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Post-harvest Management and Value-addition

Thermal disinfestation set-up for pulses: Optimum combinations of temperature-time, vacuum-time and microwave energy-time were determined for chemical-free disinfestation of pulses. Insect mortality of 100% for the pulse beetle could be achieved at the temperature - time combinations of 55°C and 60 s or 60°C and 50s for all the 3 pulses, i.e. greengram, pigeonpea and chickpea. Optimum combinations of vacuum pressure and treatment duration in vacuum treatment of pigeonpea, chickpea, and greengram were 100 mm-Hg and 168 hr, 120 mm-Hg and 360 hr, and 120 mm-Hg and 96 hr, respectively. Optimum microwave exposure time at 700 W microwave exposure was found to be 70, 90 and 100 s for greengram, pigeonpea and chickpea, respectively. Thermal disinfestation equipment developed has a batch capacity of 100 kg. The cost of disinfestation is Rs. 1.10/kg of grain.

Thermal disinfestation set-up for pulses has a batch capacity of 100 kg

Production of full fat soy flour from sprouted soybean: Two varieties of soybean, viz. JS 9305 and MAUS 47 were found superior in nutritional quality. The best time, temperature and humidity combination for germination of these varieties was 3 days at 25°C and 90% RH. Germination improved the nutritional profile by improving solubility of protein, decreasing levels of fat, reducing the trypsin inhibitor levels to 60% and phytic acid levels to 50%. The sprouted soybean was dried to bring down the trypsin inhibitor content to safe levels and the moisture to 6–8% for milling. Sprouting, followed by sun drying is recommended for production of full fat soy flour (FFSF) to be used for incorporation into bakery products due to its superior functional quality. The steamed sprouted soybean, followed by sun drying is ideal for use at the domestic level and microwaving at 630 W for 9 min on a commercial scale for the production of FFSF. Sprouting of soybean, followed by drying leads to production of nutritionally enriched (high protein, low fat, high fibre), anti-nutrient free (safe levels of trypsin inhibitor, low levels of phytic acid), functionally

Aonla dietary fibre-enriched biscuits

Dietary fibre, vitamin C and antioxidant-enriched biscuits were developed by incorporation of *aonla* pomace (a byproduct generated in *aonla* juice processing). The dietary fibre content of the finished product was about 5 times higher than

the control, while vitamin C and antioxidant concentration were 15.6 mg/100g and 0.25 g %, respectively. Biscuits had a shelf-life of more than 3 months when wrapped in 100-gauge polypropylene pouches under ambient conditions.

Ready-to-eat bittergourd chips

Bittergourd chips were prepared and popularized among rural and urban areas as snack foods. The process for manufacturing of bittergourd chips involves cutting of bittergourd to 0.25–0.30 cm thick slices, followed by cooking in 0.1% sodium bicarbonate solution at 100°C for 30–40 min. The cooked bittergourd slices were subjected to osmotic diffusion treatment of 1–2% brine solution at 50–60°C for 2 hr. The osmotically diffused bittergourd slices were dried at 55–60°C for 5–7 hr and fried in refined oil at 160–180°C for 5–7 sec. The fried chips were packed in laminated pouch.

superior (good colour, nitrogen solubility, water absorption capacity) FFSF. Sprouted roasted soybean as a ready-to-eat snack was prepared by roasting sprouts at 180°C for 45 min, followed by addition of spices. The products contained 39% protein, 22% fat and negligible amount of trypsin inhibitor.

HACCP protocols for the production of soy biscuits: Hazard Analysis and Critical Control Points (HACCP) protocols were drafted for the production of soy paneer and soy biscuits. The guidelines included good manufacturing practices, good hygiene practices, and standard operating procedures which are the prerequisites for implementing the HACCP. The expected quality of these products under study were put forth which were experimentally verified with and without HACCP. The data indicate that HACCP yielded better quality soy paneer and soy biscuits. The soy biscuits may be used for theraputic purposes.

SUCCESS STORY

Using palm oil mill effluent

Palm oil mill effluent (POME), a waste released while processing fresh fruit bunches (FFB) in palm oil mills was evaluated for its use in animal and fish feed formulations as organic fertilizer and biogas production. Dehydrated POME could be incorporated in the diets of buffalo calves and buffaloes up to 40 % level, lambs up to 60 % level, kids (goats) up to 50 % level and piglets up to 20 % level. Dried palm oil sludge (POS) can be incorporated in the feed of freshwater fish Rohu as well as ornamental fish Koi- Carp up to 60% and for freswater fish *Catla catla* up to 40%. Inclusion of Palm kernel cake (PKC) in diets of Rohu showed good growth rate with 10% inclusion of PKC. The POME slurry is comparable and even better than cowdung for biogas production. Composite formulation of essential micro-organisms comprising Saccharomyces, Lactobacilli and Rhodopseudomonas improved the quality of POME by reducing BOD and COD to the eco-friendly level.

Similarly, the soy paneer processed through HACCP is of better quality.

Mango: An integrated protocol consisting of pre-harvest fungicidal spray, followed by standardized post-harvest practices and ma packing in semi-permeable d-955 film extended the storage-life of mango Alphonso and Banganapalli to 5 weeks at 8°C.

Papaya: A process was standardized to make osmotically dehydrated papaya slices from Taiwan Red Lady. Slices osmotically dehydrated using 60° Brix syrup containing 0.2% citric acid with additives produced best quality products with one year shelf-life at room temperature. Pre-treatment dip of slices in calcium chloride solution (0.5%) improved textural and sensory quality.

Grape: Minimum loss of weight was recorded in bunches of Tas-A-Ganesh with knot as compared to bunches without knot. The grape juice diluted with soda water up to TSS level of 14° Brix did not affect the acceptance in terms of colour, sweetness and flavour.

Banana: The storage of Ney Poovan banana was standardized at 13.5 °C. A recipe was standardized for preparation of banana flower-based ready-to-make soup powder. Storage method using steeping solution was developed for storage of banana stem for further product preparation or culinary use. The bulk production technique of banana wine was standardized where fermentation at 10 °C took 13 days for total sugars to reach below 1% and alcohol to 15%.

Litchi: The litchi fruits treated with KMS (1%), followed by citric acid dip (2%) and dried alternatively in sun and oven gave good quality litchi nuts.

Mahua: A process was standardized for developing good quality mahua wine by fermenting fresh flower juice with *Saccharomyces cerevisiae*. The wine prepared from fresh flowers had shining light yellow appearance than that made from stored flowers, which turned brown. The burnt rice flavour of mahua was suppressed by using lemon peel. The wine was siphoned, aged and bottled. The final alcohol content in mature wine ranged from 9 to 10%.

Mushroom: The washing treatment of 100 ppm EDTA + 0.02% KMS, followed by packaging in 100-gauge thick polypropylene bags gave superior shelf-life to stored button mushrooms. Blanching of oyster mushroom and milky mushroom for 2 min in 0.2% salt + 0.1% citric acid solution, followed by sun-drying improved the post-harvest shelf-life of both the mushrooms.

Onion: Irradiation of onion bulbs with gamma rays at 60gy reduced sprouting losses as well as total losses. The irradiation helps in reducing total losses by 20% and sprouting losses by 100%.

SUCCESS STORY

Gum technology from *Acacia senegal* in the Thar desert

Acacia senegal (Kumat) is an important source of gum-arabic that finds widespread use in medicines and pharmaceuticals, and is also an important component for paper, textile, adhesive, minerals, fertilizers, explosives, cosmetics, soap, ceramics, food, beverages and confectionary industries. In India, production of gum from *A. senegal* is meagre despite the occurrence of extensive stands of the tree in the dry parts of Rajasthan, Gujarat, Madhya Pradesh and Haryana. Consequently, the country imports annually 5,000 tonnes of the gum, especially from Sudan, costing Rs 7.3 million. The average international price of the Sudanese gum arabic is ~US $ 1,500/tonne.

Considering the market potential of gum arabic, a simple technology that involves administering a gum-inducing solution (ethephon) into the main stem of a tree through a small hole, plugging the hole with cleaned clay paste, and without causing any further injury or cut to the plant. The gum exudation starts within 5-10 days of giving the treatment and may continue for 1 or 2 months. Depending on environmental conditions, the appropriate time for treating the trees in western Rajasthan starts from the last week of February and extends up to May. The physico-chemical characteristics of the exuded gum conform to Pharmacopoeia of India specifications for Indian gum. The cost of the treatment is Rs 10/tree, while the gum production/tree is 500 g (average). The current sale price of the gum is Rs 100-300/kg.

This low-cost, environment-friendly technology is now being propagated through CAZRI's extension wing and the KVKs. The state government agriculture extension department has also started propagating the technology. Due to its immense benefit at no management cost, simple technique, low capital investment, low gestation period, high benefit:cost ratio, employment generation and utilization of existing natural resource, the farmers of western Rajasthan have tremendously responded to its adoption, especially in the districts of Barmer, Jodhpur, Nagaur, Bikaner, Jaipur and Bhilwara. The farmers are not only adopting the technology, but are also demanding to plant more *A. senegal* trees in their field boundaries, and in their community lands.

Widespread application of the gum-inducing technology would not only help the country to meet the domestic demand of gum-arabic and saving precious foreign exchange, but will also open the avenue for international marketing. It is estimated that there is scope for producing 20,000 tonnes of gum arabic for the international market.

Well-cured bulbs of *rabi* season treated can be stored up to 6 months. Genotypical differential response to gamma irradiation was also observed. Light red varieties mostly recommended for *rabi* season responded very well to irradiation than dark red varieties recommended for *kharif* and late *kharif* seasons.

Coconut: A prototype of small-scale fermentation plant was developed to produce virgin coconut oil by fermentation technique. Technology to produce sweet coconut chips, osmotically dehydrated using jaggery syrup and flavoured with natural cardamom, ginger and cumin was developed.

Ginger: Fresh ginger oil was rich in citral, whereas dry ginger contained higher levels of zingiberene, farnesene and sesquiphellandrene.The chief components of *C. sulphuratum* bark oil were identified as linalool and tetradecanal.

Cassava: Graft copolymers of cassava starch with acrylamide were synthesized, which had decreased crystallinity, hard texture and excellent water absorption capacity, film-forming property etc. These properties facilitate an enhanced use of the product in cosmetic and oil-drilling industries.

Functional pasta products (protein, fibre and carotene enriched) were made from cassava flour, incorporating whey protein concentrate (WPC), oat meal and carrot powder, respectively. Besides, functional extruded snack foods having minimum oil content, good puffing and high protein were made by fortifying cassava flour with defatted soy flour, finger millet, coconut residue (after virgin oil extraction etc.).

Skin care products from *Aloe vera*: *Aloe vera*, locally known as *guar patha*, is a traditional medicinal plant and is used as an ingredient in manufacture of several products (both edible and non-edible), including cosmetic ones. The plant is hardy and well adapted to arid region of Rajasthan. Locally the plant is also used as vegetable, but the potential of the plant has not been fully exploited.

Two products for skin care namely, aloe crack cream and aloe moisturizer, which are very useful for different types of skin were developed from *Aloe vera*. Each product has a shelf-life of more than 10 months. Aloe crack cream was found very effective against cracked heels and dry and dehydrated skin. It even stops bleeding from the cracked heels and makes the hard skin smooth within a week, if used properly. Aloe moisturizer is suitable for oily skin and prevents the skin from drying in winter.

Candy and preserve from tumba fruit: Tumba (*Citrullus colocynthis*) is a natural perennial creeper of the desert. The pulp of fruit is used as feed for animals and seed for extraction of non-edible oil used in soap industry. The fresh fruits have 72% pulp containing 0.22% cucurbitacin, besides 26%

oil and 13.5% protein in seeds. It profusely produces fruits (25–30 tonnes/ha). At Jaisalmer, Rajasthan efforts were made to provide value-additions to bitter pulp. Candy and preserve were made successfully which can be used as dessert purpose in confectionary, empty stomach intake lowers acidity and constipation. The preserve costs Rs 15/kg and the candy costs Rs 20/kg. At these prices the benefit : cost ratio for the preserve and candy would be 2 and 1.5, respectively.

Date products: At Jaisalmer, products like *chutney* and toffee have been prepared from unripe and low-quality fruits of date palm or *khajoor*. The date toffee has granular texture with good elasticity, which is liked by children. The date *chutney* has a pleasant aroma.

Solar PV mobile unit: A solar PV mobile unit was designed and developed to provide a complete self-sustained mobile power unit for domestic, small agricultural and other rural applications in isolated cluster of houses (*dhanis*) of arid region. It comprises an especially designed mobile structure to keep 2 PV modules (70 Wp each) facing due south at 26° from horizontal to receive maximum solar radiation and also to provide shade to sub-components. The PV modules are fixed on a folding system with auto locking arrangement, so that these panels can be folded inwards for easy movement of the unit and again opened to place the panels at an optimum angle. The frame of the mobile unit is made of iron angle with 4 wheels at the lower end of the frame (2 on the rear side and 2 on a guiding trapezoidal frame) with an appropriate handle to pull it with ease. Side support is provided to firmly hold a storage battery and electronic sub-systems on a wooden base to ensure intactness of the components during movement of the unit.

The PV array (140 Wp) output is fed to the battery (12 V 120 Ah) through a regulator and a maximum power tracker to charge the battery in an optimum way and then to derive power through an in-built inverter for the working devices that could be operated for illumination, running radio, a small TV in the domestic front. The unit can be used also for operating a churner for butter extraction and for winnowing operation. The utility of this power unit can be extended for other cottage-scale applications.

Production of beetroot powder and its utilization: The total time taken in drying of beetroot after blanching at different temperatures was in the range of 8–13 hr. The recovery of the completely-dried beetroot at different temperatures was in the range of 13.9 – 14.6%. The hammer mill was used for grinding the beetroot for powder. About 60% of the beetroot powder of 65 mesh size can be obtained from properly-dried beetroot. The mean particle size of the beetroot powder was 0.215 mm. The solubility of beetroot powder with different particle size was in the range of 77.3 – 79.9%. Average protein, fat, ash, fibre and total carbohydrates content in beetroot powder was 11.99%, 2.17%, 4.57%, 7.40% and 79.87%, respectively. Acid insoluble ash content in beetroot powder was 0.067%.

Ready-to-serve drink was prepared from beetroot powder with different level of sugar, citric acid and water and evaluated by a panel for different sensory attributes. The overall sensory acceptability of drink was maximum for the sample with 2.6 g citric acid and 225 g sugar/litre of the ready drink. The minimum overall sensory acceptability of the drink was observed for the drink with lowest citric acid and sugar content. Reconstituted drink to get the benefits of beetroot was developed using beetroot powder at 2.5, 3.5 and 4.5% with water and evaluated for different sensory attributes with reference to the fresh beetroot juice. The mean sensory scores for overall acceptability of reconstituted beetroot powder in the form drink at 4.5% level was maximum as compared to fresh juice.

Carrot powder: Carrot was dried after blanching. The total time taken in drying of carrot at different temperatures was in the range of 8–13 hr. The recovery of the completely-dried carrot at different temperatures was in the range of 8.4 – 9.4%. Carrot samples, 2 particle size, viz. 65 mesh size and 100 mesh size were evaluated for solubility at different water temperature (30–90°C) using the water bath. Solubility of the carrot powder of 65 mesh size was in the range of 60.19 – 69.65%. The solubility of carrot powder of 100 mesh size at lower temperature (i.e. 30°C) was slightly higher than the carrot powder of 65 mesh size. Solubility of the carrot powder of 100 mesh size was in the range of 64.25% – 69.8%. Average protein, fat, ash, and fibre content in carrot powder was 6.87%, 2.77%, 8.81%, and 8.38% (d.b.), respectively. Acid insoluble ash content in carrot powder was 0.36%. The carotene content in the carrot powder samples obtained from carrot dried at different temperatures was in the range of 60.47 – 70.82 mg/100g (d.b.).

***Aonla* pricking machine:** An *aonla*-pricking machine was designed and developed which reduces labour cost, maintains uniform pricking depth and improves efficiency and accuracy. It is operated with 1 hp motor and its capacity is 100 kg/hr.

Novel value-added extruded products using apple powder: The extruded product of apple powder was prepared along with rice brokens, wheat grits (*dalia*) and *dhal*. The products obtained were very tasty, crispy, had good appearance and

look like *kukure*. It does not have any sour and hot taste or any particular flavour, because the ingredients in the extruded product are only apple powder, *dalia*, rice, and *dhal* in 15:40:35:10 proportions. Colouring agents and artificial flavours were not added. Product scored 7.7 value during sensory evaluation on 9-point hedonic scale.

Drying of henna leaves using solar energy: Solar dryer took about 12–14 hr to dry henna leaves. The thickness of henna leave was about 0.399 mm and having moisture content of 221.54% d.b. It was found that solar-dried henna leaves retained good quality of green colour. Two-term model with highest R^2 value of 0.99 was found to represent the thin layer drying behaviour of henna leaves in solar dryer. Effective moisture diffusivity of henna leaves ranged from 8.27×10^{-10} to 1.278×10^{-8} m^2/s. The moisture diffusivity increased as drying air temperature was increased. The maximum temperature inside the solar dryer was 52°C and minimum RH was 9%.

Modified atmosphere packaging for okra and betel leaf: Okra, being very delicate should be handled gently after harvest, pre-cooled (hydro-cooled as well as air-cooled) and then stored under modified atmosphere packaging in perforated polypropylene film packages to extend its shelf-life reasonably, to maintain the qualitative parameters and its market quality. Under these conditions, the green colour retention would be substantial as well as no blackening of ridges would be observed for 7 days of storage.

Okra should be stored under ideal temperature range of 10–15°C. Beneficial modified atmospheres containing low O_2 (6–8%) and high CO_2 (11–13%) concentrations can be generated automatically in polypropylene (PP) film packages. To create these modified atmospheres, okra should be packaged (500 g) in the perforated (2 holes; hole diameter: 0.3 mm, normal pinhole) normal polypropylene film packages (bag dimensions: 210 mm × 275 mm; thickness: 35 micron) and then kept for storage at 15°C. Under these conditions, the equilibrium gas concentration is suitable for retention/maintenance of its bright green colour, retention of qualitative parameters and a shelf-life of 7 days without blackening of ridges or excessive weight loss. Also, under these storage conditions, the water vapour production is checked which helps in maintaining the qualitative parameters.

Modified atmosphere (MA) technology was applied at CIPHET, Ludhiana for packaging of betel leaf for retail handling and storage. The pigments and phenolic content of betel leaf can be sufficiently maintained in polypropylene film packages which show the potential of use of MAP for packaging of betel leaf. Betel leaves can be stored for 10 days at 20°C under MAP.

Continuous feed seed removal unit for *aonla:* A continuous feed type *aonla* segmentation unit was developed for removal of seeds from fruit for use by the *aonla* processing industries. The *aonla* fruit to be processed is placed on the rotating indexing assembly having 6 holes. A hole provided at the bottom allows discharge of the seed into the bottom-collecting tray. The process time is regulated by using the control panel assembly and controls the speed of the motor, synchronization of the cutting knife assembly and indexing table.

Continuous feed seed removal unit for use by the *aonla* processing industries

Production of fruit and vegetable-based bars/ confectioneries: Production processes for 5 types of fruit-vegetable bars, papaya-pumpkin, papaya-bottleguard, papaya-brinjal, papaya-cabbage and papaya-cauliflower and candy from *aonla* for pilot-plant scale production of 50 kg/day were developed. The quality of the bars/candies was found good on account of texture, colour, microbial load and consumer acceptance. Establishment of plant for production of 12,500 bars/candies annually may need an investment of Rs10 lakhs. The cost of production will be Rs130/kg.

Production processes for 5 types of fruit and vegetable bars

Large cardamom dryer for NEH region: The dryer installed at Sikkim centre, Gangtok was tested on site. The modified drying equipment

has capacity of 600 kg/batch of fresh (wet) cardamom. The drying temperature of 55–60°C was maintained uniformly in plenum chamber. It took about 12 hr to bring down the moisture content (wb) from 85 to 15%. There was no loss in quality, especially in natural colour of the husk of cardamom, which remained same after drying. The dried product was of A-Grade quality.

Wool: Work on technical felt revealed that non-woven felts from different blends of Bharat Merino wool with rabbit hair, viscose and cigarette fibres in the proportion of 50:50 having different thickness of 2, 4 and 6 mm could be prepared. The felts of less than 4 mm thickness were converted into value-added products like jackets and women ruffles. These products enhanced quality and consumer acceptance due to better lustre, durability and thermal insulation values. These products have great demand and can create employment opportunity in the rural/unorganized sector.

Microspinning of cotton sample: A new machine for lap preparation was developed at CIRCOT that is suitable for opening cotton samples weighing approx. 60–100 g and then converting them into mini laps in about 15 min. The machine has 3 motors, one each for feed, delivery and suction. The Inverter drive for speed control enables quick adjustments of speeds of the working elements. This new device was found to perform satisfactorily with quality output.

Extraction of banana psuedostem fibre and its utilization for preperation of value-added products: Experiments conducted on spinning of banana on jute system revealed that it is possible to produce yarns to tex values matching those for jute. Doubling of banana yarn improved its breaking load, breaking extension and tenacity by more than 50%. Addition of 20% jute in banana fibres also improved the breaking extension and tenacity of the blended yarn. These yarns were converted into plain woven fabric of about 250–400 GSM. This fabric may be useful as upholstery.

Paper produced from banana cut fibres obtained from scutcher waste was noted to have high quality; with the quality improving further with the use of NaOH in pulp preparation. It was observed that paper made from long length textile grade fibres of banana was of much better quality than that obtained by using cut fibres, matching with the quality of currency paper.

Characterization of natural dyes: HPTLC patterns of the extracts from flowers of marigold (3 types), chrysanthemum (2 types) and aster were developed in a solvent system which also facilitated recording of uv-vis spectra of the separated constituents. It could be inferred from the position of spots on the chromatogram and their uv-vis spectra that basic HPTLC pattern of all marigold flowers was similar and it was different from the basic HPTLC pattern of chrysanthemum and aster flowers. Basic HPTLC patterns of both types of chrysanthemum flowers were similar and had a resemblance with a part of HPTLC pattern of aster. Thus, it is inferred that the basic HPTLC pattern can serve as a marker for identification of these flowers.

Dyeing of jute fabric with sulphur dyes: Several sulphur dyes free from banned amines and safe from ecological considerations were used for dyeing of jute fabric and the dyeing process was standardized. The dyes are Ecofast Rubber Brown 31, Ecofast Dark Olive 44, Ecosol Navy Blue IRR, Ecosol Yellow IGCD, Solsul Mandarin Orange ZYY and Solsul Swedish Blue ILW. Evaluation of sulphur-dyed samples reveal that all the above dyes produce good colour yield and fastness properties. Sulphur-dyed jute fabric retains its tensile strength and the handle properties are also improved. Accelerated tendering test of sulphur-dyed jute fabric shows no negative effect.

Ornamental jute fabric: A handloom was designed, developed and fabricated exclusively to be used for jute and other fibres in blends. Shuttle box and sley race were incorporated to run big shuttle. There is no interruption in weaving, as in conventional looms, due to a positive take up arrangement. Cloth roller and cloth beam are inside the loom to hold longer length of fabric. The double beam arrangement facilitates feeding warp yarn of different linear density so that variable warp yarn tension is avoided during weaving and varieties of designs can be made through jacquard shedding.

Bioscouring of jute: To overcome the discrepancies of scouring by alkaline treatment the process of bioscouring was developed. It is a treatment with cellulose/xylanase enzyme and non-ionic surface active agents. The process has been standardized for jute fabric and the bioscoured samples have been found to be far superior to the alkali-scoured samples in respect of optical properties, absorbency, handle property and tensile characters.

Mannual ribboner and improved ribbon retting technology for jute: Technology of accelerated and eco-friendly retting of jute, developed by NIRJAFT, has been accepted by the Ministry of Textiles, Government of India as well as Department of Agriculture, Government of West Bengal for implementation under the Jute Technology Mission programme.

Frontline demonstrations have established consistently that the fibre quality is improved by 2 grades, retting period is shortened by 7–8 days and the requirement of water is reduced from 1:20 to 1:3 (plant:water).

Visual test for detection of adulteration of soymilk in milk: A colour-based test for detection of presence of soymilk in milk was developed, which is based on inhibition of activity of exogenously added enzyme by components of soymilk. Pure milk gives pink colour, whereas adulterated milk shows drastic reduction in the intensity of pink colour, which can be visually distinguished. The test results can be obtained in 50 min. The sensitivity of test is 2.5 to 10%, depending on the methods of preparation of soymilk. Other adulterants such as urea, starch, glucose, sucrose, hydrogen peroxide and formalin do not interfere with the test. The test does not require any expensive equipment and can be applied at quality control laboratories.

Reduction in colour intensity indicates presence of soymilk in milk

Immunological test for detection of adulteration of soymilk in milk: An immuno-diffusion test for detection of adulteration of soymilk in milk was developed. The test has the sensitivity to detect presence of 3% soymilk in adulterated milk. The results are available overnight. The precipitation (antigen-antibody complex) lines are stained for enhancing visibility. An innovative step in test was added to allow flow of milk micellar proteins in agarose gel during diffusion. The test does not require any expensive equipment and can be applied at quality control laboratories.

Technology for the manufacture of *Kradi*: *Kradi* (semisoft cheese), hitherto undocumented traditional dairy product of Jammu and Kashmir, is consumed either as a fried spiced item or a culinary dish. A process was standardized for its manufacture. The product was better than market samples on sensory evaluation. The vacuum packed product had a shelf-life of 15 to 20 days at 25°C, 3.5 to 4 months at 5°C and more than 6 months at –20°C. The developed technology could be commercially utilized for large-scale manufacture of this product.

Quarg type cheese from buffalo milk: Quarg is essentially a milk protein paste, manufactured by acid coagulation of milk by proper bacterial cultures with a small rennet addition for better separation of the protein coagulum from the whey. A process was developed for its manufacture from buffalo milk. Quarg cheese is of high nutritional value due to high concentration of proteins. It is excellent carrier for probiotic micro-organisms.


Buffalo milk quarg cheese

***Khoa* from low fat milk:** An integrated three-stage thin film scraped surface heat exchanger (SSHE) was designed and fabricated. Its performance was evaluated to manufacture *khoa* using low fat milk having 2, 3 and 4% fat. Yield is 50kg/hr *khoa* with buffalo milk (6% fat) and was enhanced to 120 kg/hr, if milk is pre-concentrated to 30%. It can run with buffalo milk and cow milk with any fat level. This method is hygienic and sanitation-friendly.

Meat and meat products technology

- Technology for the production of functional mutton nuggets was evolved.
- Identified optimum handling practices, new tenderization techniques and product formulations for efficient utilization of sheep and goat meat.
- The assessment of quality and safety of meat spread revealed that the product could be safely stored up to 60 days at refrigerated and 6 months at frozen temperature.
- **Sensory evaluation of mutton nuggets:** Mutton nuggets with low salt, low fat and high dietary fibre had very good acceptability on scientific evaluation.
- **Sensory evaluation of chicken soup:** The overall acceptability of premium chicken soup, with low salt and traces of fat was evaluated as 'very good' on scientific evaluation.
- **Assessment of the impact of technologies generated by IVRI:** Impact assessment of Olinall skin ointment, IVRI crystoscope and area-specific mineral mixture was done by collecting data from dealers, field veterinarians and farmers from Uttar Pradesh and Uttarakhand. The respondents considered the technologies as very useful.

Benefits of larger weight broilers: Broilers of relatively lower live weight are being produced in the country. Yield of deboned meat from primal cuts (leg, breast, and wing drummets) could be increased by 74.49 g, 36.34 g and 27.98 g,

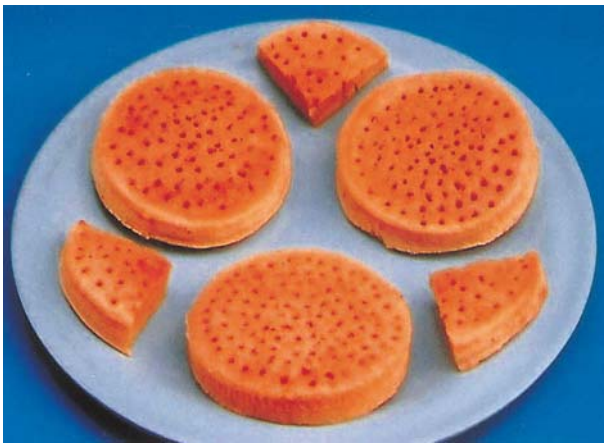
Whey-based oral rehydrating solution

The possible use of *Lactobacilli* with whey and its electrolyte for the therapy against diarrhoea was explored. Sodium, potassium, calcium and chloride contents are significantly present in higher concentration in paneer whey, the largest byproduct of dairy industry. The *Lactobacillus casei* 299 proved to be the most acid tolerant–surviving after 3 hr at pH 1.5. The highest bile tolerance was observed in NCDC 11 and NCDC 291 at 2% up to 12 hr. NCDC 17 and NCDC 299 showed maximum inhibitory zone against five diarrhoea-causing pathogens. Cell surface hydrophobicity was maximum in MTCC 1408 (77.10%), NCDC 299 (70.60%), followed by *L. paracasei* 17 (66.05%). All *Lactobacilli* strains were resistant to co-trimoxazole, metronidazole and vancomycin but sensitive to teteracycline and chloramphenicol. In simulated gastric and pancreatic juice, whey protects the cell from reaching the death by increasing the overall pH and inhibiting digestive protease activity. NCDC 17 and NCDC 299 grew faster in whey within 24 hr. The minimum residual lactose was observed for *L. paracasei* NCDC 17 (3.6mg/ml). Only NCDC 17 could suppress the growth of *Salmonella* in 24 hr of fermentation. Cell-free supernatant (whey) of NCDC 17 and NCDC 299 results in maximum reduction in viability of *Salmonella* within 8 hr of incubation.

Whey was fermented at 37°C for 24 hr with best selected probiotic culture (NCDC 17 and NCDC 299), and glucose supplement and base supplements were added along with orange flavour (food grade) after the fermentation was over. Fermented whey oral rehydrating solution (ORS) was sustainable at 4°C for 30 days. Small intestine showed the disruption of villi, oedema and increased PMNs during diarrhoeal infection. Fermented whey ORS treatment decreased intra-and-inter villi oedema and reduced villi disruption. Anti-*Salmonella* and anti-*Shigella* antibodies were secreted after drinking fermented whey ORS, which was effective in displacing pathogens. Findings indicated that whey is the best milk-based medium where fermentation with probiotic bacteria can enhance its therapeutic capability. A vacuum dried Bio-ORS was prepared by using whey as base and a standardized method for the formulation.

respectively, when broilers were grown from low to heavy, low to medium and medium to heavy weight, respectively. Cost of protein production was 26.86% less in heavy weight broilers compared to low weight. Heavy weight broilers also facilitate development of processed meat sector with higher yields of special cuts like chicken tenders. Thus, producing broilers of heavier weights has indicated benefits of producing primal cuts, deboned meat and valuable protein at lower cost to benefit the producers and consumers.

Shelf-stable meat products: ***Chicken dried meat:*** Technologies to prepare dried meat were developed. It is not only a value-added variety product but the technology is also useful when chicken prices are low due to poor demand.



Egg waffles

Chicken meat pickle: Technology was developed for preparing chicken meat pickle utilizing cooked meat from deboned frames, a byproduct of poultry processing industries. It is a value-added product and shelf stable for about 5 months.

Value-added egg product: Egg waffle, a nutritious and versatile snack food perfect for the breakfast meal, has good market potential, particularly at growing fast food outlets. Standardized processing methodology was developed. Egg waffles contain 13.72% protein, 12.53% fat and 34.1% moisture with low aerobic bacteria and yeast and mould counts (log 1.4–1.9 cfu/g, respectively) and complete absence of coliforms and staphylococci. Egg waffles, in vacuum, indicated an ambient (24±1°C) shelf-life of 4 days, and in aerobic packaging 3 days as against 10 and 6 days in respective packs at refrigeration temperature (4±1°C) with acceptable sensory and satisfactory microbiological quality. The cost of formulating one kg of processed ready-to-eat egg waffles was Rs 73.85 and of one cooked egg waffle weighing about 45g was estimated to be Rs 3.32.

Maricream: Maricream, essentially a ready-to-eat and highly nutritious product containing deodorized fish protein, is a mix of water, cooked cuttlefish, meat, sugar, butter, egg white, flavouring substances, stabilizers and emulsifiers. Cephalopods other than cuttlefish can also be used for maricream preparation. One important difference with other desserts is that the protein component is provided from a marine source. The product packed in plastic containers (food grade polypropylene), is frozen at –20°C and stored at –15°C. The product may be transported in insulated boxes under cold chain conditions.

Fish-enriched noodles: Fish-enriched noodles

were prepared to improve the nutritional value (protein, calcium and phosphorous) and taste of the market noodles. Shelf-life of dried fish noodles is 4 months at room temperature, and it could be a popular fast food item considering its nutritional and organoleptic qualities.

- Sandwich paste was prepared from Sciaenid fish and fortified with EPA and DHA in retortable pouch
- Fish curry prepared from freshwater fish tilapia (*Oreochromis mossambicus*) in retortable pouch

Improved lobster traps: Improved standard lobster traps were fabricated under the collaborative project Participatory Management and Conservation of Lobster Resources along the South West Coast of India (MPEDA, CMFRI and CIFT), and these traps were distributed to fishermen of Kadiyaptnam and Enyam fishing villages of Kanyakumari.

Solar dryer with LPG back-up: A fish drying system was developed using solar energy. Fish can be dried continuously by harnessing solar energy and using LPG back-up system to obtain a good quality product, with reduced drying time, without insect damage or contamination, and longer shelf-life. The dryer could also be used for fish, fruits, vegetables, spices and agroproducts.

Status of lac production, marketing and processing: Chhattisgarh and Jharkhand together produce two-thirds of the total lac production in the country. The total lac production during 2007–08 was estimated to be 20.6 m.kg. The other major lac producing states are Madhya Pradesh, West Bengal, Maharastra, Gujarat and Andhra Pradesh. A total of 29.8 m.kg. lac was processed during 2007–08. The import and export of lac was about 7.3 m.kg. each during the period.

Genetic diversity in Indian lac insects: Forty-eight lac insect lines, of the above collection were analyzed through RAPD markers. The RAPD profiles could clearly discriminate the lines and was used to develop a dendrogram based on Jaccard's similarity co-efficient and UPGMA method. The similarity co-efficient calculated was 0.34-0.92, suggesting the existence of a wide genetic diversity between the lines. The clustering analysis from RAPD data revealed 6 distinct clusters. Twenty lac insect lines were analyzed through ISSR markers which showed a similarity co-efficient range of 0.25–0.81, demonstrating a wide genetic variation of the lac insect lines studied. The clustering analysis from the ISSR data could group the 20 lac insect lines into 4 major clusters. The RAPD and ISSR markers were also employed to differentiate between 8 wild type (crimson) and yellow colour mutant of lac insect populations, each in a pair-wise fashion. Besides characterization, the above study has helped in understanding the genetic diversity in the lac insect lines and their phylogenetic relationship.

Physico-chemical parameters of lac from different countries

Seedlac of various countries	Major physico-chemical parameters			
	Colour	Flow (mm)	Life (min)	Bleach index
Indian	9	54	61	80
Thai	18	20	46	140
Chinese	20	20	44	140
Indonesian	16	16	60	110

Technologies assigned for commercial transfer

- A latex agglutination test for detection of Newcastle disease (NRDC)
- Swine fever virus cell culture vaccine (NRDC)
- Fusion protein and nucleotide as *Brucella* vaccine (BCIL)

Pilot plant of aleuritic acid: A pilot plant of aleuritic acid (capacity: 2 kg/batch) was set-up at Processing and Demonstration Unit of IINRG, Ranchi for training, demonstration and process refinement. Aleuritic acid (9, 10, 16-Trihydroxy-hexadecanoic acid), a major constituent acid of lac resin is present to an extent of 35%. It is a white powder moderately soluble in hot water and completely soluble in the lower alcohols such as methyl, ethyl and isopropyl alcohols. Most of the present production of aleuritic acid is exported. The market price for bleached aleuritic acid is about 1,000–1,200/kg.

Pilot plant for preparation of pure lac dye: A pilot plant for preparation of pure grade lac dye was set-up for training, demonstration and process refinement at IINRG, Ranchi. Natural pure lac dye represents a more sustainable source of colourants compared to synthetic counterparts. Natural colourants are used widely in food and beverage industry. The yield of pure lac dye was about 0.25% on the weight of sticklac, with purity of more than 99%. The dye gave a deep orange-red colour in aqueous solution.

The dye content was 70–71% and ash content 0.71–1.10%, respectively. The melting point was 230–238°C and soluble in cold water.

Transfer of technology: Training of lac cultivation, processing and uses was provided. A total of 161 courses were conducted benefiting some 10,643 people.

Entrepreneurship training was provided on the preparation of aleuritic acid, bleached lac, isoamberlite and processing of lac.