

Value Addition and Processing of Underutilized Fruits

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Available online at
www.sunshineagriculture.vitalbiotech.org

Article History

Received: 1. 5.2026

Revised: 5. 5.2026

Accepted: 10. 5.2026

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INTRODUCTION

India is one of the world's richest centers of biodiversity and is home to a large number of indigenous and wild fruit species. Many of these fruits are nutritionally superior and possess medicinal properties, yet they remain underexploited due to inadequate commercial attention. These fruits are referred to as underutilized, neglected, or minor fruits.

Underutilized fruits are indigenous and minor fruit species that possess high nutritional, medicinal, and economic value but remain largely neglected in commercial agriculture and food industries. Important examples include Aonla, Bael, Jamun, Karonda, and Phalsa. These fruits are rich in vitamins, minerals, antioxidants, and bioactive compounds and are well adapted to adverse climatic conditions. However, their perishability and poor market infrastructure limit their commercial use. Value addition through processing into juices, jams, jellies, candies, powders, pickles, and nutraceutical products extends shelf life, reduces post-harvest losses, and enhances market value. Processing of underutilized fruits offers significant opportunities for improving nutrition, increasing farmers' income, and promoting sustainable rural entrepreneurship and biodiversity conservation.

2. Concept of Underutilized Fruits

Underutilized fruits are indigenous or regionally important fruit species that have long been part of local diets, traditional medicine, and cultural practices but have received limited attention in scientific research, crop improvement, extension services, and commercial markets.

Examples include Aonla, Bael, Jamun, Karonda, and Ber. These fruits are well adapted to local agro-climatic conditions, require fewer external inputs, and are often tolerant to pests, diseases, drought, and poor soils. They are rich in vitamins, minerals,

antioxidants, and other bioactive compounds. In sustainable agriculture, underutilized fruits help diversify farming systems, strengthen nutrition security, generate rural income, conserve biodiversity, and enhance resilience to climate change.



Source: <https://www.agriclinics.net/>

Characteristics of Underutilized Fruits

- Adapted to local agro-climatic conditions
- Require low agricultural inputs
- Resistant to many pests and diseases
- Rich in nutrients and bioactive compounds
- Seasonal and highly perishable
- Limited organized marketing
- Strong potential for processing and export

Importance in Sustainable Agriculture

- Diversify farming systems
- Improve nutrition security
- Generate income in rural areas
- Conserve biodiversity
- Enhance climate resilience

3. Nutritional and Medicinal Significance

Underutilized fruits are widely recognized as functional foods because they contain essential nutrients and bioactive compounds that

promote health and help prevent disease. Aonla is exceptionally rich in vitamin C and polyphenols, making it a powerful antioxidant and immunity enhancer. Jamun contains anthocyanins and iron and is valued for its anti-diabetic and blood-purifying properties. Bael provides pectin and tannins that support digestive health. Karonda is rich in iron and vitamin C and helps prevent anemia. Phalsa has cooling and anti-inflammatory effects, while Tamarind aids digestion. Ber supplies vitamin C and natural sugars that provide energy and strengthen immunity. These fruits are extensively used in Ayurveda and traditional healthcare systems. Underutilized fruits are often referred to as "functional foods" because they provide health-promoting compounds.

Fruit	Major Nutrients	Health Benefits
Aonla	Vitamin C, polyphenols	Immunity booster, antioxidant
Jamun	Anthocyanins, iron	Anti-diabetic, blood purifier
Bael	Pectin, tannins	Digestive health
Karonda	Iron, vitamin C	Anti-anemic

Phalsa	Antioxidants	Cooling and anti-inflammatory
Tamarind	Organic acids, minerals	Digestive aid
Ber	Vitamin C, sugars	Energy and immunity

4. Need for Value Addition

Value addition is the process of converting fresh fruits into products with improved quality, convenience, shelf life, and market value. Underutilized fruits are often highly perishable and available only for a short season, which leads to market glut, price reduction, and significant post-harvest losses. Limited transportation and storage facilities further restrict their commercialization. By processing fruits into juices, jams, jellies, candies, squashes, powders, pickles, and nutraceutical products, their usability and consumer appeal can be greatly enhanced.

The major reasons for value addition include reducing wastage, meeting the growing demand for processed and health-oriented foods, generating employment, and creating export opportunities. It also ensures better returns to farmers and promotes year-round availability of nutritious products. Value addition supports the development of agro-based industries, strengthens rural entrepreneurship, and increases the economic importance of fruits such as Aonla, Jamun, and Bael.

5. Post-Harvest Handling of Underutilized Fruits

Efficient post-harvest handling is essential to preserve the quality, nutritional value, and processing suitability of underutilized fruits. Proper management begins with harvesting fruits at the optimum stage of maturity to ensure desirable flavor, color, and nutrient content. After harvesting, fruits are sorted and graded to remove damaged, diseased, or immature produce. They are then thoroughly washed and sanitized to eliminate dirt and microbial contamination. Depending on the fruit type, peeling, deseeding, and pulp extraction are carried out before preservation or immediate processing into value-added

products. Finally, processed materials are packaged and stored under appropriate conditions to maintain quality and extend shelf life.

Key quality parameters evaluated during post-harvest handling include total soluble solids (TSS), acidity, pH, color, texture, and nutritional composition. Maintaining these attributes is critical for producing high-quality products from fruits such as Aonla, Bael, and Jamun.

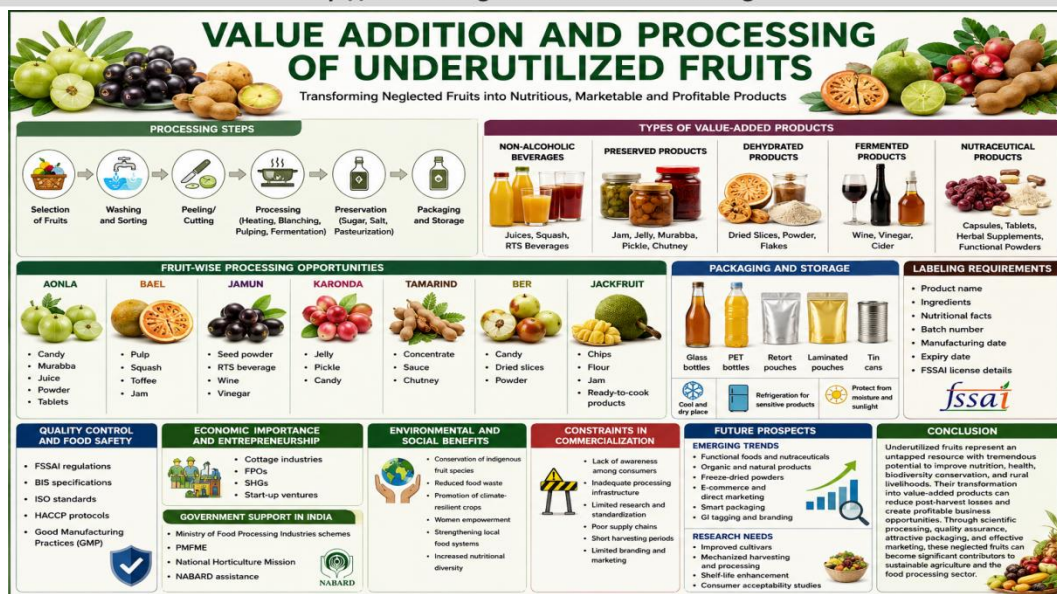
6. Processing Technologies

A wide range of processing methods can be used depending on fruit type and desired product.

6.1 Thermal Processing

Thermal processing is one of the most widely used methods for preserving underutilized fruits and their products. It involves the application of controlled heat to destroy spoilage microorganisms, inactivate enzymes, and improve product safety and shelf life. This technique is especially important in the preparation of juices, pulps, jams, squashes, and ready-to-serve beverages from fruits such as Aonla, Bael, and Jamun.

- **Pasteurization:** Heating the product at moderate temperatures (generally 60–100°C) for a specified period to destroy pathogenic and spoilage microorganisms while retaining much of the flavor and nutritional quality.
- **Sterilization:** Applying higher temperatures, often above 100°C, to eliminate all microorganisms and spores, resulting in commercially sterile products with long shelf life.
- **Blanching:** Exposing fruits briefly to hot water or steam before further processing to inactivate enzymes, soften tissues, and preserve color and texture.



6.2 Dehydration

Dehydration is a widely used preservation technique in which moisture is removed from fruits to inhibit microbial growth and enzymatic activity, thereby extending shelf life and reducing storage and transportation costs. This method is particularly suitable for underutilized fruits such as Aonla, Ber, Karonda, and Phalsa. Dehydrated fruits can be processed into dried slices, powders, candies, and fruit leathers.

- **Sun Drying:** Traditional and low-cost method in which fruits are dried under direct sunlight.
- **Tray Drying:** Fruits are dried in controlled hot-air dryers, resulting in better quality and uniform drying.
- **Solar Drying:** Uses solar energy in enclosed dryers to improve hygiene and drying efficiency.
- **Freeze Drying:** Advanced technique where water is removed by sublimation under vacuum, preserving color, flavor, nutrients, and texture.

6.3 Fermentation

Fermentation is a biochemical process in which beneficial microorganisms such as yeasts and bacteria convert natural sugars present in fruits into alcohol, organic acids, and other valuable compounds. This technology is widely used to transform

underutilized fruits into high-value products with improved shelf life, flavor, and functional properties. Fruits such as Jamun, Bael, Tamarind, and Phalsa are particularly suitable for fermentation.

- **Fruit Wine:** Produced by yeast fermentation of fruit juices, resulting in beverages with unique flavor and aroma.
- **Vinegar:** Obtained through the conversion of alcohol into acetic acid by acetic acid bacteria and used as a preservative and condiment.
- **Probiotic Beverages:** Developed using beneficial microorganisms to create functional drinks that support digestive health and immunity.

6.4 Freezing

Freezing is an effective preservation technique in which fruits are stored at very low temperatures, usually at or below -18°C , to slow down microbial growth, enzymatic activity, and chemical changes. This method helps maintain the natural color, flavor, texture, and nutritional quality of underutilized fruits such as Jamun, Phalsa, and Custard Apple. Frozen fruits and pulps can be used throughout the year for making juices, desserts, and other processed products.

6.5 Osmotic Dehydration

Osmotic dehydration involves immersing fruit pieces in concentrated sugar syrup, causing

partial removal of water and absorption of sugar. This process improves texture, flavor, and shelf life and is commonly used to prepare candies and sweetened fruit pieces from Aonla, Karonda, and Ber.

6.6 Minimal Processing

Minimal processing includes operations such as washing, peeling, cutting, and packaging to produce fresh-cut and ready-to-eat fruit products. These products retain much of their natural nutritional and sensory qualities while offering greater convenience to consumers.

7. Major Value-Added Products

7.1 Beverages

Beverages are among the most popular value-added products prepared from underutilized fruits because they are nutritious, refreshing, and convenient for consumers. Processing fruits into beverages helps preserve their natural flavor, color, and health-promoting compounds while extending shelf life and improving marketability. Depending on fruit type and consumer preference, a wide range of products can be developed from Aonla, Bael, Jamun, Phalsa, and Tamarind.

- **Juice:** Extracted liquid containing the natural nutrients and flavor of fresh fruits.
- **Nectar:** Beverage prepared by diluting fruit pulp with water and adding sugar and acid.
- **RTS (Ready-to-Serve) Drinks:** Convenient beverages formulated for direct consumption without further dilution.
- **Squash:** Concentrated fruit beverage that is diluted with water before serving.
- **Syrup:** Thick, sweet liquid used in beverages, desserts, and medicinal preparations.
- **Sharbat:** Traditional flavored drink concentrate popular in South Asia.

7.2 Preserves

Preserves are concentrated fruit products prepared by cooking fruit pulp or juice with sugar to obtain a thick consistency and extended shelf life. They are among the most widely accepted value-added products derived

from underutilized fruits and help retain the characteristic flavor, color, and nutritional qualities of the original fruit. Fruits rich in pectin and natural acids, such as Aonla, Karonda, Bael, and Ber, are particularly suitable for preparing preserves.

- **Jam:** Made by boiling fruit pulp with sugar to produce a smooth, spreadable product.
- **Jelly:** Prepared from clarified fruit juice and sugar, resulting in a clear, firm gel.
- **Marmalade:** A jelly-like preserve containing suspended pieces of fruit peel, commonly used for citrus-type fruits.
- **Preserve:** Whole fruits or large fruit pieces cooked in heavy sugar syrup to maintain their shape and texture.

7.3 Dehydrated Products

Dehydrated products are prepared by removing moisture from fruits, which inhibits microbial growth and enzymatic deterioration, thereby extending shelf life and reducing storage and transportation costs. Underutilized fruits such as Aonla, Ber, Karonda, and Jackfruit are highly suitable for dehydration. These products retain much of the fruit's nutrients and provide convenient, ready-to-use forms for consumers and the food industry.

- **Dried Slices:** Thin fruit pieces dried to produce shelf-stable snacks.
- **Powder:** Finely ground dehydrated fruit used in beverages, bakery products, and nutraceutical formulations.
- **Leather:** Flexible sheets made from concentrated fruit pulp and dried to a chewy texture.
- **Candy:** Sweetened fruit pieces prepared through osmotic dehydration and drying.

7.4 Pickles and Chutneys

Pickles and chutneys are traditional value-added products prepared from underutilized fruits such as Bael, Tamarind, Karonda, and Jackfruit. Pickles are made by preserving fruit pieces in salt, oil, spices, or vinegar, whereas chutneys are prepared by cooking fruit pulp with sugar and spices. These products improve flavor, extend shelf life, and reduce post-

harvest losses. They are highly popular among consumers and provide profitable opportunities for small-scale food processing and rural entrepreneurship.

7.5 Fermented Products

Fermented products are prepared by microbial conversion of fruit sugars into alcohol and organic acids, resulting in products with improved flavor, shelf life, and functional properties. Underutilized fruits such as Jamun, Bael, and Tamarind can be processed into wine, vinegar, and cider. These products possess unique sensory qualities and offer substantial commercial potential in specialty food markets.

7.6 Nutraceutical Products

Nutraceutical products are health-oriented formulations developed from fruits rich in antioxidants and bioactive compounds. Aonla and Jamun are commonly used to prepare capsules, tablets, herbal supplements, and functional powders. These products support immunity, digestive health, and metabolic wellness, and they represent a rapidly growing segment of the food and wellness industry.

8. Fruit-Wise Processing Opportunities

Different underutilized fruits offer diverse opportunities for processing and product development based on their unique nutritional composition, flavor, and functional properties. Aonla is widely used for preparing candy, murabba, juice, powder, and nutraceutical tablets because of its exceptionally high vitamin C content. Bael can be processed into pulp, squash, toffee, and jam, while Jamun is suitable for seed powder, ready-to-serve beverages, wine, and vinegar due to its anti-diabetic properties. Karonda is ideal for jelly, pickles, and candy. Tamarind is commonly processed into concentrate, sauce, and chutney. Ber can be made into candy, dried slices, and powder. Jackfruit offers opportunities for chips, flour, jam, and ready-to-cook products. These fruit-specific processing options help reduce wastage and increase farmers' income.

9. Packaging and Storage

Packaging and storage are critical components of value addition because they protect processed fruit products from physical damage, moisture, oxygen, light, and microbial contamination while enhancing consumer appeal and marketability. Common packaging materials include glass bottles, PET bottles, retort pouches, laminated pouches, and tin cans, selected according to the nature of the product and its storage requirements. Products should be stored in a cool and dry environment, and sensitive items such as juices and probiotic beverages may require refrigeration. Protection from moisture and direct sunlight is essential to maintain quality and extend shelf life.

Proper labeling is equally important for regulatory compliance and consumer information. Labels should include the product name, list of ingredients, nutritional facts, batch number, manufacturing and expiry dates, and license details issued by Food Safety and Standards Authority of India. Appropriate packaging and storage ensure product safety, preserve nutritional quality, and improve acceptance in domestic and export markets.

10. Quality Control and Food Safety

Quality control and food safety are essential to ensure that value-added products prepared from underutilized fruits are safe, nutritious, and acceptable to consumers. Effective quality control begins with the selection of sound raw materials and continues through processing, packaging, storage, and distribution. Regular monitoring of parameters such as moisture content, total soluble solids, acidity, pH, microbial load, color, texture, and sensory attributes helps maintain product consistency and shelf stability.

Compliance with recognized standards is necessary for regulatory approval and market access. In India, processed foods must adhere to regulations established by the Food Safety and Standards Authority of India and specifications prescribed by the Bureau of Indian Standards. International trade often

requires conformity with International Organization for Standardization standards, Hazard Analysis and Critical Control Point (HACCP) protocols, and Good Manufacturing Practices (GMP). These systems ensure hygiene, traceability, and product safety, thereby enhancing consumer confidence and facilitating domestic and export marketing.

Quality Tests

- Microbial load
- Moisture content
- TSS and acidity
- Sensory evaluation

11. Economic Importance and Entrepreneurship

Processing of underutilized fruits creates significant economic opportunities by converting low-value seasonal produce into high-value marketable products. It is particularly beneficial for small-scale enterprises, rural women, and youth entrepreneurs. Value-added products such as juices, candies, powders, pickles, and nutraceuticals can be produced through cottage industries, Farmer Producer Organization (FPOs), Self-Help Group (SHGs), and start-up ventures. These enterprises generate employment, reduce post-harvest losses, and provide better returns to farmers.

In India, several government initiatives support agro-processing and entrepreneurship, including schemes of the Ministry of Food Processing Industries, the PM Formalisation of Micro Food Processing Enterprises (PMFME), the National Horticulture Mission, and financial assistance from National Bank for Agriculture and Rural Development. Natural, organic, and functional products derived from underutilized fruits are increasingly in demand in international markets, offering substantial export potential and opportunities for sustainable rural development.

12. Environmental and Social Benefits

Value addition and processing of underutilized fruits provide important environmental and social benefits. They encourage the conservation of indigenous fruit species and

help maintain valuable genetic diversity. Processing reduces post-harvest losses and food waste by converting surplus produce into shelf-stable products. Promotion of hardy, climate-resilient fruits supports sustainable agriculture under changing weather conditions. These activities also create income-generating opportunities for women through self-help groups and microenterprises. In addition, they strengthen local food systems and increase dietary diversity by making nutritious fruit-based products available throughout the year.

13. Constraints in Commercialization

The commercialization of underutilized fruits faces several important challenges. Consumer awareness regarding their nutritional and medicinal benefits remains limited, resulting in low market demand. Inadequate processing infrastructure and insufficient access to modern equipment restrict large-scale value addition. Limited research and lack of standardized processing protocols affect product quality and consistency. Poor supply chains, weak cold storage facilities, and transportation constraints reduce market efficiency. In addition, many of these fruits have short harvesting periods and high perishability, which lead to seasonal gluts and post-harvest losses. Limited branding, packaging, and marketing strategies further hinder their acceptance in domestic and international markets. Overcoming these constraints is essential to unlock the full economic potential of underutilized fruits.

14. Future Prospects

The future of underutilized fruits depends on combining traditional knowledge with modern food processing and marketing technologies. Emerging trends include the development of functional foods, nutraceuticals, organic and natural products, freeze-dried powders, e-commerce, smart packaging, and geographical indication (GI) branding. Research is needed to develop improved cultivars, mechanized harvesting and processing systems, shelf-life enhancement techniques, and consumer acceptability studies. With continued

innovation and institutional support, underutilized fruits can become important contributors to nutrition security, rural entrepreneurship, biodiversity conservation, and sustainable agricultural development.

CONCLUSION

Underutilized fruits constitute a valuable yet largely untapped resource with immense potential to enhance nutritional security, public health, biodiversity conservation, and rural livelihoods. Fruits such as Aonla, Bael, Jamun, and Karonda are rich in nutrients and bioactive compounds and are well suited to climate-resilient agriculture. Their conversion into juices, preserves, dehydrated products, fermented beverages, and nutraceuticals reduces post-harvest losses and creates profitable opportunities for farmers, self-help groups, and agro-entrepreneurs. Through scientific processing, strict quality control, attractive packaging, and effective marketing, these neglected fruits can become important drivers of sustainable agriculture, food processing, and inclusive rural development.

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