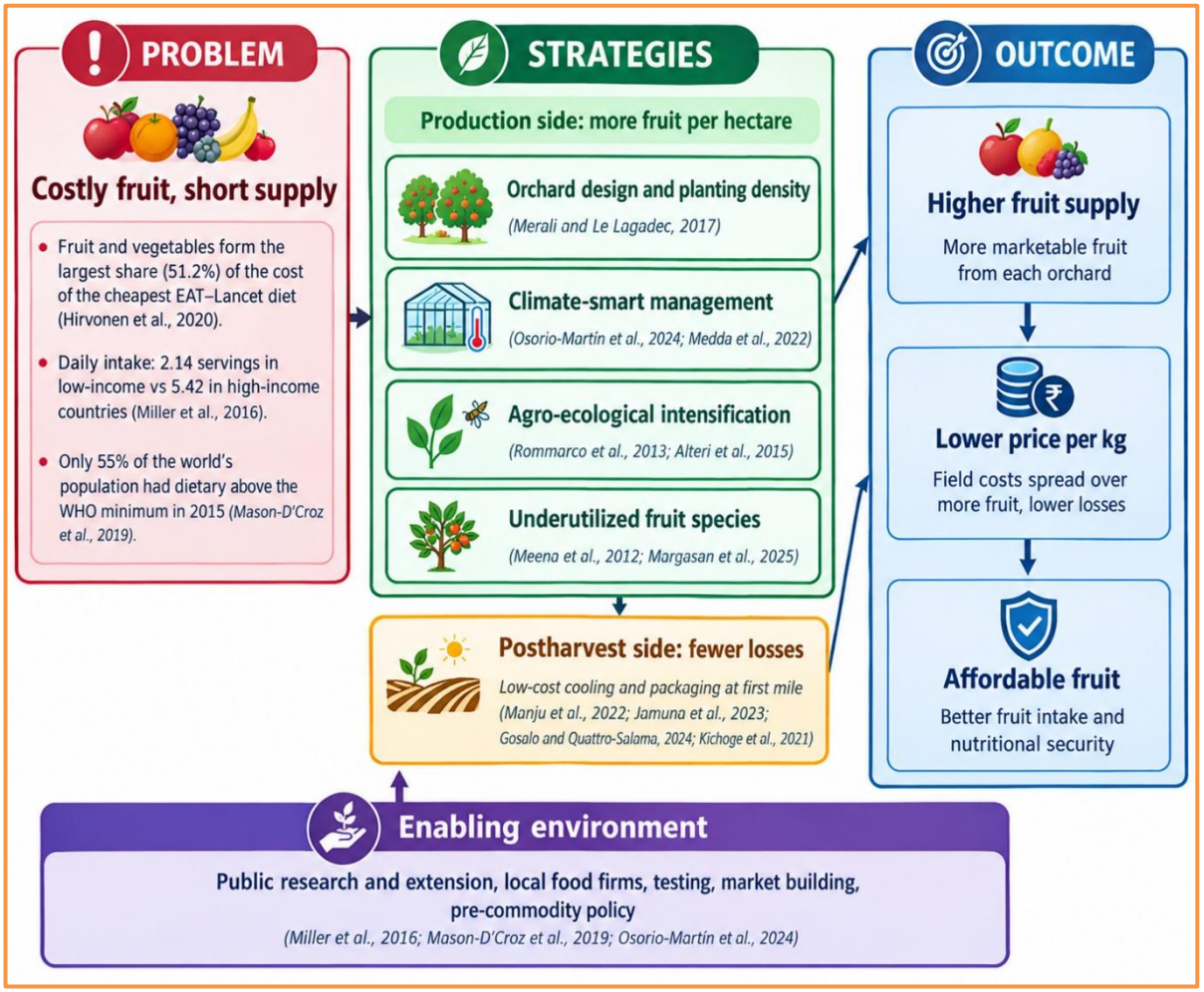


Figure 1. Framework linking the affordability problem, production and postharvest strategies, and an enabling environment to affordable fruit and nutritional security.

Production strategies

Orchard design and planting density

Increasing the number of trees per hectare is an obvious way to increase output and bring returns forward. Mango shows both the promise and the limits. Trees were traditionally set at about 100–200 per hectare, while trials have tested 200 to 4000. Trees planted close together soon crowd and shade each other and yield falls. It is not easy to find agreement on the best tree density for commercial orchards (Menzel and Le Lagadec, 2017). The same review concluded that the future of high-density planting depends upon dwarfing cultivars or rootstocks and upon improved canopy management. Without extensive work in breeding and canopy management productivity is unlikely to rise. The practical lesson is to move in steps, matching density to the vigour of the cultivar and the pruning skill of the grower. In principle, a higher yield per hectare spreads land and labour costs over more fruit which is what lowers the cost per kilogram.

Climate-smart orchard management

Fruit trees are perennial crops and thus their fate is sealed when they are planted according to the climate in which they find themselves. Forty-three systematic reviews of studies on temperate fruit and nut crops revealed that temperature increases reduce the amount of winter cold, droughts are becoming more severe, spring frosts destroy bud and pest pressure is shifting. Growers are taking adaptive measures such as using improved cultivars, shade nets, protective covers and irrigation schedules adjusted to the phenology of the plant (Osorio-

Marín et al., 2024). The same review highlights the risks associated with deficit irrigation, identifies flowering and fruit filling as particularly sensitive stages affected by this form of water management. The authors note that woody fruit crops have a certain advantage over other crops due to their long life cycle but this also means that growers have only one chance to make the right choice (Medda et al., 2022). Adaptation measures in the short term require 10 to 20 years before they can be implemented, therefore local research and public policy initiatives are critical to making informed decisions (Osorio-Marín et al., 2024). One potential limitation worth considering is that of the 403 systematic reviews included in the analysis, 88% of the authors were based in the northern hemisphere, the evidence was largely related to temperate and Mediterranean fruits.

Agroecological intensification

Ecological intensification is about harnessing ecosystem services as a partial substitute for fertilizers and agrochemicals farmers buy (Bommarco et al., 2013). Agro-ecological systems have also been characterized as relatively resilient to climatic shocks (Altieri et al., 2015). In orchards the practices described include cover crops, reduced tillage, organic amendments, wildflower strips and agroforestry. Lower cash costs would be of most importance to smallholders though this saving depends on the site and has to be confirmed in the field. The review by Osorio-Marín et al. (2024) noted that none of these practices in isolation yielded consistent benefits and advocated studies of integrated agro-ecological management rather than individual practices.

Underutilized fruit species

Commercial fruit crops are becoming increasingly reliant on purchased inputs to manage biotic and abiotic stress. Many underutilized fruits are hardier and more tolerant of climate stress. A review of 19 such crops common to the Indian arid and semi-arid regions including ber, aonla, bael, jamun and custard apple described their stress tolerance, nutritional value and conservation needs. There is a need for careful study and nutritional characterisation to widen the future food basket (Meena et al., 2022). The fruits are rich in vitamin C, dietary fibre, antioxidants, can be grown on dry land and poor soils where conventional crops cannot grow. With investment in research, extension and community programmes they can move from niche to mainstream markets (Marappan et al., 2025). For low-income consumers, locally-grown fruits that require few inputs are often the cheapest source of micronutrients.

Cutting losses after harvest

A fruit that is produced but not sold adds to the cost of all fruits. Postharvest losses of Fruits and Vegetables in Sub-Saharan Africa are between 30-50% and up to 60% of total food losses occur at first-mile distribution in farms (Makule et al., 2022). For low- and middle-income countries, where smallholder farming systems dominate food production, losses are high and the benefits of agricultural innovations have not been evenly distributed (Jarman et al., 2023). Costly cold chains are inaccessible to most smallholder farmers. Low-cost alternatives include shading, low-cost packaging, porous evaporative cooling, zero-energy cooling chambers and pot-in-pot coolers (Gouda and Duarte-Sierra, 2024). According to Jarman et al. (2023), cold-chain and dry-chain innovations tailored to small businesses can have a significant impact. Kitinoja et al. (2011) emphasize that these modifications must be simple to use, science-based, proven cost-effective for specific crops, locations while generating local capacity for adaptation in agricultural universities and extension services.

Summary of strategies

Table 1 sets strategies side by side. Each one has a clear benefit and a clear limit. The limits are mostly about local fit, capital and institutional support rather than about the science itself.

Table 1. Strategies for producing affordable fruit, with main constraints and sources.

Strategy	What it offers	Main constraint	Key sources
Orchard design and planting density	More fruit per unit of land and earlier returns	Crowding and shading; needs dwarfing material and canopy control	Menzel and Le Lagadec, 2017

Strategy	What it offers	Main constraint	Key sources
Climate-smart management	Protects yield and quality under heat, drought and frost	Long lag in adoption; costs of covers and irrigation; evidence mostly from temperate regions	Osorio-Marín et al., 2024; Medda et al., 2022
Agro-ecological intensification	Uses ecosystem services in place of part of the purchased inputs	No single practice works everywhere; local testing needed	Bommarco et al., 2013; Altieri et al., 2015
Underutilized fruits	Hardy, nutrient-rich crops for dry and poor soils	Weak markets, little research and extension support	Meena et al., 2022; Marappan et al., 2025
Postharvest loss reduction	Lowers the price of fruit reaching the consumer	Missing cold chain; smallholder capital limits	Makule et al., 2022; Jarman et al., 2023; Gouda and Duarte-Sierra, 2024

Policy and institutional needs

The modelling results show that a combination of approaches would be most effective including increased production of fruits and vegetables, innovative technologies that reduce waste while being affordable to consumers and consumer education (Mason-D'Croz et al., 2019). Miller et al. (2016) suggest a similar strategy of expanding the availability and affordability of fruits and vegetables through specific policies. They highlight the importance of public research and extension to generate knowledge on cultivars, rootstocks and canopy systems adapted to tropical environments as well as low-cost postharvest handling methods at the first-mile level, where losses tend to be highest. Miller et al. (2016) also recommend that underutilized fruits be developed, marketed with due consideration of their nutritional properties which will require both local and international efforts as well as capacity building to be effective (Osorio-Marín et al., 2024).

Conclusions

Affordable fruit is a food-systems issue not just farm issue. Growing quantities, which are well below recommended levels in many countries and a high relative cost restrict the amount of fruit that poor households can afford to buy. Rising incomes alone will not solve this gap. The reviewed strategies aim in different ways to address the challenge. Gradual increases in planting densities through the use of dwarfing material and canopy management can increase yields per unit area. Climate-smart, agroecological approaches may help to safeguard production and reduce purchased inputs. Underutilized fruits provide resilient and nutritious options for marginal areas. Reducing post-harvest losses at first-mile can cut the consumer price. Each strategy has limitations however and none is universally applicable: the reviewed evidence was generated mainly in temperate and Mediterranean regions, whereas the need for solutions is greatest in other geographical areas. The next step should be a local on-the-ground investigation of the various strategies – applied in combination – to generate further evidence, which would benefit from public research and extension, affordable post-harvest technologies, market building and pro-smallholder policies.

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