

BIOTECHNOLOGY FOR OBTAINING FUNCTIONAL FOOD COMPONENTS FROM MEDICINAL PLANTS CULTIVATED UNDER BUKHARA CONDITIONS (ROSEHIP, *ROSA CANINA* L.)

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Abstract. Rosehip (*Rosa canina* L.) is a medicinal and food plant rich in vitamin C, polyphenols, carotenoids, dietary fibre and polyunsaturated fatty acids. The arid continental conditions of Bukhara, characterized by low precipitation, high summer temperatures and saline soils, require resource-efficient cultivation and gentle post-harvest processing. This thesis systematizes international evidence and proposes a biotechnology chain for transforming locally cultivated rosehip into standardized functional food components. The approach combines raw-material selection, controlled drying, seed and pulp fractionation, green extraction, concentration, optional microencapsulation and quality-control stages. Particular emphasis is placed on preserving ascorbic acid and phenolic compounds, valorizing seed oil and pomace, and adapting processing to the hot and dry Bukhara environment. The proposed framework can support development of functional powders, antioxidant extracts, beverage bases, bakery enrichers and encapsulated nutraceutical ingredients, while reducing processing waste and increasing the added value of medicinal plant cultivation in the region.

Keywords: *Rosa canina* L.; rosehip; Bukhara; functional food; biotechnology; vitamin C; polyphenols; green extraction; microencapsulation; nutraceutical ingredients.

INTRODUCTION

Functional foods are increasingly developed from plant raw materials that contain physiologically active compounds beyond basic nutrients. Rosehip is one of the most promising underutilized fruit resources because its pulp and skin contain high amounts of ascorbic acid, phenolic acids, flavonoids, carotenoids and other antioxidants, while the seeds provide oil rich in unsaturated fatty acids (1,2). These properties explain the growing interest in rosehip as a raw material for functional beverages, powders, bakery enrichers, nutraceutical extracts and dietary supplements.

The suitability of rosehip for biotechnology is strongly influenced by genotype, maturity, environmental conditions and processing. International studies have reported wide variability in vitamin C and phenolic composition among *Rosa canina* ecotypes, confirming that cultivation environment and harvest stage should be treated as technological variables rather than background factors (2,3). Therefore, when rosehip is cultivated in a specific agroecological zone such as Bukhara, a region-specific processing concept is required.

Bukhara belongs to an arid agroecosystem with very low annual precipitation, high evaporative demand, hot summers and saline or salt-affected soils. Research conducted in the Bukhara region reports annual rainfall of approximately 90-150 mm and strong drought pressure, emphasizing the importance of water-saving and adaptive agricultural technologies (4). Such conditions may affect fruit size, accumulation of secondary metabolites, harvest timing and post-harvest stability. At the same time, the dry climate may facilitate rapid dehydration, but uncontrolled sun drying can accelerate oxidative loss of vitamin C and discoloration.

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The aim of this thesis is to substantiate a biotechnology for obtaining functional food components from rosehip cultivated under Bukhara conditions. The main objectives are: (i) to characterize the functional potential of rosehip fractions; (ii) to identify processing operations that preserve thermolabile bioactive compounds; (iii) to propose green extraction and stabilization methods; and (iv) to develop a zero- or low-waste utilization model suitable for regional food biotechnology.

MAIN PART

1. Functional composition of rosehip and relevance for Bukhara-grown raw material

Rosa canina fruits contain a complex matrix of hydrophilic and lipophilic compounds. Vitamin C is the best-known component, but its concentration varies greatly across ecotypes and handling conditions. Roman et al. demonstrated substantial differences among biotypes, whereas more recent research on Iranian ecotypes likewise confirmed high variability in ascorbic acid, carotenoids, phenolics and flavonoids (2,8). This variability means that a Bukhara processing line should include raw-material standardization rather than assuming a fixed composition.

Phenolic acids and flavonoids contribute strongly to antioxidant potential. Studies using chromatographic profiling identified quercetin derivatives, gallic acid, protocatechuic acid and other phenolics in rosehip products (3,7). Carotenoids, tocopherols and polysaccharides further broaden the functional profile. Rosehip seed oil is also valuable because it contains nutritionally relevant unsaturated fatty acids; therefore, separating seeds before aqueous or hydroethanolic extraction allows parallel production of a lipid fraction and a phenolic-rich pulp fraction (8,9).

From a functional-food perspective, the technological goal is not to isolate a single compound at maximum purity. Instead, it is often preferable to obtain standardized multi-component fractions that combine antioxidant compounds, fibre and natural colour while maintaining acceptable sensory properties and food-grade safety.

Table 1. Major rosehip fractions relevant to functional food production

Fraction	Key constituents	Functional role	Potential product form
Fruit pulp/skin	Vitamin C, polyphenols, carotenoids	Antioxidant and nutritional enrichment	Powders, beverages, extracts
Seeds	Unsaturated fatty acids, tocopherols	Lipid fraction and oxidative-stability support	Cold-pressed oil, emulsified ingredients
Pomace	Dietary fibre, residual phenolics	Fibre enrichment and by-product valorization	Bakery, snack and cereal formulations
Aqueous/hydroethanolic extract	Phenolic acids, flavonoids, vitamin C	Standardized antioxidant ingredient	Drinks, gels, encapsulated powders

The table illustrates why complete biomass fractionation is preferable to processing the fruit as a single undifferentiated raw material. Modern studies emphasize valorization of rosehip by-products, particularly seed oil and pomace, as a way to improve sustainability and economic efficiency (9).

2. Post-harvest stabilization and drying strategy

Immediately after harvest, fruits should be sorted to remove damaged material, washed with potable water and rapidly cooled or processed. Because vitamin C is highly sensitive to oxygen, heat and

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prolonged storage, post-harvest delays should be minimized. Frost damage can markedly reduce ascorbic acid and certain flavonoid glycosides, which supports harvesting before severe frost when the target product is a vitamin-C-rich ingredient (5).

Drying is the most critical preservation stage. Conventional hot-air drying is economical, but higher temperature and longer residence time increase ascorbic acid degradation. Classic kinetic work on rosehip demonstrated that vitamin C loss rises with drying temperature and exposure time (6). Freeze-drying provides excellent retention of bioactive properties, although its cost is high; comparative studies have shown strong preservation of phenolics and ascorbic acid in freeze-dried material (7). Recent work suggests that low-temperature convective drying around 30°C with adequate airflow can provide a practical balance between physical quality and antioxidant retention (10).

For Bukhara, a two-tier strategy is rational: premium products may use freeze-drying, whereas larger-volume ingredients may use controlled low-temperature convective or heat-pump drying. Uncontrolled open-air sun drying should not be the primary method for standardized functional ingredients because it provides insufficient control over oxidation, dust contamination and nutrient degradation.

Figure 1. Proposed biotechnology chain for obtaining rosehip functional food components



3. Green extraction and fractionation technology

After drying, deseeded pulp can be milled to a defined particle size. The simplest product is a whole-fruit functional powder, which preserves fibre and minimizes solvent use. When a concentrated antioxidant component is required, food-grade water or aqueous ethanol can be used. Ultrasound-assisted extraction (UAE) is particularly suitable because cavitation enhances mass transfer at moderate temperatures, reducing extraction time and the thermal burden on vitamin C and phenolics (1,9).

A proposed starting condition for laboratory optimization is 30-50% ethanol in water, a solid-to-liquid ratio of approximately 1:10 to 1:20, extraction below 40°C and a short ultrasound treatment. These parameters should not be treated as universal optimum values; they require experimental optimization for Bukhara-grown material using total phenolic content, ascorbic acid retention, antioxidant capacity and sensory acceptability as response variables. If the final product is intended for children's foods or products where ethanol use is undesirable, hot-water or enzyme-assisted extraction can be investigated instead.

Following extraction, coarse filtration is followed by clarification and vacuum concentration at reduced temperature. To increase shelf life, the concentrate can be spray-dried with carrier materials such as maltodextrin or gum arabic, or freeze-dried for high-value products. Microencapsulation is particularly

useful for protecting oxidation-sensitive vitamin C, carotenoids and phenolics and for masking excessive acidity or astringency.

Table 2. Proposed technological stages and critical control points

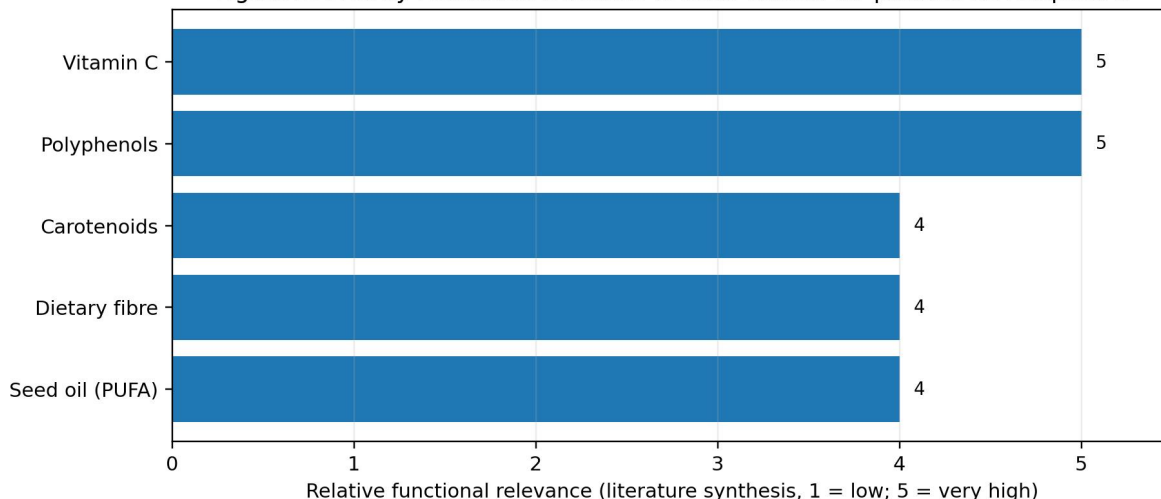
Stage	Critical variables	Recommended approach
Harvest & sorting	Maturity, absence of decay	Selective harvest; rapid processing
Drying	Temperature, time, oxygen exposure	30-50°C controlled drying or freeze-drying
Milling	Particle size, metal contamination	Food-grade mill; sieving
Extraction	Solvent ratio, temperature, time	Water/ethanol; UAE under mild conditions
Concentration	Vacuum, product temperature	Reduced-pressure evaporation
Stabilization	Moisture, water activity, oxygen	Spray/freeze drying; encapsulation
Quality control	Vitamin C, TPC, moisture, microbiology	Batch standardization

4. Functional product design and quality indicators

The proposed rosehip ingredients can be incorporated into several product classes. A fibre-rich powder can enrich bread, biscuits, snack bars and cereal blends; a standardized antioxidant extract can be used in functional beverages and gel products; seed oil can be formulated as an emulsion or incorporated into lipid-based foods; and encapsulated powder can serve as a stable nutraceutical or fortification ingredient. Previous studies show that rosehip preserves and processed products retain meaningful phenolic and antioxidant activity, although composition depends on processing intensity (3,7).

Quality control should include moisture content, water activity, vitamin C, total phenolic content, total flavonoids, carotenoids, antioxidant activity, microbiological safety and heavy-metal/pesticide screening according to the intended food category. In addition, colour and sensory acceptance should be monitored because over-extraction or excessive pomace addition can increase bitterness and astringency. A batch standardization approach is essential because environmental variation may cause meaningful compositional differences among harvests (2,8).

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Figure 2. Priority functional fractions of *Rosa canina* for product development

5. Adaptation of the biotechnology to Bukhara conditions

The Bukhara environment creates both constraints and opportunities. High summer temperatures and limited water resources increase the need for drip irrigation, mulching, soil-moisture monitoring and salinity management during cultivation. From a processing perspective, low ambient humidity can reduce the energy demand for dehydration, but direct solar exposure should be replaced with enclosed solar-assisted or controlled convective systems to protect sensitive bioactives and prevent contamination.

A regional pilot line could therefore be organized around four linked modules: (1) cultivation and harvest standardization; (2) controlled drying and milling; (3) food-grade extraction and concentration; and (4) fraction-specific product manufacture. Such an integrated scheme can also support circular processing: seeds are directed to oil production, pulp to antioxidant powder or extract, and pomace to fibre-rich food formulations. This improves raw-material utilization and reduces organic waste (9).

For scientific validation, the next experimental stage should compare Bukhara-grown rosehip from at least two harvest seasons and evaluate the effects of maturity, drying regime and extraction conditions. A factorial or response-surface design can then identify conditions that maximize vitamin C and phenolic retention while minimizing energy input and solvent use.

CONCLUSION

Rosehip cultivated under Bukhara conditions has strong potential as a regional source of functional food components because the fruit combines vitamin C, phenolics, carotenoids, dietary fibre and valuable seed lipids. International evidence confirms that the functional value of *Rosa canina* depends not only on genotype but also on maturity, drying, storage and extraction conditions (1-3,5-10).

The most rational biotechnology for Bukhara is a fractionated, low-waste process that includes rapid post-harvest handling, controlled low-temperature drying or freeze-drying, seed separation, milling, green aqueous or hydroethanolic extraction, vacuum concentration and optional microencapsulation. Such a scheme can yield several marketable ingredients from one raw material: antioxidant powder, phenolic-rich extract, seed oil and fibre-rich pomace.

The proposed technology is a literature-grounded framework rather than a claim of completed local industrial validation. Its practical implementation should be preceded by laboratory characterization of

Bukhara-grown rosehip and optimization of drying and extraction parameters. With this validation, rosehip may become a scientifically standardized raw material for functional foods and nutraceutical products adapted to the ecological and economic conditions of the Bukhara region.

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