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Beyond Calories: Roots and Tubers for Health Equity and Sustainable Development

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Abstract- *Introduction:* India faces a double burden of malnutrition persistent undernutrition alongside rising obesity and non-communicable diseases (NCDs). Addressing this requires nutrition-sensitive strategies aligned with the United Nations Sustainable Development Goals (SDGs). Despite their nutrient density and climate resilience, roots and tubers remain underutilized in national nutrition interventions.

Methods: This study conducted a comprehensive literature review and secondary data analysis using the Indian Food Composition Tables (IFCT, 2017) and national health surveys. Nutrient profiling evaluated macronutrients, micronutrients (vitamins, minerals), carotenoids, amino acids, and bioactive compounds. Functional contributions to metabolic health and chronic disease prevention were assessed.

Results: Roots and tubers such as sweet potato, yam, beetroot, carrot, colocasia, and lotus root are rich in complex carbohydrates, dietary fiber, B-complex and C vitamins, iron, calcium, potassium, and bioactives like β-carotene, lutein, and polyphenols.

Keywords: *roots and tubers, nutrition-sensitive agriculture, micronutrient deficiency, diet-related chronic diseases, sustainable food systems, public health nutrition, functional foods, climate-resilient crops, indigenous foods, food policy.*

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Discussion: Incorporating roots and tubers into daily diets can address micronutrient deficiencies and reduce NCD risk. Their low glycemic index and phytochemical content make them especially beneficial for diabetes and weight management. However, their exclusion from mainstream food policies and public nutrition programs limits their reach.

Conclusion: Roots and tubers represent a sustainable, nutrient-rich solution to India's complex nutrition challenges. Their inclusion in dietary guidelines and public health programs should be prioritized by health professionals and policymakers to promote food security, public health, and climate resilience.

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I. Introduction

The adoption of the United Nations Sustainable Development Goals (SDGs) in 2015 marked a shift toward integrated strategies that address interconnected challenges such as poverty, malnutrition, and environmental degradation. Among these, SDG 2 (Zero Hunger) and SDG 3 (Good Health and Well-being) are especially critical for low- and middle-income countries (LMICs), where food insecurity, diet-related diseases, and healthcare disparities persist (FAO et al., 2022). These goals emphasize not only access to sufficient calories, but also the need for diverse, nutrient-dense, and sustainable diets (Popkin, Adair, & Ng, 2012).

In India, the nutrition landscape is marked by a double burden of malnutrition: widespread under-nutrition including child stunting, maternal underweight, and micronutrient deficiencies coexists with rising rates of obesity and non-communicable diseases (NCDs) such as diabetes, hypertension, and cardiovascular conditions (ICMR-NIN, 2019; NFHS-5, 2021). This dual crisis places immense strain on health systems and calls for multisectoral responses that go beyond calorie-centric interventions (Popkin, Corvalan, & Grummer-Strawn, 2020).

India has launched several large-scale programs to tackle malnutrition and improve health, including POSHAN Abhiyaan, the Mid-Day Meal Scheme, and Ayushman Bharat. While these initiatives promote convergence across sectors like health, education, and agriculture, they largely prioritize staple cereals and pulses. Indigenous, nutrient-rich crops such as roots and tubers remain excluded from most food security and nutrition strategies, despite their cultural relevance and ecological advantages (Khanna, 2019).

Roots and tubers including sweet potato, yam, carrot, beetroot, colocasia (taro), radish, and lotus root have long played a central role in the diets of tribal and rainfed-farming communities in India. However, they are often dismissed as 'secondary' or 'famine foods,' leading to their marginalization in research, markets, and policy discourse (Nair et al., 2020; Shukla, 2016). This neglect represents a missed opportunity, particularly given their high nutritional value, climate resilience, and potential to improve both food system sustainability and health equity.

Biophysically, these crops thrive in marginal agro-ecological conditions and require fewer inputs, making them ideal for smallholder and low-resource farming systems (CIAT, 2021). Nutritionally, they are rich in complex carbohydrates, dietary fiber, and essential micronutrients such as iron, potassium, and vitamin A precursors (Dey et al., 2017). For example, orange-fleshed sweet potatoes are a key source of β-carotene,

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critical for vision and immune function, while beetroot contributes iron and nitrates, which aid cardiovascular health (Low et al., 2007; Lansley et al., 2011).

Their health benefits such as low glycemic index, high fiber, and antioxidant-rich profiles make them suitable for addressing micronutrient deficiencies, supporting gut health, and preventing chronic diseases, especially among vulnerable populations (Aune et al., 2018). However, their integration into public nutrition programs like ICDS and PDS remains limited, reflecting deeper institutional, behavioral, and market-level barriers, including urban consumer preferences, limited awareness, and procurement bottlenecks.

Moreover, the undervaluation of these crops undermines broader development goals. Roots and tubers support not just SDG 2 and SDG 3, but also SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action), due to their low carbon footprint and biodiversity-supporting qualities (Glover et al., 2017). Promoting their cultivation and consumption could also advance SDG 1 (No Poverty) and SDG 5 (Gender Equality) by generating income opportunities for smallholder farmers, especially women and tribal groups (Chauhan et al., 2021).

This paper argues that roots and tubers must be repositioned from peripheral to strategic assets in India's nutrition and agricultural agenda. Drawing on evidence from nutrition science, agronomy, and policy, it explores how these crops can contribute to a more inclusive, climate-resilient, and nutrition-sensitive food system aligned with the SDG framework.

II. Methodology

This study employed a multidisciplinary, desk-based methodology to evaluate the nutritional, biochemical, and public health relevance of selected root and tuber crops in India. First, a structured literature review was conducted using academic databases such as PubMed, Scopus, and Web of Science to identify peer-reviewed articles, compositional studies, and official publications from recognized agencies including the FAO, WHO, and Indian Council of Medical Research (ICMR). The search focused on studies published between 2000 and 2023 using keywords such as "roots and tubers," "nutrition composition," "bioactive compounds," and "India." Inclusion criteria required studies to be in English, focused on human nutrition, and specific to root and tuber crops; grey literature, animal studies, and non-nutrition-specific articles were excluded. The review followed PRISMA screening guidelines, and studies were appraised for methodological rigor and relevance to dietary health outcomes.

Second, nutrient profiling of eight selected crops sweet potato, yam, carrot, beetroot, radish, colocasia (taro), lotus root, and tapioca was carried out using data from the Indian Food Composition Tables (IFCT, 2017) published by ICMR-NIN. Nutrient values were standardized per 100 grams of edible portion. Key metrics assessed included energy, carbohydrates (starch and sugars), dietary fiber (soluble and insoluble), vitamins (B-complex, C, D, E, and K), minerals (iron, calcium, potassium, magnesium), carotenoids (β-carotene, α-carotene, lutein, lycopene), amino acids (lysine, leucine), and fatty acid profiles. Where data permitted, comparative nutrient density scores were generated based on WHO/FAO dietary reference values to assess the relative contribution of each crop to nutritional adequacy, weight management, and chronic disease prevention.

Third, the presence and functional roles of bioactive compounds were examined through a review of published biochemical and compositional studies. Emphasis was placed on compounds such as quercetin, lutein, lycopene, oxalates, and hesperidin, with attention to their antioxidant, anti-inflammatory, and metabolic regulatory properties. These compounds were evaluated for their influence on nutrient bioavailability, gut health, and systemic inflammation. Due to variations in analytical techniques and reporting standards, quantitative synthesis (e.g., meta-analysis) was not feasible; instead, a descriptive and comparative framework was applied.

Finally, findings were contextualized using secondary data analysis from national health and nutrition databases, including the National Family Health Survey (NFHS-5, 2019–21), National Nutrition Monitoring Bureau (NNMB), and relevant reports from the Ministry of Health and Family Welfare and the Ministry of Women and Child Development. These datasets provided insights into population-level dietary patterns, micronutrient deficiencies, and demographic variations in nutritional status, helping to evaluate the relevance of root and tuber integration in targeted food and nutrition programs such as the Integrated Child Development Services (ICDS), Public Distribution System (PDS), and Mid-Day Meal Scheme.

While this study offers a comprehensive and integrative perspective, it is limited by its reliance on secondary and descriptive data. Variability in nutritional analyses across sources and a lack of standardized reporting for certain bioactive compounds may constrain direct comparisons. Nonetheless, by triangulating evidence from nutrition science, health policy, and compositional data, this methodology provides a robust foundation for advocating the inclusion of roots and tubers in nutrition-sensitive strategies aimed at improving public health outcomes and food system resilience in India.

III. Results

Roots and tubers are fundamental components of the human diet, offering a wide spectrum of nutrients that contribute to metabolic health, disease prevention, and dietary diversity. Rich in complex carbohydrates and dietary fiber, crops like sweet potatoes, yams, carrots, beetroot, radish, colocasia, and lotus root provide sustained energy while remaining low in fat, making them ideal for balanced diets and weight management (Table 1). Their fiber content both soluble and insoluble enhances digestive health, supports gut microbiota, and regulates blood glucose and cholesterol levels. Soluble fiber, abundant in carrots and sweet potatoes, is particularly effective in modulating glucose absorption and lowering cardiovascular risk, while insoluble fiber promotes bowel regularity and satiety. Some varieties, such as wild yam and colocasia, also offer relatively higher protein content compared to other starchy vegetables, which supports muscle maintenance and metabolic processes. In addition, their high-water content as in radish and beetroot assists with hydration and detoxification, especially in hot climates or low-fluid diets.

From a micronutrient perspective, roots and tubers are valuable sources of both water- and fat-soluble vitamins essential for physiological functioning (Tables 2 and 3). B-complex vitamins including thiamine, riboflavin, niacin, folate, and vitamin B6 are widely distributed across these crops and play crucial roles in energy metabolism, neurological function, and red blood cell formation. For instance, sweet potatoes and lotus root are notably high in vitamin B6 and biotin, supporting cognitive performance and hormone regulation. Folate-rich beetroot and tapioca contribute to fetal neural development and are particularly beneficial for pregnant women. Vitamin C levels are highest in lotus root and potatoes, aiding immune defense and collagen synthesis. Fat-soluble vitamins, though less concentrated, are still nutritionally meaningful vitamin D_2 is detectable in red carrots, sweet potatoes, and yams, while lotus root contains high levels of vitamin E (44.45 mg/100g), providing strong antioxidant protection. Trace amounts of vitamin K further support blood coagulation and bone health.

The antioxidant capacity of these crops is amplified by their diverse carotenoid profiles (Table 4). β-carotene and α-carotene, prevalent in orange carrots and sweet potatoes, serve as vitamin A precursors critical for vision, immunity, and epithelial health. Lutein and zeaxanthin, which help prevent age-related macular degeneration, are particularly abundant in yellow and orange-fleshed varieties. Lycopene, found in red carrots and wild yams, has been linked to reduced risks of prostate cancer and cardiovascular disease. These carotenoids work synergistically to reduce oxidative stress and support healthy aging making roots and tubers especially relevant in the diets of older adults, diabetics, and populations with limited access to diversified micronutrients.

In terms of mineral content, roots and tubers deliver a range of macro and trace elements essential for structural, enzymatic, and metabolic functions (Table 5). Calcium levels are substantial in sweet potatoes and yams, supporting bone development in children and older adults. Iron content is strikingly high in beetroot (69.44 mg/100g) and carrots (60.69 mg/100g), making them potent tools against iron-deficiency anemia, particularly in adolescent girls and pregnant women. Lotus root contains considerable amounts of copper and cobalt, aiding enzymatic function and red blood cell production. While trace elements such as arsenic and cadmium are present in small quantities, their levels remain within safe consumption thresholds. These micronutrients, when regularly consumed as part of a varied diet, contribute to immune resilience and metabolic regulation.

Macronutrient-wise, these crops primarily supply starch and natural sugars, complemented by small quantities of essential amino acids and minimal fats (Tables 6, 7, and 8). Colocasia, potatoes, and lotus root provide between 10–14 g of starch per 100 g, ensuring slow-release energy appropriate for physically active populations and school-age children. Natural sugars like glucose and sucrose in carrots and beetroot offer quick energy and palatability, which can be especially beneficial in low-appetite individuals such as the elderly. Fat content remains low across all crops, with small amounts of saturated fatty acids like palmitic acid detected in lotus root. Although unsaturated fat levels are minimal, roots and tubers pair well with fat-containing foods to aid nutrient absorption. Amino acids such as lysine (~28.7 mg/g in beetroot and carrot) and leucine (~26 mg/g in lotus root) contribute to protein synthesis and tissue repair, though overall protein density remains lower than in legumes or animal sources highlighting their complementary, rather than primary, role in meeting protein requirements.

Roots and tubers offer a wide array of bioactive compounds that contribute to their functional health benefits (Tables 9 and 10). Organic acids such as citric acid (in carrots and elephant yam), malic acid (652 mg/100g in sweet potato), and quinic acid (167 mg/100g in tapioca) influence flavor, improve nutrient absorption, and support digestive metabolism. Oxalate levels vary, with lotus root showing the highest concentration (~364 mg/100g), which may inhibit calcium absorption if consumed in excess or without adequate dietary calcium a factor worth noting for individuals prone to kidney stones or with mineral absorption concerns. Polyphenols like quercetin-3-β-galactoside and isorhamnetin, especially abundant in red carrots, offer potent anti-inflammatory and antioxidant effects. Compounds such as hesperidin and myricetin, found in brown-skin potatoes, further support vascular health and immune modulation. These phytochemicals not only enhance flavor and shelf-life but also reinforce the preventive health value of roots and tubers, especially in resource-poor settings with limited access to clinical care.

In sum, the rich nutrient and phytochemical diversity of roots and tubers affirms their strategic relevance in addressing India's dual burden of malnutrition and chronic disease. Compared to commonly consumed staples like polished rice or refined wheat, these crops provide superior fiber, micronutrient density, and antioxidant content especially when consumed with minimal processing. Their suitability for diverse populations from pregnant women and schoolchildren to diabetics and the elderly makes them powerful yet underutilized assets in building equitable and sustainable food systems. Further research, coupled with policy advocacy and dietary education, is essential to reposition roots and tubers as central not supplementary components of nutrition-sensitive public health strategies.

IV. Discussion

Roots and tubers, though traditionally classified as subsistence or "secondary" crops, emerge from this analysis as nutritionally potent and contextually indispensable components of health-promoting diets. Their dense profiles of complex carbohydrates, dietary fiber, and phytonutrients place them at the intersection of energy sufficiency, metabolic health, and disease prevention. With starch contents averaging 10–14 g/100 g in staples like colocasia and lotus root, these crops offer slow-digesting, sustained energy suitable for populations in rural and low-income contexts. Simultaneously, their moderate sugar profiles and high soluble fiber ranging from 1.7 to 4.7 g/100 g contribute to glycemic control and lipid regulation, aligning with dietary strategies for preventing type 2 diabetes and cardiovascular disease. Compared to refined cereals like polished rice, roots and tubers provide superior dietary fiber and micronutrient density, though they fall short in protein concentration and require complementary sources such as legumes for amino acid adequacy. Their B-complex vitamin content (notably B6, folate, and biotin), vitamin C, and modest quantities of vitamin E and provitamin A carotenoids link them directly to critical physiological functions from neurocognitive development to immune regulation and fetal health yet questions remain about bioavailability under typical cooking methods, regional varietal differences, and losses due to storage or processing. For instance, while beetroot is rich in iron (69.44 mg/100 g), the presence of oxalates and phytates may inhibit absorption, especially in diets lacking enhancers like vitamin C. Similarly, oxalate levels in lotus root may raise concerns for calcium balance in individuals predisposed to kidney stones, necessitating dietary guidance and moderation.

Despite these caveats, the bioactive compound composition particularly carotenoids, polyphenols (e.g., quercetin, hesperidin), and organic acids offers a compelling argument for classifying these foods as functional or preventive in nature. Their antioxidant and anti-inflammatory properties, as evidenced in red carrots and sweet potatoes, position them not only as nutrient sources but as contributors to long-term disease mitigation, especially in aging populations or those at risk of metabolic syndrome. However, this discussion would benefit from a stronger evidence base linking consumption pattern to specific health outcomes in Indian contexts, as few controlled studies exist beyond compositional analyses. Moreover, cultural and market factors such as urban consumer preferences, low shelf-life, and limited culinary integration in mainstream food programs present real-world barriers to scaling up their use.

Policy-wise, the implications are significant. Roots and tubers could enhance the nutritional quality of India's public feeding programs, such as the Mid-Day Meal Scheme and the Public Distribution System, which currently remain cereal-dominated. Their inclusion could improve micronutrient delivery, diversify diets, and reduce over-reliance on fortified staples. At the same time, promoting their cultivation among smallholder farmers, especially in tribal and rainfed regions, could support agroecological resilience, market diversification, and women's livelihoods. To this end, agricultural extension services must go beyond yield-centric messaging to emphasize nutritional value, while nutrition policy must adopt a more biodiversity-inclusive lens. This calls for interdisciplinary strategies that integrate agronomy, public health, food science, and behavioral economics. Ultimately, repositioning roots and tubers from marginal supplements to core components of nutrition-sensitive planning can simultaneously address undernutrition, NCDs, and rural economic vulnerability. However, further research is needed to assess bioavailability, acceptability, and cost-effectiveness under real-world programmatic conditions, ensuring that the potential of these crops translates into measurable health outcomes across diverse Indian populations.

V. Conclusion and Recommendations

Roots and tubers represent a nutritionally rich, affordable, and culturally significant food group with immense, yet underleveraged, potential to address malnutrition, chronic disease, and food insecurity particularly in tropical and subtropical regions like India. Their composition featuring slow-digesting carbohydrates, dietary fiber, essential micronutrients, and bioactive compounds positions them as valuable allies in managing metabolic disorders, enhancing immune function, and promoting gastrointestinal health. Crops like sweet potato, beetroot, and carrot offer tangible dietary solutions to vitamin A and iron deficiencies, while the polyphenols and organic acids found in lotus root, carrots, and potatoes contribute to antioxidant and anti-inflammatory defense mechanisms. Medical practitioners can recommend these crops as food-based interventions for patients vulnerable to anemia, diabetes, and digestive ailments, while also noting the need for moderation in the case of high-oxalate tubers like lotus root among individuals with kidney-related risks.

Beyond health, the promotion of roots and tubers carries vital ecological, economic, and cultural implications. These crops are climate-resilient, thrive in rainfed and marginal environments, and demand fewer chemical inputs, making them well-suited for smallholder and tribal farming systems under increasing climate stress. Their cultivation supports biodiversity, preserves agroecological knowledge, and can create livelihood opportunities for women and rural communities. From a policy perspective, integrating roots and tubers into national food and nutrition programs such as the Mid-Day Meal Scheme, Integrated Child Development Services (ICDS), and the Public Distribution System (PDS) can diversify diets and improve micronutrient coverage at scale. Targeted strategies could include the development of value-added tuber-based products to enhance shelf life and consumer appeal, the inclusion of these crops in hospital and school canteens, and the dissemination of IEC (Information, Education, and Communication) materials for ASHAs and anganwadi workers to promote awareness at the grassroots level.

Nevertheless, barriers such as urban taste preferences, limited culinary familiarity, and market invisibility must be acknowledged. Future research should examine bioavailability under typical cooking practices, consumer acceptance, and cost-effectiveness relative to existing staples. Addressing these gaps is crucial for evidence-informed policymaking and the design of culturally resonant nutrition interventions. In sum, repositioning roots and tubers from peripheral to strategic components of India's food system offers a powerful pathway to improve public health, support sustainable agriculture, and meet multiple Sustainable Development Goals in an integrated and inclusive manner.

Clinical trial number: Not applicable

Consent to Participate declaration: Not applicable

Ethical Considerations: This study relies exclusively on secondary data from publicly available sources, including the Indian Food Composition Tables (IFCT, 2017), NFHS-5, NNMB reports, and peer-reviewed literature. No human subjects were directly involved, and all data used were anonymized and aggregated. Ethical approval was not required, as the research did not involve primary data collection. All sources have been properly cited, and academic integrity has been maintained throughout.

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Table 1: Proximate Principles and Dietary Fiber Roots and Tubers

Code	Food Name	Moisture (g)	Protein (g)	Ash (g)	Fat (g)	Dietary Fibre (g)	Insoluble Fibre (g)	Soluble Fibre (g)	Carbohydrate (g)	Energy (kJ)
F001	Beet root (Beta vulgaris)	86.95±0.50	1.95±0.14	1.46±0.21	0.14±0.01	3.31±0.32	2.60±0.30	0.71±0.06	6.18±0.61	149±9
F002	Carrot, orange (Daucus carota)	87.69±0.56	0.95±0.15	1.16±0.09	0.47±0.02	4.18±0.30	2.81±0.18	1.37±0.21	5.55±0.48	139±9
F003	Carrot, red (Daucus carota)	86.07±1.34	1.04±0.09	1.22±0.10	0.47±0.04	4.49±0.19	3.09±0.26	1.40±0.21	6.71±1.11	160±19
F004	Colocasia (Colocasia esculenta)	73.49±0.32	3.31±0.59	1.95±0.27	0.17±0.03	3.22±0.34	2.54±0.30	0.68±0.05	17.85±0.94	372±9
F005	Lotus root (Nelumbium nelumbo)	76.26±0.87	1.94±0.32	1.50±0.10	0.93±0.06	4.70±0.04	2.86±0.01	1.84±0.05	14.67±0.45	332±14
F006	Potato, brown skin, big (Solanum tuberosum)	80.72±0.40	1.54±0.17	0.92±0.08	0.23±0.02	1.71±0.03	1.13±0.02	0.58±0.04	14.89±0.40	292±7
F007	Potato, brown skin, small (Solanum tuberosum)	82.97	1.35	0.87	0.22	1.69	1.15	0.54	12.9	255
F008	Potato, red skin (Solanum tuberosum)	79.72	1.83	1.13	0.22	1.68	1.11	0.57	15.43	306
F009	Radish, elongate, red skin (Raphanus sativus)	89.32±0.29	0.67±0.03	0.73±0.02	0.13±0.02	2.46±0.16	1.96±0.03	0.49±0.15	6.71±0.12	134±3
F010	Radish, elongate, white skin (Raphanus sativus)	89.05±0.72	0.77±0.08	0.82±0.10	0.15±0.02	2.65±0.15	1.98±0.16	0.67±0.08	6.56±0.70	135±11
F011	Radish, round, red skin (Raphanus sativus)	89.68	0.89	0.91	0.16	2.29	1.56	0.73	6.07	130
F012	Radish, round, white skin (Raphanus sativus)	89.76	0.8	0.8	0.14	2.37	1.63	0.74	6.13	129
F013	Sweet potato, brown skin (Ipomoea batatas)	69.21±0.83	1.33±0.12	0.96±0.07	0.26±0.06	3.99±0.05	2.57±0.07	1.43±0.04	24.25±0.77	456±15
F014	Sweet potato, pink skin (Ipomoea batatas)	69.58±0.22	1.27±0.09	0.95±0.01	0.33±0.06	3.94±0.10	2.53±0.04	1.41±0.07	23.93±0.15	452±4
F015	Tapioca (Manihot esculenta)	75.23±0.55	1.03±0.10	1.12±0.11	0.20±0.01	4.61±0.12	3.85±0.08	0.76±0.05	17.81±0.57	334±10
F016	Water Chestnut (Eleocharis dulcis)	73.34	0.86	0.95	0.37	3.02	2.15	0.87	21.46	400
F017	Yam, elephant (Amorphophallus campanulatus)	74.39±0.31	2.56±0.28	1.29±0.10	0.14±0.02	4.17±0.05	3.25±0.03	0.92±0.03	17.46±0.55	353±5
F018	Yam, ordinary (Amorphophallus sp.)	74.28±0.63	2.18±0.26	1.64±0.19	0.17±0.02	4.08±0.07	3.32±0.32	0.76±0.25	17.65±0.57	349±12
F019	Yam, wild (Dioscorea villosa)	69.35	3.07	1.76	0.3	4.57	3.29	1.29	20.95	430

Source: Indian Food Composition Tables, NIN – 2017

Table 2: Water Soluble Vitamins Roots and Tubers

Code	Food Name	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Pantothenic Acid (mg)	Total B6 (mg)	Biotin (µg)	Folates (µg)	Ascorbic Acid (mg)
F001	Beet root (Beta vulgaris)	0.01±0.001	0.01±0.002	0.21±0.01	0.26±0.04	0.07±0.011	2.56±0.19	97.37±7.06	5.26±0.85
F002	Carrot, orange (Daucus carota)	0.04±0.003	0.03±0.003	0.22±0.02	0.30±0.03	0.11±0.016	1.50±0.23	24.04±2.07	6.22±1.99
F003	Carrot, red (Daucus carota)	0.04±0.017	0.03±0.016	0.25±0.05	0.27±0.04	0.07±0.012	1.30±0.14	23.67±3.25	6.76±1.56
F004	Colocasia (Colocasia esculenta)	0.06±0.007	0.03±0.002	0.51±0.09	0.12±0.02	0.17±0.038	3.69±0.22	19.91±2.90	1.83±0.64
F005	Lotus root (Nelumbium nelumbo)	0.07±0.008	0.05±0.023	0.43±0.05	0.20±0.02	0.19±0.017	2.85±0.32	26.49±6.85	26.63±7.02
F006	Potato, brown skin, big (Solanum tuberosum)	0.06±0.004	0.01±0.001	1.04±0.14	0.38±0.06	0.10±0.008	1.35±0.17	15.51±1.66	23.15±3.98
F007	Potato, brown skin, small (Solanum tuberosum)	0.05	0.01	1.36	0.49	0.12	1.82	13.85	26.41
F008	Potato, red skin (Solanum tuberosum)	0.06	0.01	1.13	0.39	0.1	1.68	17.83	25.04
F009	Radish, elongate, red skin (Raphanus sativus)	0.03±0.007	0.02±0.004	0.31±0.02	0.13±0.01	0.07±0.002	2.65±0.07	24.65±5.84	17.63±3.89
F010	Radish, elongate, white skin (Raphanus sativus)	0.02±0.004	0.02±0.003	0.30±0.03	0.15±0.03	0.07±0.008	2.48±0.21	29.75±8.30	19.91±5.69
F011	Radish, round, red skin (Raphanus sativus)	0.03	0.02	0.3	0.18	0.07	2.92	24.59	15.69

F012	Radish, round, white skin (Raphanus sativus)	0.03	0.02	0.24	0.15	0.07	2.59	22.6	14
F013	Sweet potato, brown skin (Ipomoea batatas)	0.07±0.085	0.04±0.012	0.67±0.09	0.89±0.10	0.12±0.006	5.19±0.78	15.62±2.13	17.94±1.40
F014	Sweet potato, pink skin (Ipomoea batatas)	0.06±0.012	0.04±0.001	0.69±0.12	0.56±0.34	0.09±0.007	5.71±0.28	14.44±2.06	22.20±2.32
F015	Tapioca (Manihot esculenta)	0.07±0.003	0.02±0.001	0.45±0.01	0.17±0.05	0.09±0.006	1.93±0.09	25.64±0.47	15.51±3.19
F016	Water Chestnut (Eleocharis dulcis)	0.02	0.02	0.74	0.52	0.13	1.08	9.8	5.26
F017	Yam, elephant (Amorphophallus campanulatus)	0.04±0.004	0.05±0.017	0.61±0.10	0.23±0.03	0.22±0.044	4.51±0.37	20.54±2.42	15.22±1.84
F018	Yam, ordinary (Amorphophallus sp.)	0.04±0.003	0.02±0.006	0.56±0.06	0.32±0.04	0.17±0.06	4.19±0.41	15.68±1.61	13.88±3.43
F019	Yam, wild (Dioscorea villosa)	0.121	0.015	0.7	0.23	0.2	4.09	21.01	14.06

Source: Indian Food Composition Tables, NIN – 2017

Table 3: Fat Soluble Vitamins Roots and Tubers

Code	Food Name	Ergocalciferol (µg)	α-Tocopherol (mg)	β-Tocopherol (mg)	γ-Tocopherol (mg)	δ-Tocopherol (mg)	α-Tocotrienol (mg)	β-Tocotrienol (mg)	γ-Tocotrienol (mg)	δ-Tocotrienol (mg)	α-Tocopherol Equivalent (mg)	Phylloquinones (µg)
F001	Beet root (Beta vulgaris)	0.18±0.01	0.09±0.01	0.09±0.01	–	–	–	–	–	–	2.98±0.94	—
F003	Carrot, red (Daucus carota)	1.39±0.09	0.19±0.03	0.20±0.03	0.03±0.01	0.22±0.03	–	–	–	–	18.75±0.81	—
F005	Lotus root (Nelumbium nelumbo)	0.27±0.06	0.73±0.11	0.73±0.11	–	–	–	–	–	–	44.45±4.37	—
F007	Potato, brown skin, small (Solanum tuberosum)	0.22	0.07	0.07	–	–	–	–	–	–	1.8	—
F008	Potato, red skin (Solanum tuberosum)	0.2	0.06	0.06	–	–	–	–	–	–	2.3	—
F009	Radish, elongate, red skin (Raphanus sativus)	0.04±0.02	0.01±0.01	0.01±0.01	–	–	–	–	–	–	2.10±0.12	—
F011	Radish, round, red skin (Raphanus sativus)	0.05	0.01	0.01	–	–	–	–	–	–	2.6	—
F012	Radish, round, white skin (Raphanus sativus)	–	–	–	–	–	–	–	–	–	–	—
F013	Sweet potato, brown skin (Ipomoea batatas)	1.26±0.31	0.01±0.01	0.01±0.01	–	–	–	–	–	–	3.00±0.84	—
F015	Tapioca (Manihot esculenta)	0.13±0.01	0.19±0.02	0.19±0.02	–	–	–	–	–	–	2.80±0.83	—
F017	Yam, elephant (Amorphophallus campanulatus)	1.30±0.23	0.06±0.01	0.69±0.04	0.03±0.01	0.17±0.02	0.34±0.02	–	–	–	4.80±1.46	—
F019	Yam, wild (Dioscorea villosa)	1.18	0.4	0.28	0.05	0.13	0.53	–	–	–	6	—

Source: Indian Food Composition Tables, NIN – 2017

Table 4: Carotenoids Roots and Tubers

Code	Food Name	Lutein (µg)	Zeaxanthin (µg)	Lycopene (µg)	γ-Carotene (µg)	α-Carotene (µg)	β-Carotene (µg)	Total Carotenoids (µg)
F001	Beet root (Beta vulgaris)	28.6±10.9	4.57±2.69	10.14±2.52	12.88±1.58	–	–	–
F003	Carrot, red (Daucus carota)	224±45.1	15.49±4.61	871±95.9	1128±179	2706±298	7570±412	–
F005	Lotus root (Nelumbium nelumbo)	13.0±1.58	–	–	–	156±19.5	–	–
F007	Potato, brown skin, small (Solanum tuberosum)	7.86	–	–	–	125	224	–
F009	Radish, elongate, red skin (Raphanus sativus)	8.68±1.90	2.38±0.93	1.62±0.37	17.61±5.77	–	–	–
F011	Radish, round, red skin (Raphanus sativus)	7.8	2.5	1.2	13.07	–	–	–

F0 12	Radish, round, white skin (Raphanus sativus)	–	–	–	–	–	–	–
F0 13	Sweet potato, brown skin (Ipomoea batatas)	282±56.1	146±22.7	–	–	5376±816	8653±749	–
F0 15	Tapioca (Manihot esculenta)	5.93±1.86	2.38±0.95	–	–	–	–	60.90±8.50
F0 16	Water Chestnut (Eleocharis dulcis)	8.12	2.5	–	–	–	–	93.08
F0 17	Yam, elephant (Amorphophallus campanulatus)	168±14.8	10.43±2.76	–	32.32±3.56	176±19.3	599±70.0	–
F0 18	Yam, ordinary (Amorphophallus sp.)	273±51.3	8.69±3.43	–	–	158±31.8	51.04±7.68	–
F0 19	Yam, wild (Dioscorea villosa)	11.39	1.2	8.95	230	94.53	–	–

Source: Indian Food Composition Tables, NIN – 2017

Table 5: Minerals and Trace Elements Roots and Tubers

Code	Food Name	Aluminium (mg)	Arsenic (µg)	Cadmium (mg)	Calcium (mg)	Chromium (mg)	Cobalt (mg)	Copper (mg)	Iron (mg)	Lead (mg)	Lithium (mg)
F0 01	Beet root (Beta vulgaris)	33.21±2.70	0.57±0.11	0.002±0.001	0.008±0.002	36.33±4.84	306±26.9	0.25±0.05	69.44±0.83	0.30±0.09	–
F0 03	Carrot, red (Daucus carota)	18.83±7.02	0.20±0.05	0.008±0.002	0.011±0.006	25.81±11.63	267±15.7	0.29±0.14	60.69±7.21	0.34±0.09	–
F0 05	Lotus root (Nelumbium nelumbo)	26.58±1.74	1.40±0.81	0.002±0.000	0.023±0.008	74.30±7.54	611±105	4.61±4.35	20.63±1.33	0.35±0.11	–
F0 07	Potato, brown skin, small (Solanum tuberosum)	22.34	0.16	0.003	0.013	37.9	474	0.28	3.97	0.38	–
F0 09	Radish, elongate, red skin (Raphanus sativus)	13.34±1.14	0.09±0.01	0.011±0.007	0.005±0.002	27.51±6.96	255±6.0	0.13±0.01	24.73±2.82	0.16±0.02	–
F0 11	Radish, round, red skin (Raphanus sativus)	0.17	–	35.76	0.003	–	–	0.03	0.42	–	–
F0 13	Sweet potato, brown skin (Ipomoea batatas)	0.15±0.16	0.001±0.000	–	27.50±5.24	0.002±0.001	0.002±0.002	0.17±0.02	0.35±0.03	–	–
F0 15	Tapioca (Manihot esculenta)	0.26±0.18	–	25.89±6.52	0.005±0.001	0.002±0.001	0.19±0.04	0.81±0.18	0.001±0.001	0.001±0.001	
F0 17	Yam, elephant (Amorphophallu s campanulatus)	0.72±0.19	0.001±0.001	–	46.91±5.12	0.009±0.003	0.006±0.004	0.17±0.04	1.22±0.11	0.001±0.001	0.001±0.000
F0 19	Yam, wild (Dioscorea villosa)	0.21	0.001	–	44.13	0.003	–	0.21	1.04	0.006	–

Source: Indian Food Composition Tables, NIN – 2017

Table 6: Starch and Individual Sugars Roots and Tubers

Code	Food Name	Total CHO (g)	Total Starch (g)	Fructose (g)	Glucose (g)	Sucrose (g)	Maltose (g)	Total Free Sugars (g)
F0 01	Beet root (Beta vulgaris)	6.04±0.94	1.69±0.43	1.67±0.02	1.46±0.02	1.21±0.03	–	4.35±0.02
F0 02	Carrot, orange (Daucus carota)	4.48±0.65	1.24±0.27	0.11±0.02	1.15±0.03	1.98±0.02	–	3.23±0.03
F0 03	Carrot, red (Daucus carota)	5.35±0.03	1.39±0.05	1.08±0.02	1.13±0.02	1.75±0.02	–	3.96±0.03
F0 04	Colocasia (Colocasia esculenta)	14.78±0.71	13.88±0.74	0.54±0.03	0.25±0.03	0.12±0.02	–	0.90±0.05
F0 05	Lotus root (Nelumbium nelumbo)	13.46±0.78	13.22±0.82	0.07±0.02	0.11±0.02	0.07±0.02	–	0.24±0.04
F0 06	Potato, brown skin, big (Solanum tuberosum)	11.79±0.76	11.47±0.71	0.24±0.02	0.05±0.02	0.04±0.02	–	0.32±0.02
F0 07	Potato, brown skin, small (Solanum tuberosum)	10.73	10.29	0.26	0.08	0.1	–	0.44
F0 08	Potato, red skin (Solanum tuberosum)	13.46	13.08	0.22	0.1	0.05	–	0.38
F0 09	Radish, elongate, red skin (Raphanus sativus)	1.56±0.04	0.41±0.02	0.48±0.06	0.27±0.04	0.40±0.04	–	1.15±0.03
F0 10	Radish, elongate, white skin (Raphanus sativus)	1.54±0.11	0.59±0.09	0.31±0.05	0.03±0.01	0.62±0.03	–	0.95±0.04
F0 11	Radish, round, red skin (Raphanus sativus)	1.5						

Source: Indian Food Composition Tables, NIN – 2017

Table 7: Fatty Acid Profile Roots and Tubers

Code	Food Name	Capric (C10:0)	Lauric (C12:0)	Myristic (C14:0)	Palmitic (C16:0)	Stearic (C18:0)	Arachidic (C20:0)	Behenic (C22:0)	Lignoceric (C24:0)	Myristoleic (C14:1)	Palmitoleic (C16:1)	Oleic (C18:1n9)
F0 01	Beet root (Beta vulgaris)	57.23±5.65	6.98±0.71	31.17±3.30	21.96±2.57	64.21±6.24	–	–	–	–	–	–
F0 03	Carrot, red (Daucus carota)	246±0.3	24.10±0.25	88.91±1.03	18.27±0.53	270±0.3	–	–	–	–	–	–
F0 05	Lotus root (Nelumbium nelumbo)	291±23.3	123±8.9	249±20.3	84.12±3.38	414±31.1	–	–	–	–	–	–
F0 07	Potato, brown skin, small (Solanum tuberosum)	54.34	73.68	44.03	11.94	128	–	–	–	–	–	–
F0 09	Radish, elongate, red skin (Raphanus sativus)	23.71±1.6	33.02±4.55	42.65±3.07	7.29±0.74	56.73±5.71	–	–	–	–	–	–
F0 11	Radish, round, red skin (Raphanus sativus)	21.18	54.67	46.08	6.08	75.85	–	–	–	–	–	–
F0 13	Sweet potato, brown skin (Ipomoea batatas)	96.29±7.72	19.52±0.67	66.10±3.26	4.10±0.60	116±8.3	–	–	–	–	–	–
F0 15	Tapioca(Manihot esculenta)	78.47±5.88	12.83±0.98	59.50±2.11	9.20±0.72	91.29±6.85	–	–	–	–	–	–
F0 17	Yam, elephant (Amorphophallus campanulatus)	–	–	31.01±3.20	4.72±0.52	6.75±0.92	–	–	–	–	–	–
F0 19	Yam, wild (Dioscorea villosa)	–	–	67.83	11.68	22.66	–	–	–	–	–	–

Source: Indian Food Composition Tables, NIN – 2017

Table 8: Amino Acid Profile Roots and Tubers

Code	Food Name	Histidine	Isoleucine	Leucine	Lysine	Methionine	Cystine	Phenylalanine	Threonine	Tryptophan	Valine
F0 01	Beet root (*Beta vulgaris*)	8.76±0.71	3.51±0.25	7.52±0.76	28.73±0.85	3.37±0.44	3.35±0.32	4.28±0.36	2.76±0.56	–	–
F0 03	Carrot, red (*Daucus carota*)	10.23±2.20	2.47±0.13	15.01±0.32	28.68±0.42	3.07±0.47	5.50±2.64	3.97±0.68	1.74±0.03	–	–
F0 05	Lotus root (*Nelumbium nelumbo*)	5.11±1.11	5.57±0.58	26.00±5.38	14.81±2.20	3.91±0.43	3.16±0.96	4.33±0.23	2.70±0.11	–	–
F0 07	Potato, brown skin, small (*Solanum tuberosum*)	5.63	3.55	9.76	19.04	3	3.19	4.17	2.94	–	–
F0 09	Radish, elongate, red skin (*Raphanus sativus*)	7.36±0.11	4.53±0.01	9.70±0.96	28.02±1.14	4.08±0.05	4.29±0.13	4.33±0.05	1.62±0.30	–	–
F0 11	Radish, round, red skin (*Raphanus sativus*)	7.12	4.89	10.1	24.98	4.12	4.84	4.01	1.43	–	–
F0 13	Sweet potato, brown skin (*Ipomoea batatas*)	8.00±1.11	3.48±1.23	22.80±1.34	9.65±0.44	4.90±0.66	3.83±0.07	5.21±0.44	3.26±0.41	–	–
F0 17	Yam, elephant (*Amorphophallus campanulatus*)	2.89±0.11	3.36±0.24	6.00±0.56	2.99±0.38	1.55±0.16	1.66±0.10	6.46±0.71	3.81±0.33	1.13±0.04	5.84±0.49
F0 19	Yam, wild (*Dioscorea villosa*)	2.37	3.27	6.09	3.13	1.18	1.76	6.23	4	1.25	5.98

Source: Indian Food Composition Tables, NIN – 2017

Table 9: Organic Acids Roots and Tubers

Code	Food Name	Total Oxalate	Soluble Oxalate	Insoluble Oxalate	Cis-Aconitic Acid	Citric Acid	Fumaric Acid	Malic Acid	Quinic Acid	Succinic Acid	Tartaric Acid
F0 01	Beet root (*Beta vulgaris*)	71.37±13.10	30.15±1.79	41.21±12.20	45.43±3.34	134±16.2	0.02±0.01	0.33±0.18	–	0.29±0.12	–
F0 02	Carrot, orange (*Daucus carota*)	17.45±6.32	12.63±5.24	4.82±4.30	37.50±1.80	222±11.2	5.62±0.33	4.83±1.42	–	5.58±1.00	–
F0 03	Carrot, red (*Daucus carota*)	16.41±7.00	15.43±7.09	0.98±0.09	39.15±2.74	105±0.8	–	5.01±1.22	–	5.13±0.01	–
F0 05	Lotus root (*Nelumbium nelumbo*)	364±33.9	26.03±2.84	116±186	0.85±0.03	55.38±1.77	1.48±0.33	84.39±1.25	4.89±0.77	85.92±3.20	
F0 07	Potato, brown skin, small (*Solanum tuberosum*)	13.63	10.71	2.92	15.63	56.81	1.82	94.52	7.11	–	
F0 09	Radish, elongate, red skin (*Raphanus sativus*)	12.73±2.11	5.37±1.13	7.36±1.01	4.20±1.14	2.94±0.52	1.34±0.27	4.53±1.12	2.59±0.39	–	
F0 11	Radish, round, red skin (*Raphanus sativus*)	12.27	9.12	3.15	3.27	6.12	1.36	6.41	2.82	–	
F0 13	Sweet potato, brown skin (*Ipomoea batatas*)	14.39±4.70	6.56±1.55	6.27±4.47	15.66±0.41	1.92±0.64	127±3.2	652±8.2	6.42±0.76	–	
F0 15	Tapioca (*Manihot esculenta*)	16.86±3.83	10.93±1.91	5.93±1.94	1.21±0.07	8.83±0.41	1.87±0.89	8.82±1.50	167±1.9	18.23±1.38	
F0 17	Yam, elephant (*Amorphophallus campanulatus*)	15.58±3.80	12.39±4.77	3.18±1.93	1.63±0.23	354±5.3	5.92±0.90	122±1.5	15.88±1.71	16.18±4.13	
F0 19	Yam, wild (*Dioscorea villosa*)	13.45	3.63	9.82	–	286	1.11	138	10.48	20.65	

Source: Indian Food Composition Tables, NIN – 2017

Table 10: Polyphenols Roots and Tubers

Code	Food Name	Quercetin -3-β-galactoside	Isorhamnetin	Myricetin	Resveratrol	Hesperetin	Naringenin	Hesperidin	Daidzein	Genistein	(-)-Epicatechin
F0 01	Beet root (*Beta vulgaris*)	0.38±0.08	–	–	–	0.34±0.08	–	–	0.15±0.05	–	–
F0 02	Carrot, orange (*Daucus carota*)	2.66±0.41	5.35±0.58	–	–	2.66±0.25	1.49±0.22	0.54±0.09	–	–	–
F0 03	Carrot, red (*Daucus carota*)	4.57±0.45	5.89±0.03	–	–	3.64±0.69	1.67±0.05	0.63±0.00	–	–	–
F0 04	Colocasia (*Colocasia esculenta*)	2.01±0.61	1.55±0.15	–	–	–	–	–	–	–	–
F0 05	Lotus root (*Nelumbium nelumbo*)	0.37±0.04	–	–	–	–	–	–	–	–	–
F0 06	Potato, brown skin, big (*Solanum tuberosum*)	2.98±0.32	–	2.99±0.29	–	0.11±0.02	0.15±0.02	6.87±0.71	–	–	–

Source: Indian Food Composition Tables, NIN – 2017