

Vegetables in secondary agriculture

Currently, the value-addition is at a dismal low of around 2%. Besides, lack of infrastructure and proper temperature management, transit and storage further reduces the storability and marketing window for the fresh produce. Among the approaches that can be taken to reduce food loss and waste, secondary agriculture, i.e. value-addition particularly, low cost drying to prepare value added processed product always top the chart. Drying process is a major consumer of energy, about 20-25% in the food processing industry. It is being used as a valuable technology to reduce volume, preserve quality and enhance storability much beyond possible for fresh horticultural commodities since ages. With advancement in time, different drying technologies have come up. Several techniques of drying are used currently like hot air-controlled drying, spray drying, freeze drying, infrared drying, superheated steam drying, osmotic dehydration, microwave drying, hybrid drying methods etc. Notable among them being the freeze drying which is known to produce the best quality dried produce and air drying which is used most commonly due to ease in handling and cost efficacy. However, the major drawbacks in freeze drying are the long drying time and the higher energy consumption which lead to higher per unit cost of the dried product. The current times demand an intelligent, cost-effective drying system with the quality of dried produce comparable to their fresh counterpart.

THE diverse group of vegetables present an array of nutritional and health benefitting bioactive compounds, vitamins and minerals. Vegetable production is reaching new heights every passing year which, in turn, increases the need, potential and scope of processing and value addition. India is the second largest producer of vegetables after China. The major states with high vegetable production are West Bengal, Bihar, Uttar Pradesh, Madhya Pradesh and Andhra Pradesh. According to the 3rd advance estimates, the production of vegetables is estimated at 204.84 million tonnes from about 10.35 million ha land at a productivity of around 19.7 t/ha (GoI, 2021-22). After production, produce undergoes a series of post-harvest operations, handling stages and storage before reaching to the consumers. Each operation and handling stage results in some losses. There are sizable losses of vegetables during harvesting, post-harvest operations, handling and storage due to spoilage. It has been reported that postharvest losses and waste amount to approximately ₹ 1 lakh crores (NAAS 2019), while internationally it is estimated at 750 billion US\$ (FAOSTAT 2019). The major reasons for higher perishability in fresh horticultural crops are higher moisture content, soft texture, higher susceptibility to diseases and high metabolic rates. Despite these huge monetary losses, the loss of input resources and time, hard work and dedication of the farmer-grower and the nutritional wastage cannot be compensated for

at a time when tens of millions of people worldwide are suffering from hunger, malnutrition and other chronic conditions like diabetes, hypertension, cardiovascular diseases, allergies and diabetes, etc. Diverse group of vegetables provides immense opportunities for processing and production of diversified products. Thus, indeed we need to additionally focus on development of infrastructure facilities for vegetable storage, transportation and processing.

Processing and value-addition

The vegetables belonging to different families are each a powerhouse of different phyto-chemicals which help to maintain health and keep diseases at bay. Cucurbits like bottle gourd, bitter gourd, cucumber, sponge gourd, pointed gourd, ridge gourd, ivy gourd; solanaceous vegetables like tomato, brinjal, chilli; leguminous vegetables like Indian bean, French bean, broad bean, pea; leafy vegetables like spinach, amaranth, fenugreek, lettuce; cruciferous vegetables like cauliflower, cabbage, broccoli, radish; carrot and tree vegetables like moringa all are representative of different nutritional compounds in various ratios. These can be used to prepare a number of vegetable based processed products. Drying process effectively removes moisture from product. It leads to development of shelf stable products. Moreover, due to drastic volume reduction, the packaging, storage and



transportation costs are reduced. The selection of drying technique varies with raw material, availability of dryer, cost of operation, maintenance and operating easiness and final quality of dehydrated product. A number of products like green chilli powder, dehydrated okra, bitter gourd chips, instant bottle gourd kheer mix, moringa soup and moringa drink have been developed at ICAR-IIVR. These technologies have commercial applications and can be utilized for reducing the post-harvest food losses and wastage. There is need to increase focus towards secondary agriculture for increasing employment, increased incomes and reduce losses. It will act as a boost to add value to product, generate employment and promote agro-start ups.

Now a days, pre-packaged fresh-cut vegetable industry is on the rise due to the inclination of consumers towards self-preparation of healthy food. Minimally processed vegetables are highly susceptible to attacks by pathogenic micro-organisms due to increased surface area, tissue injury, leachate loss and heightened metabolic rates. It is difficult to store fresh-cut or minimally processed vegetables because of rapid deterioration in quality, appearance, leaching losses, change in colour and rapid attacks of pathogenic micro-organisms. The packaging technique, storage temperature and relative humidity should be carefully selected. The genotype selection is possibly the most important variable determining overall quality of minimal processed vegetables. Different ways like use of texture improvers, anti-browning and antimicrobial agents, and mild heat treatment coupled with modified atmospheric storage can be used for increasing the storability beyond 1-2 days at supermarket conditions. It is a low energy consuming industry suitable for urban and peri-urban areas due to the high demand of fresh cut products in local regions.

Convenience based ready-to-eat food has a definite edge over other products. It has added advantage in today's busy times when convenience is demanded by all consumers while looking for food products with added health benefits. During present times, the preparation of many traditional foods is deemed as difficult due to being cumbersome and taking time for preparation. One of the products developed at ICAR-IIVR, Varanasi is instant bottle gourd kheer mix. It is a dessert product which can be easily prepared without any hassle in 2 minutes. This product is not only liked due to its sweet taste, but also the nutritional and functional characteristics obtained from vegetable based desserts.

Nevertheless, there are some serious challenges which will come along during processing. Important among them are lack of genotypes possessing processable traits, lack of basic mechanization and storage infra-structure, high temperatures all the year round in most parts of the country and cold chain management. The high base investment, operational cost, maintenance difficulties and marketing challenges are also few deterrent for the new entrants to the food processing sector. However, once these challenges are overcome, food processing and nutraceuticals development are very rewarding industries in terms of growth, profit, easy product storage, easy availability of raw material and labour, increasing demand due to change in consumers perception, employment generation, industry development and drastic reduction in losses and waste. Most significantly, it helps us to become sustainable while attempting to reach the goals of food and nutritional security for all.

Wealth from vegetable wastes

As per the research report (2011) of National Institute of Agricultural Marketing, Jaipur, conducted across the

the major APMCs of the country, it was found that a huge quantum of fresh fruits and vegetables are transacted daily in the markets. Wastage in vegetables ranged from 3.15% to 12.6%. Majority of the wastes generated in the APMCs are disposed-off as garbage. Vegetable waste from market and homes are source of environmental pollution, and human health hazards. Besides, the entire volume of food waste is unutilized and results in food loss and hence economic loss. Recycling of fruit and vegetable waste is one of the most important means of utilizing it in a number of innovative ways yielding new products and meeting the requirements of essential products required in human, animal and plant nutrition as well as in the pharmaceutical industry. Agricultural wastes may be used as a source of energy, bedding, animal feed, mulch, organic matter, or plant nutrients. Properly treated, they can be marketable. Futuristic concept is to generate electricity from these bio-wastes. This is a cleaner, greener and economical method of power generation.

Microbial technology is available for recycling and processing of fruit and vegetables waste. These could be utilized for production of compost for use in crops. Composting can be done through use of mechanical shredders and microbial consortium, pit or heap method (NADEP Compost) or through different species of earthworm (Vermicompost). Moreover, vegetable crops generate a large amount of crop residues after harvesting of economic part. These potentially nutritious residues are soft, succulent and easily decomposable and instead of disposing or damping, it can be used as source of organic residues for utilizing the embedded nutrients through compost production. There exist a number of potential fungal and bacterial decomposers for the decomposition of either fresh tissue of vegetable leaves, roots, stems and fruits or degrade dead tissues of the plants. Species of *Trichoderma*, *Aspergillus*, *Pseudomonas*, *Bacillus* and several

yeasts can effectively decompose vegetable residues in a less time. There also exist enzymatic degradation processes, in which the soft tissues of vegetable residues can be decomposed into compost by the enzymes like oxidoreductases, transferases, hydrolases, lyases and chitinases, etc. for the further recycling of the composted products into the soils.

At IIVR, studies were conducted on composting and waste recycling of different vegetables. The effect of the composted products was evaluated in organic vegetable production field. For quality compost production, judicious mixture of different vegetable wastes is required. Involvement of earthworm for degradation of organic wastes promotes faster decomposition with increased rate of mineralization, humification of organic matter and increased microbial diversity that improves the quality of the final compost. The study demonstrated that vermicompost produced from a mixture of non-legume and legume vegetable waste in 1:1 ratio with cow dung (50%) can provide major nutrients in more balanced proportion as compared to sole individual family waste (vermicompost obtained from the waste of one single plant family). The findings can be promoted as a sound vegetable wastes recycling technology to conserve natural resources for organic production of vegetables.

It was observed that the prepared vermicompost and NADEP compost from vegetable residues improved the yield of brinjal, cabbage and pea under organic farming system. There was increase in yield of brinjal, cabbage and pea by 12.0, 19.1 and 9.01% respectively due to the application of vermicompost @ 10 t/ha, FYM @ 10 t/ha + NADEP compost @ 10 t/ha and NADEP compost @ 25 t/ha. A number of studies conducted by many workers have demonstrated the viability of composting technology for utilization of fruit and vegetable wastes for production of vermicompost.

Table 1. Quality and recovery of vermicompost and NADEP compost produced from vegetable wastes

Vegetable residue	C:N ratio	Nutrient content (%)			Dry matter (%)	Recovery (%)
		N	P	K		
Solanaceae waste + Cow dung (A)	25.47	1.63	0.64	1.23	40.12	42.23
Cruciferae waste + Cow dung (B)	28.12	1.67	0.67	1.26	43.32	38.54
Cucurbitaceae waste + Cow dung (C)	32.45	1.56	0.58	1.22	44.31	41.56
Waste of Solanaceae + Cruciferae + Cucurbitaceae (1:1:1) + Cow dung (D)	26.45	1.61	0.63	1.24	42.45	45.23
A + Leguminosae (1:1)	25.17	1.72	0.74	1.32	46.45	46.24
B + Leguminosae (1:1)	26.20	1.73	0.75	1.34	45.62	42.54
C + Leguminosae (1:1)	27.32	1.72	0.69	1.31	45.12	45.86
D + Leguminosae (1:1)	23.15	1.72	0.76	1.34	44.21	46.12
Leguminosae + Cow dung only	22.14	1.74	0.81	1.36	48.27	48.56
Cow dung only	26.84	1.54	0.76	1.20	40.23	51.20
NADEP compost						
Brinjal	36.14	0.69	0.32	0.67	72.51	65.32
Cucurbits	32.52	0.61	0.24	0.54	74.31	64.27
Cowpea	25.42	1.11	0.46	0.72	76.12	66.4
Crucifers	34.21	0.71	0.31	0.74	68.23	61.12



Vermicompost from vegetable waste

Table 2. Yield of brinjal, pea and cabbage under organic system of cultivation

Treatment	Brinjal	Pea	Cabbage
	yield (t/ha)	yield (t/ha)	yield (t/ha)
FYM @ 25 t/ha	38.64	6.4	27.6
NADEP compost @ 25 t/ha	40.1	7.3	27.78
Vermicompost @ 7.5 t/ha	39.91	7.1	29.28
FYM + Vermicompost (10 t+2.5 t/ ha)	39.63	9.4	28.51
NADEP + Vermicompost (10 t+2.5 t /ha)	37.82	10.6	28.84
FYM + NADEP compost (10 t+10 t/ha)	40.83	9.9	29.06
Inorganic RDF	37.43	8.9	26.14

Microbial inoculants for vegetable production and value-addition

Small-land ecosystems, being majorly adopted by the vegetable growers worldwide play crucial role in food and nutritional security and share almost 50% of the food produce globally. However, this ecosystem is always at threat due to abiotic and anthropogenic activities, which majorly damage soil and plant health. Major threats are due to degrading lands and excessive use of chemical fertilizers, pesticides and weedicides, which hugely affect the crop production and quality of vegetable crops. As a supplement to these chemical entities, biofertilizers and biopesticides along with the bioorganic botanical and microbial bioproducts have emerged to benefit small farms producing quality and organic vegetables with very low load of synthetic chemical molecules. Among the majorly used bioproducts, nitrogen fixer *Rhizobium*, *Azotobacter* and *Azospirillum*, phosphate solubilizer and potash mobilizer *Bacillus* species and arbuscular mycorrhizal fungi, plant growth promoting bacteria *Pseudomonas*, biofungicide *Trichoderma*, bioinsecticide *Beauveria*, *Metarrhizium* and bionematicide *Paecilomyces* are to name a few which are now being promoted among the vegetable growers. These microbial inoculants to be used at different stages of plant growth can help plants tolerate abiotic and biotic stresses, thereby reducing losses in the field and maintain nutritional quality of the produce by imparting mechanism-level changes in metabolic pathways. Application of the microbial inoculants can reduce the dependency of

farmers on synthetic fertilizers and pesticides which persist longer in the vegetable produce and make the fruits chemical contaminant-free for consumption by the consumers. This way, the microbial applications in crop production system can add value to the crop and help farmers to gain more monetary benefits from value added products.

SUMMARY

Overall, the primary goal of the secondary agriculture to provide value added agricultural products through processing and stress management can be achieved in the vegetable production system by precise processing of the crop produce that go waste in the fields. The application of microbial inoculants and the recycling of soil nutrient in the agricultural farms through composting are added advantageous operations in the vegetable production system, with the help of which chemical contamination free-soil and plants can be nurtured in the fields. The produce from such soils and crops could yield more for the farmers in terms of economics and thus enhance their income.

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