

11. Post-harvest Management and Value-addition

Post-harvest management and value-addition is integral to agricultural production for reduction in post-harvest losses, meet consumer requirements, preserve nutritional quality, optimize the utilization of by-products and create employment opportunities. A number of machines, hand tools, gadgets, structures for safe handling and processing of farm produce, process protocols for value-added products, novel products and technologies for farmers have been developed and commercialized. The current research efforts emphasize on the development of equipment, process protocols and value-added products suiting the production catchments and meeting the health requirements of various sections of the population.

Autoclavable microencapsulation system: An autoclavable microencapsulation system was developed for microencapsulation of sensitive functional ingredients. The heart of the system is a two-fluid nozzle with multiple inlets for air or inert gas at different pressures. The kinetic energy of high pressure air or inert gas is used for breaking up of matrix fluid (containing functional ingredients) into small droplets which fall in reaction vessel. The reaction vessel contains divalent cations or polycationic substances which replace monovalent ions resulting in ionotropic gelification to yield microcapsules. It can be used for producing microcapsules having particle size in the range of 100 to 1,000 μm . The applications include microencapsulation of bacteriocins, enzymes, nutraceuticals, probiotics and prebiotics for food and feed applications. The system is cost-effective and an import substitute.



Autoclavable microencapsulator

Insulated and ventilated containers for National Horticulture Board: The National Horticulture Board (NHB) initiated collaboration with the CIPHET to overcome the problems associated with long-distance

transportation of fruits and vegetables through trucks. Insulated and ventilated freight container to suit transport of fruits and vegetables over long distance was designed. Its fabrication and trial runs using trucks and rail wagons were conducted by the NHB. A 5–8°C drop in temperature was observed inside container as compared to outside air temperature. The reduction in post-harvest losses was observed around 4%, in case of modified container. The NHB has tested the design of the container for transportation of various fruits and vegetables through railways, and the train with these containers is called National Horticulture Train.

Fruit and vegetable grader: A fruit and vegetable grader of capacity 2 tonnes/h was developed, suitable for grading of apple, guava, mango, sapota, citrus, tomato, onion, potato etc. The rollers rotating in opposite directions are inclined for ease of forward movement while grading. Grading efficiency was more than 92%.



Fruit and vegetable grader

Rotary areca nut dehusker: A rotary areca nut dehusker was developed. Areca nuts are harvested and sun-dried to a moisture content of 6–7% before being dehusked. Graded nuts are fed to the dehusker. The mean values of throughput, working heart rate and change in heart rate (Δ HR) were 5.0 kg/h, 108 beats/min and 34 beats/min, respectively, and the dehusking efficiency was 88.5%.

Development of walnut planting material in polyhouse: Walnut is an important plantation crop of Kashmir valley. Grafted plant takes about 4 years for fruit bearing compared to 12 years for non-grafted one. The walnuts were grafted inside and outside the polyhouse (walk-in-tunnel, 17.5 m \times 3.5 m \times 2.2 m) at a spacing of 20 cm \times 60 cm. Maximum grafting success of 68% was obtained inside polyhouse compared to 32% in open field conditions. Black plastic mulch (54%) was found better than hay mulch (46%). Basal



Walnut propagation inside walk-in-tunnel type polyhouse in Kashmir valley

application of fertilizers proved better (53%) than split fertigation (50% and 47%), respectively, for 100% and 70% of recommended dose of fertilizers. The combination of polyhouse with black mulch and basal fertilizer application showed the highest success (>75%). Walnut plants were ready for transplanting in field after one year. The analysis based on annualized cost indicated benefit : cost ratio of 2.54, which is economically viable.

Development of mulching sheet from jute nonwoven: Mechanically entangled jute nonwoven mulching sheet was developed and compared with different mulch materials including plastic for cultivation of strawberry at Abohar, Punjab. Jute nonwoven mulch sheets of different area density and thickness were tested and compared with black and white plastic of different thickness. It was observed that the availability of strawberry in the field was extended up to middle of May in case of jute mulching, whereas the fruits were no longer available in middle of April with plastic mulching. Jute mulching retains moisture, resists erosion, protects soil from strong impact of raindrop, and protects soil from atmospheric temperature. It enhanced yield by around 10% and improved quality of strawberry fruit.

In another trial, effect of different mulch materials, e.g. straw, saw dust, banana leaf, white plastic, black plastic and jute nonwoven, was studied on cultivation of heat-resistant (summer variety) tomato. Of these, jute nonwoven and straw mulches were found better for tomato production and health of plant. Thus, jute nonwoven mulching is suitable and economically viable for strawberry and tomato. The cost of waste jute nonwoven (500 g/m²) is ₹ 8.75/m².

Eco-friendly hydrophobic and UV-protective finish for cotton fabrics: Cotton fabrics are hydrophilic in nature but for many applications such as raincoats, umbrellas, upholstery, uniforms, etc., they need to have hydrophobic finish. Generally, toxic fluorocarbon chemicals are used for this purpose. A new eco-friendly hydrophobic finish for cotton fabrics, developed using zinc oxide nano particles, silicones and organic acid, was durable up to 20 hand washes with spray rating

of 70, indicating good hydrophobic characteristic. The fabric also provided protection from the harmful effects of ultra-violet rays (UPF rating 50) present in the light.

Litchi fruit peeling machine: Litchi fruits are perishable in nature and are processed to make juice and concentrates. A machine for peeling litchi was developed, consisting of two stainless steel rollers of 60 mm diameter; rotating in opposite direction at differential speed. Due to differential speed of the rollers, the peel is separated from the fruit. After removal of peel, the friction force between roller and pulp is reduced and moving belt guides the peeled fruit towards outlet. The peel passes through the rollers and moves down whereas peeled fruit is conveyed ahead. The capacity of the machine is 150 kg/h with peeling efficiency of 96%. It is operated by 750 W electric motor.



Litchi fruit peeling machine

Prefabricated grass carpet with natural fibre-based backing material: A study was conducted to eliminate the use of plastic for growing and transporting prefabricated grass carpet, using suitable 100% natural fibre-based backing material. In this case, coconut fibre-based net (489 g/m²) and jute cloth (woven and nonwoven) are used as bio-friendly backing of the grass carpets. Use of jute also decreased the requirement



Jute-coconut fibre composite structured as backing material for making grass carpet

of soil during seedling plantation. The coconut fibre-based net acted as the binder of the grass-carpet base. Longevity of coconut fibre under soil is very high, sustaining its structure for even several months. The cost of the prefabricated grass carpet is 380/m².

Development of coconut-fibre segregator machine:

A coconut-fibre segregator was developed for grading coconut fibres into various grades. These different quality grades can be used selectively according to the product need or blended with other fibres for making innovative and value-added products. The principle of air drag and gravity was used in the machine for quality-based segregation of coconut fibres. The opening roller of the machine initially opens the fibre and throws them into a chamber. The fibre mass is sucked through a dumb-bell shaped conduit by air flow. The geometry of the conduit is so designed that only light fibres are carried away by the airflow to the cyclone



Coconut fibre segregator machine (top) and segregated coconut fibres – a, segregated coarse fibres; b, unsegregated (bulk) fibres; c, segregated fine fibres

separator. The heavy fibres remain in the chamber and get carried forward by a conveyor. The outturn of the segregator is 50–60 kg/h.

Value-added bajra products: Efforts were made to overcome storability constraints of *bajra* flour through pearling process using a simple pearler. Fat acidity of flour prepared from unpearled grain increased from 4.5 to 79 mg KOH/100 g, while it increased from 2.3 to 37 mg KOH/100 g in the flour from pearled grain after 20 days storage period. Similarly, free fatty acid was also higher in flour from unpearled grain (2.3 to 40%) compared to that made from pearled grain (1.2 to 18%). Further, analysis of different fractions (pearled grains, partially pearled grains, partially pearled grains-fines, grit and fine bran) revealed that grit fraction had 4.3% ash content, 18.9% crude protein and 17% ether extract (lipid) indicating that these are good sources of dietary energy. Biscuits prepared from pearled *bajra* flour were palatable and acceptable. Bran, usually a waste material, was successfully used for making multi-nutrient animal feed block.

Chemical and biochemical characteristics of tobacco-seed oil:

Oil yield from seeds of tobacco, Siri (FCV), GT 7 (*bidi*), Manasi (*Jati* tobacco), Dharla (*Motihari* tobacco), HDBRG (burley type), Banket A1 (burley) and Abirami (chewing type) ranges from 32.79 to 38.14%. HDBRG yielded maximum oil (38.14%), followed by *bidi* tobacco variety GT 7(37.70%). Saponification value of the oil varied from 186.3 to 208.6, and its iodine value (IV) from 134 to 182.2. Predominant fatty acids in the oil are palmitic, stearic, oleic, linoleic and linolenic acids. Oleic and linoleic acid content range from 9.22 to 13.60% and 72.49 to 79.07% respectively. The oil also contains 1.30% of omega-3-fatty acid, an essential fatty acid for human-beings. It has higher ratio of polyunsaturated to saturated fatty acids than sunflower and groundnut oils, and comes under class 1 of the nutrition classes of edible oils. Protein content of the de-oiled seed-cake varies from 27 to 32.12%. The oxidative deterioration of tobacco seed-oil is at par with sunflower oil.

Tobacco-seed crushed with oil expeller, followed by solvent extraction yielded maximum oil (44%). De-colourization of oil with 4% Fullers' earth gives light-golden yellow colour similar to sunflower oil.

Fruit crops: Mango peel was utilized for production of pectinases through microbial fermentation using *Aspergillus niger*. Extracellular pectinase was immobilized in calcium alginate beads through entrapment technique. Thermal stability of immobilized enzyme after heat inactivation at 60°C was observed higher than free enzyme over a longer time interval. Isoforms of pectinase, viz. polygalacturonase, pectin methyl esterase and pectin lyase, were identified from *Aspergillus niger* multiplied on pectin (extracted from mango peel) using gene-specific PCR.

In grapes cultivar Cabernet Sauvignon, pruning time and bunch load affected wine parameters. Retaining 20 bunches/vine resulted in more TSS, anthocyanin and TTA in juice. Wine prepared from early pruned

vines had high pH, low TTA, more anthocyanin and alcohol and high colour intensity. Wine from late pruned vines with 30 bunch load was found to contain no sugar and high alcohol content. In raisins prepared from Tas-A-Ganesh, moisture content, colour intensity and phenol content were significantly affected by pre-treatment of bunches with ascorbic acid prior to dipping. Minimum colour intensity and moisture content were obtained in raisins prepared from bunches pre-treated with ascorbic acid at 300 ppm.

Maturity indices revealed that fruits of cultivar Bhagawa may be harvested around 180 days after anthesis when TSS : acid ratio reaches 32.31 but fruits of cultivar Ganesh can be harvested by 154 days. Further, post-harvest dipping of fruits of Bhagawa in different lac formulations increased the shelf-life to 23.3 days under SH 2–100%, followed by SH 1–50% (22.7 days) compared to the control (16.7 days).

Antioxidant capacity in mulberry was higher in genotype with dark fruits, i.e. CIAH-M 1. One serving of fruit beverage (100 ml) prepared from CIAH-M1 contained 29.8 mg phenol, 12.6 mg flavonoids, while total antioxidant activities were observed to be 98 mMTE. Highest TSS (18–20°Brix), colour and size (>20 g) was obtained when litchi fruits were harvested during last week of May. Treatment with 2% citric acid + 500 ppm KMS dip (8–10 min) and kept at 15°C extended the shelf-life of litchi fruits by 16 days. Further, fruits packed in perforated LDPE bags and stored in CFB has <5% damaged fruits as compared to wooden box packaging (>15%). Cabinet drying after 2 days of sun drying at 45°C gave best quality litchi nuts.

Vegetable crops: Capsicum could be stored in fresh condition without shriveling, maintaining firmness for 7 days in high humidity and low-cost polyethylene tent with a weight loss of only 2.2% compared to 8% weight loss by 3 days itself in the open (25–30°C and 40–52% relative humidity).



Capsicum stored in low cost polythene tent

Green chilli powder has assumed special importance due to presence of high vitamin C (105 mg/100 g) and capsaicin content. To develop this product, the blanched green chilli pieces were osmotically diffused in sodium chloride solution for 2–3 h at 40–50°C, followed by drying at 50–60°C for 8–10 h to reduce the moisture content to less than 2%. The drying process retained 35–38% ascorbic acid, 90–94% chlorophyll

Success story

Green algal extract (GAe)

Green algal extract (GAe), a nutraceutical provides a unique blend of 100% natural, bioactive anti-inflammatory ingredient. It was extracted from seaweeds with an ecofriendly green technology to combat joint pain and arthritic condition. These are natural alternatives to synthetic anti-inflammatory drugs for controlling arthritis. The existing allopathic medications used in the treatment of joint pain and arthritis produce several undesirable side-effects, especially when used for longer duration. GAe is a green alternative to these allopathic preparations. The active ingredients are chemically engineered to retain the anti-inflammatory properties for an extended shelf-life and stability packed in low moisture content. 'Naturecaps' CadalminGAe™ meets the needs of end-users.

content and 82–84% capsaicin content. The dried green chilli pieces were ground and the powder can be stored up to 8–10 months at room temperature (22–30°C) without loss of green colour, nutrients and sensory attributes.

A probiotic drink of cucumber was prepared through lactic acid fermentation using salt (2%) and mustard seeds (0.5%). The ready-to-serve probiotic drink supplemented with capsicum flavour, had TSS 2.4, pH 3.6, acidity 0.2%, tannins 6 mg/100 ml, 10⁶ counts/ml of *Lactobacillus* sp. with a high sensory acceptability.

Spices: Storing nutmeg at 100% vacuum or 100% N₂ was ideal for long-term storage without aflatoxin contamination, insect damage and loss in quality of the produce. Cryo-ground cinnamon powder showed advantage in oil and oleoresin contents compared to conventionally ground sample using pin mill.

Medicinal crops: A rapid and sensitive liquid chromatography/electro spray ionization tandem mass spectrometry (LC/ESI-MS/MS) method was developed for the identification and quantification of three withanolides, namely withaferin A, 12 deoxy withastramonolide and withanolide A, in the extracts of *ashwagandha*. A HPLC-ELSD method was developed for identification and quantification of major saponins in *shatavari* (*Asparagus racemosus*). Extraction of aerial parts of mamejo (*Enicostemma axillare*) with water and methanol at room temperature was found to give maximum yield of swertiamarin.

Tuber crops: In potato, resistant starch content in Kufri Chipsona 1 was 1 mg/100 mg before storage and it increased to 1.4 and 1.3, after 90 days of storage at 4 and 12°C respectively. Foliar spraying of growth retardants (Paclobutrazol and etrel) 4 or 6 weeks before harvesting resulted in mild sprout suppression of tubers up to 90 days of storage in heaps.

Detection of detergent in milk: Synthetic milk is the latest entry in the list of adulterants of milk. Detergents are the essential ingredient of synthetic milk, and it is reported to be used for the adulteration of dairy milk from 5 to 10%. A new test for detection

of anionic detergent in milk (dye-detergent complex extraction method) was developed. The developed rapid colour based method is more sensitive and can provide the results in less than five minutes. The limit of detection of this method is 0.02% labolene in milk. The other common adulterants and preservatives do not interfere in the developed test. The test does not require use of any equipment and the cost of ingredient used for preparation of test reagent is very low.

Polyphenol extract (strawberry) fortified stirred dahi: The low calorie strawberry polyphenol (SBPP) fortified stirred *dahi* had a better flavour and appearance with comparable compositional and physico-chemical parameters (water-holding capacity and viscosity). The acidity of SBPP fortified stirred *dahi* was slightly higher. Antioxidant activity and total phenol content of developed product was significantly higher than control. Sensory analysis indicated that the product was acceptable up to 2 weeks when stored at 7–8°C, with no significant difference in the anti-oxidant activity and total phenolic content.

Miniaturized spore-based assay on biochip for aflatoxin M1 in milk : Biochip-based technology has superior quantum efficiency, signal capturing at a single photon level and minimal background noise. A miniaturized spore-based assay for detection of aflatoxin M1 in milk on functionalized gold chip, was developed. It requires minimal quantity of milk (25 µl) and other reagents (0.5 µl). The new assay had higher sensitivity (0.5 ppb).

Oat- and milk-based probiotic fermented products for type-II diabetes: Oat-based probiotic fermented milk product containing *Lactobacillus rhamnosus* (LGG) was formulated and its effect on type-II diabetes was studied *in vivo* using wistar rats. Type-II diabetic rats showed significant decrease in blood glucose level (36.46–45%), HBA1c, oxidative stress, cholesterol (8.04–13.58%) and triglycerides (18.66–30.38%) level during progression and induction study. Promising results were obtained in progression study. Expression of certain genes like GLUT-4, IRS-2, ppar-γ increased and of TNF-α and IL-6 expression decreased during the study. Oat- and milk-based probiotic fermented products showed the synergistic effect of probiotics and oats especially in progression of type-II diabetes and can be considered as an important dietary defense weapon to fight type-II diabetes.

Traditional meat products in retortable pouches: The technologies for ready-to-eat (RTE) and shelf-stable traditional Indian meat varieties such as curries, *kheena*, soups in transparent and non-transparent flexible retortable pouches were developed with acceptable sensory attributes up to a period of 12 months.

Shelf-life of meat: Super-chilling and vacuum packaging technology for enhancing the quality and shelf-life of buffalo meat steaks was developed. This process improved the shelf-life of fresh buffalo meat steaks up to three months without freezing, thereby significantly reducing the drip loss, labour charges, storage and transportation cost, electricity and space

Success story

CIFT-OPex (oyster peptide extract) developed

An edible oyster (*Crassostrea madrasensis*) peptide-based nutraceutical, OPex was developed. OPex is a 100% natural blend of oyster peptide and oyster protein concentrate that possesses several bioactivities like anti-inflammatory, anti-oxidant and anti-bacterial properties. Oyster peptide extract was prepared using enzymatic method and the same was found to possess antioxidant effect. Also the extract inhibited ascorbate-Fe²⁺-induced *in vitro* lipid peroxidation in rat liver and hydrogen peroxide-induced *in vitro* lipid peroxidation in brain. It is postulated that the active antioxidant peptides preserve the glutathione peroxidase system, recognized for its potent antioxidant capabilities and protect cells from lipid peroxidation and deleterious membrane structure changes.

requirement to meat processors and buffalo meat exporters.

Functional restructured meat products: Restructured mutton chops extended with 5% pea hull flour (hydrated 1 : 1) and 5% boiled and mashed potato were formulated. The product had comparatively high cooked yield (87.02%) and very good appearance, flavour and overall acceptability. Incorporation of 1% tamarind seed powder or flaxseed flour and 0.1% gum tragacanth or 0.5% gum acacia significantly enhanced the binding strength and texture of extended restructured mutton chops. The products remained shelf-stable at refrigerated temperature (4±1°C) for 15 days with sensory ratings between good and very good. *Bael* powder at 1% and *mousambi* peel powder at 0.5% were optimum for fortification of restructured buffalo meat steaks. The fortified products had a refrigerated shelf-life of 20 days with sensory ratings ranging between good and very good.

Products from spent animal's meat: Shelf-stable ready-to-cook meat rings from meat of spent hens containing 10% rice flour were found to be the most acceptable. No marked changes in the quality of product were observed up to 45th day of storage at room temperature. Dry pet food was developed by incorporation of different buffalo offal. The food was prepared with incorporation of offal meals, soya meals and cereal flours by baking at 150°C for one hour. All the variants were fairly acceptable.

Slaughtering and meat processing equipment: Model plan of abattoir suitable for slaughtering 50–100 small ruminants—sheep and goat— under prevailing Indian conditions was designed. Dispositions of various components of abattoir were made to produce wholesome meat. Equipment such as restrainer, stunner and overhead rails were designed to carry out the slaughtering in humane manner and dressing operations in hygienic way. This model is suitable for medium scale entrepreneurs.

Processing of fabric: A protease enzyme-based finishing process was developed which improved the

handle/softness of tweed fabric from Chokla wool to the accepted level. It significantly reduced the fibre shedding property of Angora–Bharat Merino shawls.

Walnut husk and pomegranate rind extracts have anti-moth properties and addition of mordents during dyeing increased the moth resistance properties of the dyed materials.

Drug residues and environmental pollutants: Drug residues in meat and milk were analysed in respect to enrofloxacin. Meat and milk samples of yak were collected from Arunachal Pradesh. A total of 17.4% of collected yak meat showed an average of 4.06 ng/g concentration of enrofloxacin and 21.74% samples were below limit of quantification (LOQ). Average concentration of enrofloxacin in yak milk was 0.871 µg/ml with a range of 0.514–1.442 µg/ml.

Arsenic concentration was determined in urine, feces and wool in yak. The result revealed that arsenic concentration in wool was comparable to cattle hair of contaminated zone of West Bengal, India, whereas arsenic concentration in urine and feces of yak were very low.

Trawl to harvest myctophids in the Arabian sea: Myctophids which get harvested as a bycatch along deep sea shrimp trawlers are generally discarded because of its low sale value. The newly developed post-harvest utilization and value-addition indicated that judiciously utilized myctophids can form a significant source of fish protein and contribute to the nutritional security of the people. A 49.5 m midwater trawl was developed

for sustainable harvesting of myctophids off southwest coast of India in Arabian Sea.

Product development from myctophid: Battered and breaded products were prepared from the myctophid, *Diaphus watasei*, a deep sea resource. The product is acceptable even after 12 months of storage. Specialty products, viz. momo and rolls, were prepared from the cooked mince of *Diaphus watasei* and were rated high on sensory evaluation.

Collagen peptides: Collagen, a group of naturally occurring proteins found in vertebrate animals including fish, has a wide variety of applications in pharmaceutical, cosmetic, and photography industries. Fish-scale collagen peptides were prepared from scales of rohu (*Labeo rohita*) and catla (*Catla catla*). Specific peptides from each hydrolysate were selected and submitted to database. According to online databases, these peptides are present in human, bovine, fish and rat. Acid soluble collagen, pepsin digestible collagen and insoluble collagen were isolated from tuna and rohu skin. Yield of acid soluble collagen from tuna skin was the highest (14%).

Utilization of chromatophores: The chromatophores from squid skins were isolated, and used as natural pigment in lipsticks. Five shades (SQ1, SQ2, SQ3, SQ4 and SQ5) were developed using this pigment and they were screened for consumer acceptance. The new product was found acceptable, and it also met the national quality standards laid down for such category of products.

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