



वार्षिक प्रतिवेदन **ANNUAL REPORT**

PRODUCE

PROCESS

PROSPER

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भारत अनुप
ICAR

केन्द्रीय कटाई-उपरांत इन्जीनियरिंग एवं प्रौद्योगिकी संस्थान
CENTRAL INSTITUTE OF POST HARVEST ENGINEERING & TECHNOLOGY
LUDHIANA

PREFACE

The Institute made good progress in research and extension activities during the period 2008-2009. Research and extension activities were accelerated through in-house and externally funded projects. The research projects covered the areas of value addition of food grains, oilseeds, spices, fruits and vegetables, storage of fruits and vegetables, environment control of cattle and poultry, development of tools and equipments for pomegranate and other crops, non destructive techniques of quality determination, micro encapsulation of micro-organisms and diversified value added products from meat.


The research outputs were protein enriched ready-to-eat extruded snacks, beetroot powder incorporated defatted soy-flour fortified biscuits, roasting and popping unit for makhana, CIPHET-pomegranate aril extractor, blade tenderizer for meat, ready to constitute mustard saag, system for micro encapsulation of probiotics and foam mat drying of kinnow juice. Standardization of packaging systems for guava, sapota, royal delicious apples, baby corn, broccoli and capsicum shreds was done. Effect of by-products such as pomegranate rind powder, kinnow rind powder and pomegranate seed powder was studied on storage of goat meat.

Physico-chemical and microbiological quality of the fresh and stored mango samples of cultivars, Banganapalli, Dasherri and Langra were evaluated for development of non-destructive system for quality evaluation. Performance evaluation of hand tool for easy separation of arils from pomegranate and CIPHET-pomegranate aril extractor was conducted on prominent cultivars of the fruit. Fungal cultures *Trichoderma reesei* and *Aspergillus niger* were isolated and screened for cellulose production and their filter paper activity was measured. Work on environmental control for poultry and cattle was initiated in collaboration with Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana.

Patent on process for de-hulling guar seeds for refined guar split production, process for preparing ready to reconstitute mustard (*Brassica juncea*) Saag, CIPHET-pomegranate aril extractor, method for developing porous bricks, novel process of vermi- drain (a liquid plant growth tonic), low cost firmness tester for fruits and vegetables, new process for milling of coarse cereals and millets to get refined powder, were filed during the year 2008-09. Nineteen EDP's were conducted and more than 250 farmers / entrepreneurs were trained on various aspects of post harvest technology. CIPHET Banana comb cutter was licensed to M/s National Agro Industries Ludhiana. Consultancy on refining of soybean oil and extraction of soybean lecithin was provided to M/s Khyati Foods Pvt. Ltd., Bhopal. A good number of research papers were published. The scientists of the institute participated in various conferences, meetings and workshops.

The AICRP on post harvest technology and application of plastics in agriculture have developed many useful technologies.

We thankfully acknowledge constant encouragement of Dr. Mangala Rai, Secretary DARE and DG (ICAR) and Sh. A.K. Upadhyay, Special Secretary DARE and Secretary ICAR for the cause of post harvest management and value addition. I acknowledge with thanks the support and co-operation extended by Dr M. M. Pandey, DDG (Engg.), Dr Nawab Ali, ex-DDG (Engg.), Dr Pitam Chandra, ADG (PE) and Dr S. K. Tandon, ADG (Engg.), ICAR New Delhi. The help rendered by Drs S. K. Nanda, PC (PHT), P. R. Bhatnagar, PC (APA), K. K. Singh, R. K. Gupta, S. N. Jha, R. K. Goyal, D. Dhingra, Sh Tej Ram, Sh Vijay Kumar, Sh J S Paul, all scientific, administrative, technical and supporting staff at CIPHET in institute activities and preparation of this report is highly appreciated.



R T Patil
Director, CIPHET

EXECUTIVE SUMMARY

The Institute made good progress in research and extension activities during the reported period of 2008-2009. Research and extension activities were accelerated through in house and externally funded projects. The research projects covered the areas of value addition of food grains, oilseeds, spices, fruits and vegetables, storage of fruits and vegetables, environment control of cattle and poultry houses, development of tools and equipments for pomegranate and other crops, non-destructive techniques for quality determination diversified value added products from meat, and micro-encapsulation of micro-organisms. Seven patent applications were filed. Transfer of technologies was done through licensing of technologies, publications, presentations and training of entrepreneurs and farmers.

Protein enriched ready-to-eat extrudates from selected de-hulled legumes (black gram, green gram, lentil and peas) blended with rice, maize, wheat, sorghum and finger millets were made using low cost collet extruder. Acceptable low cost expanded snacks were obtained by blending of legumes up to 15%.

Beetroot powder incorporated defatted soy flour fortified biscuits were prepared. Beetroot powder was used up to 10 % and the level of defatted soy flour was kept 5 % in all the recipes. Physical, chemical and sensory attributes of the samples were analyzed. Overall acceptability of biscuits prepared with various levels of beetroot powder and ascorbic acid was observed to be better.

A roasting and popping unit for processing *makhana* has been developed. The popping and de-humidification efficiency was observed to be 25 and 65 % respectively and the modification to improve the efficiency are in progress. Ready to serve *makhana* cracker mix was developed and its storage and sensory attributes were studied.

Fruit growth of rainy season and winter season guava was evaluated. Winter season guava was observed to have higher acidity, soluble solids and vitamin C content as compared to rainy season guava. External fruit color was observed to be a reliable harvest index. Effect of shrink and seal

packaging on shelf life and biochemical composition of guava and mango was studied. Shrink wrapped individual guava fruits were observed to be better in quality after storage for 9 days. Seal packing of individual mangoes was observed to be effective in comparison to shrink wrapping and cling wrapping during short term storage under ambient and low temperature conditions.

Shelf life of sapota fruit was evaluated by shrink wrapping, cling wrapping and seal packing in different plastic films. Shrink wrapping resulted in maximum shelf life under different conditions.

The performance of the hand tool for easy separation of arils from pomegranate was evaluated on five prominent cultivars of the fruit. The aril separation efficiency was observed to be in the range of 30 - 45 %. The rest of the arils became loose and could be easily removed by finger tips.

CIPHET- Pomegranate Aril Extractor has been developed for extraction of arils from fruits of any size, shape and variety of pomegranates. The capacity of the machine was observed to be 500 kg/h with an extraction efficiency of 90-94 %.

Raisins like pills were prepared from the pulp of 'Perlette' grapes. After juice extraction, the remaining mass was converted into fine pulp. The pulp was concentrated and additives were added to produce raisin like product.

Studies on packaging of Royal Delicious apples for enhancing their quality and shelf- life were conducted. Shrink wrapping and zip-lock envelop packaged apples were observed to be better in terms of weight loss, firmness and color in comparison to unpacked fruits (control).

Physico-chemical characteristics of soybean milk whey were analyzed. The whey was used to prepare ready-to-serve (RTS) beverages from guava, mango and pineapple. Soybean milk whey could be used up to 30 % by weight in the beverages to impart the benefit of soy phyto-chemicals to the drink.

Ready to constitute mustard 'Saag' was developed. The moisture content of the dried

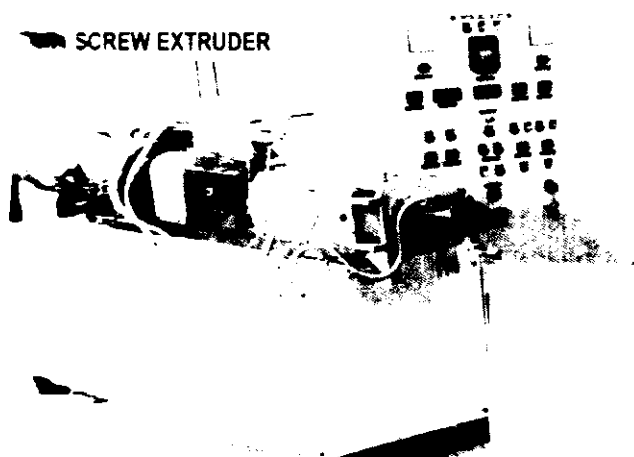
RESEARCH ACHIEVEMENTS

A. FOOD GRAINS & OIL SEEDS PROCESSING

Development of formulated foods through extrusion technique

Dr. S. S. Chakrabarti, Dr. S. K. Ghosh and Dr. S. K. Ghosh

Different combinations of least cost composite blends were prepared with linear programming technique in accordance to RDA. The least cost formulation of composite flour consisting of bajra, maize and dehulled soybean was extruded in cooking twin screw extruder (Fig.1). Response surface methodology was used to evaluate the effect of independent variables, viz., feed rate (6.5, 9.5, 11.5 and 13.5 kg/h) and screw speed (200, 250, 300 and 350 rpm) on product responses viz. physical properties (expansion index, sectional expansion index, specific length and density), colour properties (Hunter colour values L, a, b and ΔE), functional properties (water absorption index and water solubility index), textural properties (hardness, moisture and breaking strength) and rheological properties (peak viscosity, breakdown viscosity, setback viscosity and final viscosity). Best fit polynomial equations were obtained to describe the effects of each variable on product responses.



Development of technology for health foods from legumes and millets using food extrusion system

Dr. S. S. Chakrabarti, Dr. S. K. Ghosh and Dr. S. K. Ghosh

Different protein enriched ready-to-eat extrudates from selected dehulled legumes (black gram, green gram, lentil and peas) blended with rice, maize, wheat, sorghum and finger millet were made using low cost collet extruder, keeping constant feed rate (25 kg/h) and feed moisture (14 % wb) at different legumes incorporation levels (0, 5, 10 and 15 %). The extrudates were subjected to physical, textural, colour, rheological, functional, nutritional and sensory evaluations. Expansion index, sectional expansion index, bulk density, true density of extrudates was found to be in the range of 4.00-3.17, 16.00-10.03, 0.79×10^4 to 0.622×10^4 , and 1.39×10^4 to 1.052×10^4 . Expansion index and sectional expansion index showed a decreasing trend with bulk density and true density for every increase of legumes incorporation level. Textural properties viz., hardness, puncture force, breaking force and breaking strength were found to be in the range of 22.22-65.71 g, 5.95-27.46 g, 15.87-25.32 g and 0.079 to 0.181 g/mm². Hunter colour 'L' value of extrudates made of rice alone showed higher value (80.63) following decreasing trend with different legumes incorporation levels. 'a' and 'b'-value of rice extrudate was lower (1.82 and 11.66) and showed a slight increasing trend with legumes incorporation levels. Water absorption index and water solubility index of rice extrudates were found to be in the range of 429-675 % and 20.2 to 25.2 %, respectively. Rheological properties of porridge made of extrudate flour were evaluated using Rapid Visco Analyser. Maximum and minimum peak viscosity for rice extrudates alone and rice extrudates blended with 15% peas were 697 cP and 523 cP, respectively. There is a decreasing trend with increase in legume incorporation level. Other RVA rheological

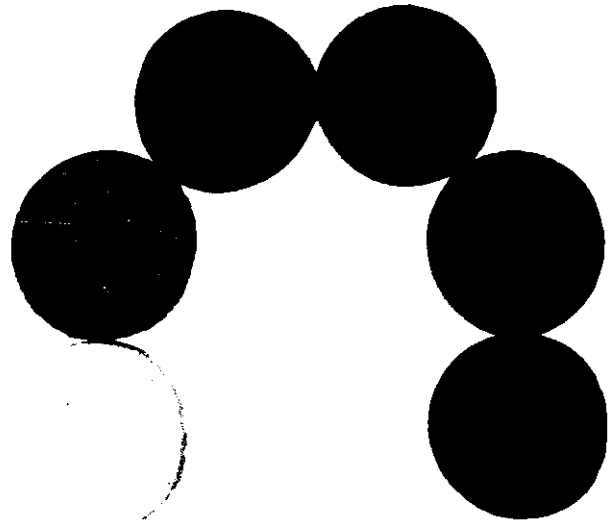
parameters viz., break down and final viscosity were observed to be in the range of 266 - 226, 431 - 297 and 452 - 375 cP. Maximum values of protein, fat, fibre and ash contents were observed for rice extrudates at 15 % legumes blend levels, lentil (11.5%), all legumes (1.03%), peas (0.50%) and green gram (0.98%), respectively. It showed an increasing trend with the increase in legume blends in rice extrudates. Degree of gelatinization for extrudates made with rice alone was 29.4 % and showed a decreasing trend with increase in legumes and observed minimum (22.4 %) for rice blended with 15 % dehulled green gram. Sensory evaluation scores for all extrudates showed the most liking range (6 to 8). Sensory evaluation scores for the extrudates were observed to be in the range of 6 - 8 for all extrudates. In this study, an incorporation level (up to 15 %) of dehulled legumes fetched good scores except black gram addition, because of its inherent characteristics. Thus, legume blend level (up to 15%) of dehulled legumes fetched good scores and shows a promising trend for the production of low cost expanded snacks and instant flour.

Processing and utilization of beetroot and carrot for value addition in health foods

Development and evaluation of beetroot powder incorporated defatted soya flour fortified biscuits

Defatted soy flour fortified biscuits were prepared using different levels of beetroot powder (0, 2, 4, 6, 8, 10 %) only, beetroot powder with egg, and beetroot powder with ascorbic acid, and evaluated for its physical properties (Table 1) and sensory characteristics (Table 2). Expansion in diameter and thickness of biscuits decreased with increased levels of beetroot powder in all three types of biscuits. Hardness and breaking strength were observed to increase with increased levels of beetroot powder in all three types of biscuit samples but addition of egg or ascorbic acid did not show any significant difference in both of these properties. Redness (a* value) of biscuits increased while lightness (L* value) decreased with increased levels of beetroot

powder in all three types of biscuits. Redness of biscuits with beetroot powder and egg, and beetroot powder and ascorbic acid was on par and higher than the biscuits with beetroot powder only. The protein content in beetroot powder was on par with wheat flour, hence the addition of different levels of beetroot powder did not affect the total protein content of biscuit samples. The protein content in biscuits with egg was higher than the other two types of biscuits because of the additional protein from the



egg. Similar trend was observed for fat content in all three types of biscuit samples. Addition of beetroot powder increased the ash and total dietary fibre content significantly in all three types of biscuits. This brought the slight reduction in total carbohydrates and total calories with increased levels of beetroot powder in biscuit samples. Although all three types of biscuits were accepted on sensory evaluation but the mean sensory scores for overall acceptability for biscuits prepared with various levels of beetroot powder and ascorbic acid were more than that of other two types of biscuits. This indicated the commercial scope for manufacturing good quality vegetarian biscuits with beetroot powder and ascorbic acid. Beetroot based different biscuit samples are presented in Fig. 2.

Table 1 Effect of beetroot powder on proximate composition of different biscuit samples

Proportion of WF: DSF: BP in biscuits	Moisture	Protein	Fat	Ash	Dietary fibre	Total carbohydrates#	Total calories (kcal)
With beetroot powder only							
5:5:0	3.54	8.34	21.11	0.63	0.48	65.90	486.79
3:5:2	3.45	8.34	21.08	0.77	0.66	65.69	485.54
1:5:4	3.57	8.33	21.11	0.81	0.85	65.32	484.56
9:5:6	3.55	8.41	21.12	1.01	0.92	64.99	483.84
7:5:8	3.58	8.33	21.12	1.07	1.07	64.82	482.82
5:5:10	3.50	8.32	21.11	1.14	1.18	64.75	482.74
With beetroot powder and egg							
5:5:0	3.44	8.69	22.88	0.62	0.43	63.93	494.86
3:5:2	3.34	8.60	22.80	0.74	0.62	63.89	493.67
1:5:4	3.50	8.64	22.87	0.82	0.76	63.40	494.05
9:5:6	3.40	8.59	22.91	1.01	0.86	63.22	493.48
7:5:8	3.45	8.64	23.26	1.05	0.93	62.67	493.09
5:5:10	3.64	8.63	22.81	1.12	1.06	62.73	489.41
With beetroot powder and ascorbic acid							
5:5:0	3.43	8.36	21.19	0.63	0.46	65.92	487.89
3:5:2	3.78	8.32	21.16	0.74	0.66	65.33	485.12
1:5:4	3.47	8.31	21.17	0.82	0.86	65.37	484.96
9:5:6	3.64	8.30	21.14	1.06	0.91	64.95	483.30
7:5:8	3.58	8.28	21.19	1.08	1.07	64.79	483.07
5:5:10	3.44	8.31	21.16	1.15	1.17	64.76	482.66
F value							
WBP	0.14 ^{ns}	0.68 ^{ns}	1.54 ^{ns}	239.60 ^{***}	318256 ^{***}	10275 ^{***}	183.96 ^{***}
Treatments	3.06 ^{ns}	183.66 ^{**}	788.21 ^{***}	0.90 ^{ns}	21009.2 ^{***}	10911 ^{***}	10911 ^{***}
WBP+Treatments	2.83 ^{ns}	* 1.13 ^{ns}	1.11 ^{ns}	0.34 ^{ns}	1168.58 ^{***}	2644.02 ^{***}	1.0 ^{ns}
CD (0.05)							
WBP	0.12	0.05	0.15	0.037	0.0013	0.004	1.49
Treatments	0.08	0.04	0.11	0.027	0.0009	0.003	1.06
WBP+Treatments	0.20	0.09	0.26	0.065	0.002	0.007	2.59
CV%	3.23	0.67	0.72	4.37	0.16	0.01	0.33

WF Refined wheat flour
 DSF : Defatted soy flour
 BP : Beetroot powder

B. HORTICULTURAL CROPS PROCESSING

Ecofriendly storage techniques for improving the post harvest physiology of mango and guava

Ramesh Kumar, A. K. Thakur and R. K. Gupta

i) Ripening changes during fruit growth and development of guava

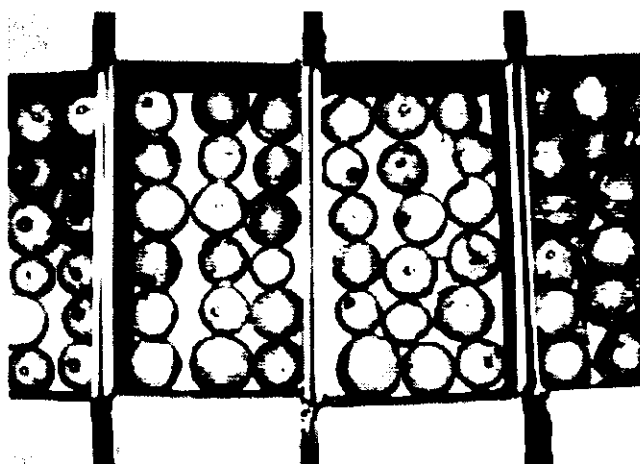
The changes in physical and chemical parameters were determined for both rainy and winter season guava. Fruit growth showed double sigmoid pattern during both the seasons. Acidity decreased during fruit development while vitamin C and soluble solid content increased during the last stage of fruit growth. It was also observed that winter season guava had more acidity, soluble solid and vitamin C content as compared to rainy season guava (Table 1). Based on various physico-chemical parameters, external fruit colour was found to be a reliable harvest index. Mature green fruit could be

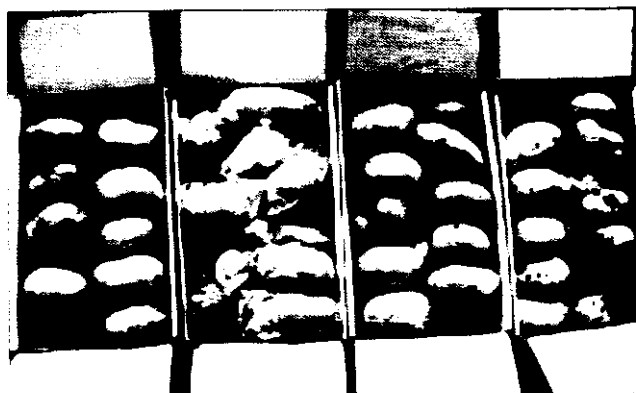
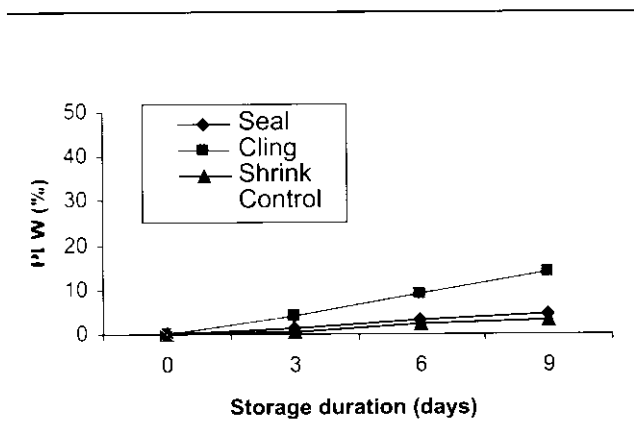
harvested with L, a and b values of 62.7, -5.43 and 25.65, respectively. These values correspond to the fruits with yellowish green external colour and marketability.

ii) Post harvest quality of rainy season guava wrapped in different plastic films

An experiment was conducted on individual fruit packaging of guava. The fruits were harvested at mature ripe stage and wrapped individually in heat shrinkable, stretchable and LDPE film with unwrapped fruits served as control (Fig. 1). Both shrink and seal packing considerably reduced the weight loss, however, seal pack resulted in maximum decay loss due to condensation of moisture inside the loose pack. Unwrapped fruits lost about 40 % of their weight by 9th day of storage (Fig. 2). Colour retention was found to be slightly better in

Harvest stage	TSS (°Brix)	Acidity (%)	Vitamin C (mg/100)
Green immature	8.0	0.68	165
Mature green	9.2	0.59	186
Yellowish green	10.5	0.51	228
Greenish yellow	11.25	0.48	215
Mature yellow	11.75	0.42	219

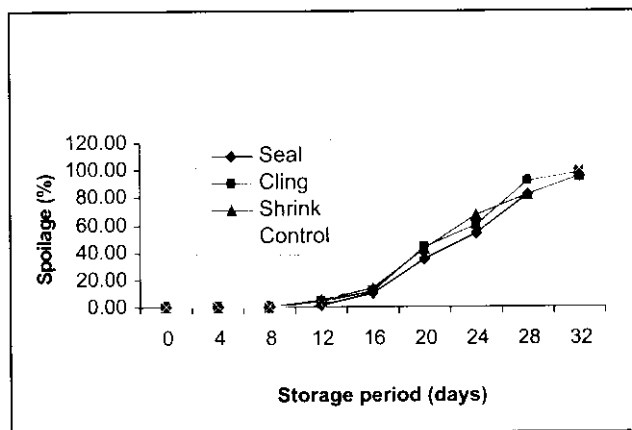




Among different methods of individual fruit packaging, seal pack was most effective in reducing the weight loss and thereby maintaining the freshness for longer period. Low temperature storage reduced both weight loss and decay loss. No decay was reported upto 8th day of storage and thereafter it increased with the increase in the duration of storage with least being observed in seal packed fruit. As far as change in visual color is concerned, it became greenish yellow at the end of storage period irrespective of packaging treatment.

ii) Effect of storage condition and individual seal packaging on mango

Fruits of mango variety *Chausa* were collected from orchard and wrapped individually as shrink-wrap, seal-pack, and cling-wrap for studying their storage life under ambient and low temperature conditions (Fig. 3). Shrink-wrapping was performed in hot tunnel while cling and seal packing were done manually. The results indicated that PLW increased with the increase in the storage period. Unwrapped mango lost 22 % of their weight and became shriveled after 4 days of ambient storage (Fig. 4). Among different methods of individual fruit packaging, seal pack was most effective in reducing the weight loss and thereby maintaining the freshness for longer period. Low temperature storage reduced both weight loss and decay loss. No decay was reported upto 8th day of storage and thereafter it increased with the increase in the duration of storage with least being observed in seal packed fruit. As far as change in visual color is concerned, it became greenish yellow at the end of storage period irrespective of packaging treatment.



iv) Biochemical changes during storage of Mango

The biochemical changes during storage of mango under ambient and low temperature conditions were studied. The results showed that the fruits maintained under low temperature condition remained fresh for 16 days. Moisture loss during storage hastened the shrinkage of fruit skin and loss of brightness in mango indicating a correlation between colour change and weight loss. Maximum firmness was recorded in seal packed fruit. Soluble solid content of the fruit increased from 18°Brix to 21°Brix at the end of three week storage. Unwrapped fruits recorded the highest TSS/acid ratio during the entire storage period, while least was recorded in shrink wrapped fruits. Both acidity and Vitamin C

decreased with the duration of storage in all packed fruit including control. This decrease was noticed more in case of individual packed fruit as compared to unwrapped fruits.

v) Modern packaging of sapota

Shelf life of sapota fruit was evaluated by modern techniques like shrink-wrap, cling-wrap and seal pack in different plastic films. Shrink and seal packaging were most effective in controlling the weight loss (Table 2). The wrapped fruits were found to be firmer than control fruits. Individual fruit packaging also reduced the problems of decay by preventing secondary infection and it was easy to discard the spoiled fruit which in turn extended the shelf-life. Among different methods, cling wrap was

to replace machinery required for shrink packaging and thereby minimizing the packaging cost.

Development of hand tool for easy separation of arils from pomegranate

A. K. Thakur, R. T. Patil, D. B. Singh and R. K. Gupta

The hand tool for easy separation of arils was tested for its performance evaluation on different varieties of pomegranate. The physical characteristics of the fruits and the separation efficiency of the hand tool on respective varieties are presented in the Table 3. Pomegranate fruit has to be held between the pair of holders, and these are turned by hand in opposite direction of each other. Due to rotating action of the holders, fruit breaks into two irregular halves as a simultaneous effect of tension

Storage duration (days)	Packaging treatment					
	Control	SL	CL	HS	LL	ML
0	0.00	0.00	0.00	0.00	0.00	0.00
2	6.68	0.51	4.13	0.34	0.33	0.33
4	15.38	1.43	9.98	1.21	1.12	1.37
6	24.32	2.14	15.10	1.68	1.54	2.10
8	27.93	2.45	16.93	1.92	1.69	2.37
10	31.92	2.98	18.95	2.29	2.10	3.00
12	37.24	2.89	9.20	2.48	3.10	3.39

least effective in preventing the decay but had a considerable effect in extending the shelf life by one week over its unwrapped control fruits. Shrink-wrap packaging was found to be most effective in maintaining the firmness. Shrink wrapped fruits could be stored for 14 days under ambient condition with acceptable fruit quality as against only two weeks of unwrapped ones. TSS and acidity increased during storage. Maximum retention of nutrients was observed in cling wrapped fruits followed by shrink wrapped fruits. Shrink wrapping resulted in maximum shelf-life under both the conditions. However, cling wrap packaging could be an answer



with twist on the peel. During this action the whole fruit experiences a shearing effect; and due to this effect the arils become loose which provides an opportunity of easy separation. The aril separation was found in between 30-45 % depending upon the varieties of the pomegranate fruit. The separation efficiency was higher in case of fresh fruit in comparison to the stored fruit of about a month. However the difference was not much. The rest of the arils become loose and could be further easily removed by the finger tips. This tool facilitates easy separation of arils from the whole pomegranate fruit without any damage to arils. The performance testing of the hand tool is shown in Fig. 5.

CIPHET-Pomegranate aril extractor (motorized version) for industrial use

S. Thakur, R. L. Patil, D. B. Singh and R. K. Gupta

Processing of pomegranate provides an opportunity to create new and innovative market for

fresh arils (juice-enclosed seeds), dried arils, juices and wines; and health and pharmaceutical products. The "CIPHET-Pomegranate Aril Extractor" (Fig. 6) relates to a mechanical and continuous system for processing of whole pomegranate of any size, shape and variety; and for recovery of clean, whole and undamaged arils. The system comprises pomegranate fruit breaking unit, drive unit, collection trays (where separated arils and extraneous matters are received), vibrating sieve unit; and the clean arils and extraneous matter collection troughs. The fruit breaking unit consists of a pair of innovative cone frustums with knives arrangement to continuously break the fruit in such a way that the major portion (85-90%) of arils is safely separated out (Fig. 7). During operation, the knives in the cone frustums act over only peel surface of the Pomegranate. The rest of the arils (about 10-15%) remain attached with the broken peels and are further separated over the vibrating screen. The machine is

Parameters	Cultivar				
	Mridula	Ganesh	Sinduri	G137	W. Muscut
Major axis dia (L), mm	73.34 ± 3.81	76.43 ± 2.82	78.67 ± 1.77	80.68 ± 6.25	85.76 ± 3.67
Minor axis dia (W), mm	70.23 ± 2.51	73.60 ± 3.12	76.95 ± 3.12	77.01 ± 6.58	83.07 ± 4.30
Axis normal to major and minor (T), mm	66.29 ± 2.69	72.19 ± 3.35	76.37 ± 2.96	74.93 ± 5.71	82.05 ± 5.21
Weight of fruit, g	198.50 ± 24.74	242.60 ± 49.27	251.92 ± 11.25	269.04 ± 47.13	333.05 ± 43.1
Peel thickness, mm	2.97 ± 0.13	3.76 ± 0.27	3.86 ± 0.48	3.48 ± 0.44	3.12 ± 0.18
Rag thickness, mm	0.15 ± 0.04	0.23 ± 0.03	0.27 ± 0.02	0.22 ± 0.02	0.25 ± 0.02
Aril. %	66.42 ± 3.27	62.28 ± 4.37	56.70 ± 4.48	61.97 ± 2.93	60.0 ± 1.66
Size (Geometric mean dia, D _p), mm	69.88 ± 2.71	74.05 ± 2.98	77.32 ± 2.52	77.48 ± 5.78	83.61 ± 4.29
Sphericity	0.953 ± 0.017	0.969 ± 0.016	1.00	0.96 ± 0.039	0.97 ± 0.02
Volume of fruit, cc	178.75	212.70	242.14	243.64	306.0
Density, g/cc	1.11	1.14	1.04	—	—
Aril separation efficiency by hand tool, by weight	35.6 ± 4.25	32.5 ± 2.84	40.0 ± 6.86	30.1 ± 3.66	32.0 ± 2.81
Aril separation efficiency by hand tool, by no. arils	36.4 ± 2.32	35.0 ± 3.15	31.32 ± 5.66	32.1 ± 3.09	33.11 ± 4.04



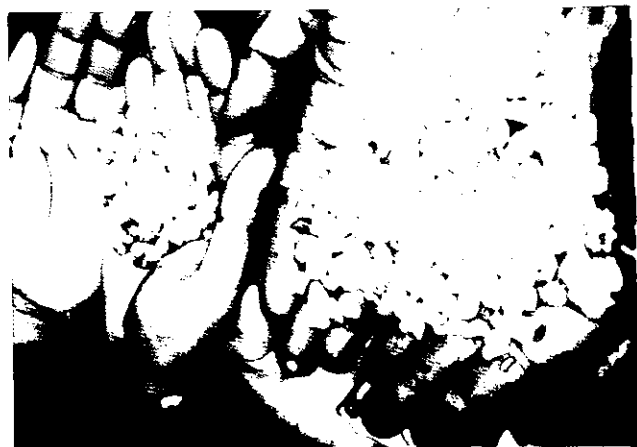
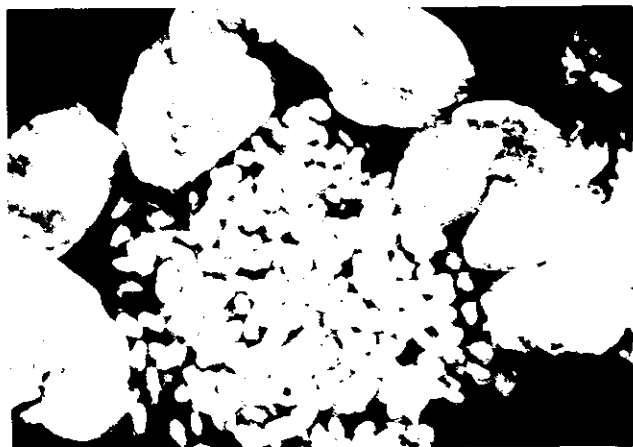
capable to process the whole pomegranate at a rate of approximately 5.0 q per hour with extraction capacity of 90-94 % and with little damage of arils that is about 1-2 %. The invented machine called "CI-PHET-Pomegranate Aril Extractor" is based on a novel working principle.

The main advantages of this novel machine are :

- The pomegranate breaking and aril's separation mechanism is highly efficient with minimum damage and waste.
- Continuous operation for rapid processing of large quantities in any shape, size and variety of the pomegranate.
- Peels and other extraneous matter are separated out, yielding clean arils that can be used for further processing or for eating fresh.

The technical specifications of the machine are :

- Aril extraction capacity 5.0 quintal per hour (approximately 35-40 fruits per minute)
- Aril extraction separation efficiency: 90-94 %



(depending on variety and Pomegranate characteristics)

- Mechanical damage of arils is only 1-2%.
- Man power required for safe and smooth running of "CI-PHET-Pomegranate Aril Extractor" is 2-3 persons
- Electrical power required- 0.75 kW (1.0hp)
- Overall size of machine : Length-1480 mm, Width-660 mm, Height-1710 mm.
- Weight: 250 kg.

C. AGRICULTURAL STRUCTURES AND ENVIRONMENTAL CONTROL

Development of cooling systems for comfort and enhanced production of dairy cow

S. K. Singh
 Director, ICAR-CIPHET

CIPHET has initiated a project on comfort of cattle in collaboration with GADVASU. Two evaporative cooling systems i.e. fan-fogger and fan-pad cooling systems were designed and fabricated for cooling the cattle shelters in the dairy farms of the Department of Animal Breeding and Genetics, GADVASU. The cattle shelters (Fig. 1) at GADVASU are partially enclosed. The size of each shelter is 50 x 6 m with an open arena on one side and a feeding line on the other side and is called loose housing system.

The fan-fogger system (Fig. 2) consists of air circulator fans (size 36") mounted on the side walls of the shelters. Five fogger nozzles (0.5 mm size, 45 psi, 50° spray angle) are mounted on a copper ring,

and fitted in front of the fan. The fans provide airflow of around 700 m³/min and are tilted downwards at an angle of 20-30°. The ring containing the foggers is connected through a pump (by a high-pressure pipe) to the water tank. When the cooling system is turned on, the fans are run continuously. An adjustable timer with ng on the ambient conditions. Water is forced through the fogger nozzles in the form of fine mist, which is blown across the shelter by the fan. The evaporation of water which is in the form of fine mist results in cooling. The entrances to the shelter have been covered by tarpaulins to preserve the microclimate in the shelter.

The fan and pad cooling system (Fig. 3) consists of two coolers containing 36" 700 rpm exhaust fans and pads. The pads are made of cellulose paper housed in a G.I casing with a water distributor through a P.V.C header. The water collecting tank is made of G.I and has a rugged construction. The



intricately woven cellulose pads provide necessary water to air contact to achieve high efficiency in cooling. The feeding side and the entrance side of the shelter have been covered with net and tarpaulin to prevent solar radiation input and the cold air from escaping the shelter.

The daily temperature and humidity in the shelters for cows at GADVASU was recorded and temperature and humidity index (THI) was calculated. THI is commonly used for evaluating heat stress in animals. It is known from review that precautionary measures need to be taken to reduce heat stress conditions in the shelters, when the THI values reach 75-78. The temperature, relative humidity and THI were observed to be in the range of 29.8 - 32.1°C, 66.3 - 75.3 % and 80.6 - 84.9 respectively. The values of THI during July to September revealed that the cows were under heat stress in these months.

Application of modified atmosphere packaging and storage of fresh vegetables

Deepak Raj Rai and S.N. Jha

a) Package headspace dynamics for baby corn under modified atmosphere packaging with macro-perforations

Baby corn is highly perishable and requires appropriate post-harvest technologies to extend its shelf-life and maintain the nutritional content. One of such technologies, viz. modified atmosphere packaging (MAP) (Fig. 4) can be suitably adapted for this purpose. However, selection and application of appropriate MAP; among its non-perforated, macro-perforated or micro-perforated modes requires repetitive experimentation to arrive at suitable desired in-pack partial pressures of O₂ and CO₂. Micro-perforated MAP is an expensive proposition and so far has limited commercial applicability, except for high value commodities; therefore macro-perforated MAP is being tried to

affect higher gaseous diffusion across the film packages. Predictive modelling represents a physical phenomenon by means of mathematical equations; whose numerical solution can fairly predict transient and steady state parameters in a dynamic system and can avoid the need of repetitive experimentation. However, representation of the respiratory behaviour of a crop is also of utmost importance as wrong selection or very straight forward assumptions can lead to wrong predictions. In this study, the respiratory behaviour and associated inhibition by CO₂ as per established enzyme kinetics theory was first assessed with in the temperature range of 5-15°C for baby corn; which was then used to model-predict the in-pack partial pressures of O₂ and CO₂ at 10 and 15°C; in non-perforated and macro-perforated polypropylene (PP) film packages; utilizing baby corn, polymeric film package and the storage environment parameters as input. Model validation during actual storage at 10 and 15°C indicated that the model-predicted or simulated in-pack partial pressures of O₂ and CO₂ agreed fairly well with the experimental observations; which indicated the appropriateness of the evaluated respiratory behaviour and the associated inhibition of O₂ consumption rate of baby corn by headspace CO₂.

The in-pack headspace partial pressures of O₂ and CO₂ inside the macro-perforated film packages containing baby corn depends upon the interaction of baby corn respiration and the diffusion of respiratory gases; through the permeable film packages and the macro-perforations contained in them. The transient-state in-pack O₂ and CO₂ partial pressures in a macro-perforated modified atmosphere system can be predicted with the help of following ordinary differential equations; by performing mass balance on produce-package system:

$$\frac{dP_{O_2}}{dt} = \left[\left[\left(n_p D_{O_2} + \frac{P_{O_2} A_p}{T_p} \right) (P_{O_2}^{out} - P_{O_2}^{in}) - R_{O_2} W \right] \frac{P_t}{V} \right]$$

$$\frac{dP_{CO_2}}{dt} = \left[\left[\left(n_p D_{CO_2} + \frac{P_{CO_2} A_p}{T_p} \right) (P_{CO_2}^{in} - P_{CO_2}^{out}) + R_{CO_2} W \right] \frac{P_t}{V} \right]$$

where, P_{O_2} and P_{CO_2} are the permeability coefficients of the polymeric film (PP, in this case) for O_2 and CO_2 , respectively in $ml\ m\ m^{-2}\ h^{-1}\ kPa^{-1}$; $P_{O_2}^{out}$ and $P_{O_2}^{in}$ are the outside and the in-pack partial pressures of O_2 , respectively, in kPa; $P_{CO_2}^{out}$ and $P_{CO_2}^{in}$ are the outside and in-pack partial pressures of CO_2 , respectively, in kPa; A_p is the total surface area of the film package in m^2 ; T_p is the thickness of the polymeric film in m; n_p is number of macro-perforations; D_{O_2} and D_{CO_2} are the effective permeabilities of a macro-perforation for O_2 and CO_2 , respectively in $ml\ h^{-1}\ kPa^{-1}$; R_{O_2} and R_{CO_2} are the rates of O_2 consumption and CO_2 evolution of the baby corn, respectively, in $ml\ kg^{-1}\ h^{-1}$; W is the weight of the baby corn inside the film package in kg; P_t is the total pressure inside the film package (normal atmospheric pressure, 101.325 kPa); V is the void volume of the film package in ml.

The O_2 consumption rate (R_{O_2}) as inhibited by CO_2 both in competitive and uncompetitive way as per enzyme kinetics was evaluated as per the following relationship:

$$R_{O_2} = \frac{V_{m_{O_2}} P_{O_2}^{in}}{K_{m_{O_2}} \left(1 + \frac{P_{CO_2}^{in}}{K_{m_{CO_2}}} \right) + P_{O_2}^{in} \left(1 + \frac{P_{CO_2}^{in}}{K_{mu_{CO_2}}} \right)}$$

where, $V_{m_{O_2}}$ is the maximum oxygen consumption rate in $ml\ kg^{-1}\ h^{-1}$; $K_{m_{O_2}}$ is Michaelis-Menten constant for oxygen consumption, in kPa; $K_{m_{CO_2}}$ is the Michaelis-Menten constant for competitive inhibition of O_2 consumption by CO_2 , in kPa; $K_{mu_{CO_2}}$ is Michaelis - Menten constant for

uncompetitive inhibition of O_2 consumption by CO_2 , in kPa.

R_{CO_2} was calculated using the experimentally observed values of respiratory quotient i.e. ratio between CO_2 evolution and O_2 consumption (R_q) and the O_2 consumption rate as per following:

$$R_{CO_2} = R_q \times R_{O_2}$$

4.2.2.2. Estimation of R_{O_2} and R_{CO_2}

The O_2 consumption rate parameters; along with the parameters of type of CO_2 inhibition ($V_{m_{O_2}}$, $K_{m_{O_2}}$, $K_{m_{CO_2}}$ and $K_{mu_{CO_2}}$) were estimated using the closed system technique for measurement of respiration. The respiration rates of baby corn were calculated at any instant of time:

$$R_{O_2} = \frac{V_v (y_{O_2}^i - y_{O_2}^f)}{(t^f - t^i) 100 W_b}$$

$$R_{CO_2} = \frac{V_v (y_{CO_2}^i - y_{CO_2}^f)}{(t^f - t^i) 100 W_b}$$

where, $y_{O_2}^i$, $y_{O_2}^f$, $y_{CO_2}^i$ and $y_{CO_2}^f$ are the initial and the final concentrations of O_2 and CO_2 inside the glass container, respectively; V_v is void volume of the container in ml; W_b is the weight of baby corn in glass container, in kg; t^i and t^f are the initial and the final times of observation, respectively, in h. The respiration rates and the gaseous concentrations converted in to partial pressures of O_2 and CO_2 were subsequently used to estimate the enzyme kinetics model parameters. Non linear regression analysis was carried out using the measured values of R_{O_2} , $P_{O_2}^{in}$ and $P_{CO_2}^{in}$ to establish the type of inhibition by CO_2 and to estimate the associated parameters for O_2 consumption [$V_{m_{O_2}}$, $K_{m_{O_2}}$, $K_{m_{CO_2}}$] for baby corn. Solution to theoretical model

Equations were solved numerically, using the classical fourth order Runge-Kutta method. The solution was programmed in Fortran 77 utilizing Force 2.08 software; to predict the transient-state

in-pack partial pressures of O_2 and CO_2 for perforated and non-perforated polypropylene (PP) film packages containing a known weight of baby corn stored under MA.

The transient state partial pressures of O_2 and CO_2 for non-perforated and differentially macro-perforated PP film packages containing baby corn were predicted using the developed computer programme. The evaluated values of the respiration rate parameters of the baby corn as per competitive inhibition by CO_2 , weight of the baby corn, respiratory quotient, package and film parameters (thickness, surface area of package, permeability coefficients for O_2 and CO_2 , effective permeability through macro-perforations, void volume of package), the initial in-pack and the environmental partial pressures of O_2 and CO_2 served as the input.

The partial pressures for O_2 and CO_2 in the storage environment were also taken as 21.16 and 0.03, respectively, as it comprised of normal air only. The appropriate step-size for the time interval selected for the simulation studies was taken as one hour for the entire simulation storage period of 120 h.

Package headspace O_2 and CO_2 dynamics; as predicted by the numerical solution were verified through actual experimentation. Freshly harvested baby corn were pre-cooled and equilibrated at the respective experimental temperatures of 10 or 15°C and 75% RH for two hours. Prior to packaging, the baby corn were sorted according to their size, appearance and diameter. Good quality baby corn having almost uniform length (110 ± 10 mm) were selected for experimentation. Damaged, extremely small or large (diameter of the central cross section < 15 mm or > 25 mm) pieces were rejected. Polymeric (PP) film packages (0, 1 or 2 perforations on package body) having film thickness of 20 μ m and overall package area of 0.06 m^2 were taken up for validation purposes. The packages were filled with

0.25 kg of baby corn and were stored for 120 hours in an environmental chamber maintained at respective storage temperature (10 or 15°C) and fixed RH of 75%, in triplicate. Measurements for the headspace gaseous environment, during the entire storage period were carried out after 12, 24, 48, 72 and 120 hours of storage under MAP.

The headspaces partial pressures ($p_{O_2}^{in}$ and $p_{CO_2}^{in}$) inside the containers containing baby corn for the temperature range studied (5-15°C) are shown in Fig. 5. It is evident that as the time progressed, the $p_{O_2}^{in}$ kept on decreasing, due to consumption of headspace O_2 by the baby corn. Whereas, during the same interval, $p_{CO_2}^{in}$ increased. While, a very little change in $p_{O_2}^{in}$ and $p_{CO_2}^{in}$ was observed with the change in the environmental temperature from 5 to 10°C, the decrease in $p_{O_2}^{in}$ and the corresponding increase in the $p_{CO_2}^{in}$ was observed to be sharper at 15°C which was indicative of the effect of increase in temperature, hereafter. Moreover, $p_{O_2}^{in}$ and $p_{CO_2}^{in}$ steadied with in approximately 2 h; under all the temperatures used in this study.

The calculated values of rates of oxygen consumption (R_{O_2}) and carbon dioxide evolution (R_{CO_2}) with in the temperature range studied: are plotted in Fig. 6. At 5°C; R_{O_2} largely remained unresponsive to the experimental time and the steady state level of the same was observed to be 41 $ml\ kg^{-1}\ h^{-1}$; due to the predominant effect of low temperature. On the other hand, at 10 and 15°C, the R_{O_2} values remained relatively higher initially; mainly due to the initial experimental environmental and respiration adjustment at higher temperature. However, as the time progressed, these kept on decreasing before arriving to constant levels. The steady state R_{O_2} values at 10 and 15°C were observed to be 52.23 and 96.32 $ml\ kg^{-1}\ h^{-1}$, respectively (Fig. 6). At 5 and 10°C; R_{CO_2} values remained largely at low levels and were also found to be insignificant and different. Our previous observations and experience with such type of situations in this case and w

different other crops such as okra, spinach and betel leaf etc. during subsequent storage at such temperatures have indicated substantial in-pack water vapour production as compared to the storage at or beyond 15°C, which indicates that at such temperatures, water vapour production rate plays a predominant role. While R_{CO_2} arrived at steady state levels of 22.26 and 25.54 ml kg⁻¹ h⁻¹ at 5 and 10°C, respectively; they stabilized around 63 ml kg⁻¹ h⁻¹ at 15°C. As compared to both 5 and 10°C; at 15°C, a significant increase in the R_{CO_2} at 95% confidence level with p-values < 0.05 was purely indicative of the dependence of R_{CO_2} upon the elevated temperature of the storage environment.

It was observed (Figs. 7 to 9) that as the value of $K_{m_{O_2}}$ tends to +∞ at all the temperatures used in this study: the uncompetitive part becomes zero which clearly indicated that the baby corn exhibited predominantly competitive type of inhibition during its respiration at all the temperatures studied. and in such cases, the is governed by:

$$r = \frac{V_{m_{O_2}} P_{O_2}^{in}}{K_{m_{O_2}} \left(1 + \frac{P_{CO_2}^{in}}{K_{m_{CO_2}}} \right) + P_{O_2}^{in}}$$

As seen in (Figs. 10 to 12) and (Figs. 13 to 15); the model-predicted and the experimental partial pressures were in fairly agreement with each other for 0, 1 and 2 macro-perforations. For non-perforated MAP (0 perforation), the headspace O₂ attained anaerobic levels within 24 h of storage (Figs. 10 and 15), while the CO₂ settled at around 5 kPa. The initial increase in the CO₂ levels observed at both the temperatures could be attributed to rapid consumption of headspace O₂ and accumulation of CO₂. However, as the storage period progressed, CO₂ diffused out of the packages and equilibrated; as the headspace O₂ still remained at anaerobic levels. The

results for non-perforated MAP indicated that the packaging material could not suffice the high respiratory requirement of baby corn and was not permeable enough to cause the required higher gaseous diffusion of both O₂ and CO₂ across the film packages which led to development of undesired anaerobic conditions. This indicated the inherent danger in packaging and storing the baby corn in the non-perforated packages and also supported our approach of using perforated MAP for baby corn. The results on macro-perforated MAP; both at 10 and 15°C (Figs. 11, 12, 13, 14) showed the effectiveness of the macro-perforations, as additional influx and outflux of O₂ and CO₂, respectively started through the perforations. This effect was observed to be cumulative as the number of perforations increased from 1 to 2. While at 10°C, the headspace O₂ and CO₂ equilibrated to 12.3 and 4.4 kPa, respectively for 1 macro-perforation, it settled around 14.9 and 3.2 kPa, respectively for 2 macro-perforations. On the other hand, at 15°C, the equilibrated levels of headspace O₂ and CO₂ were seen to 5.1 and 9.7 kPa, respectively for 1 macro-perforation; and 9.4 and 7.4 kPa, respectively for 2 macro-perforations. High partial pressures of O₂ under macro-perforated treatments at 10°C can be attributed to the relatively lower rate of headspace O₂ consumption by baby corn and thus, its successive accumulation in the package, leading to establishment of such gaseous equilibrium. However, this type of headspace O₂ is not generally recommended for MAP as it may prove to be detrimental for various physico-chemical constituents of the crop. On the other hand, at 15°C; O₂ consumption responded to the rise in temperature and partial pressures of headspace O₂ dropped. These results indicated the utility of macro-perforated MAP as on the one hand, anaerobic conditions could be prevented by means of macro-perforations; the ideal headspace partial pressures of O₂ and CO₂ required for a particular crop vis a vis the storage temperature can also be attained by computer simulation through variation in different variables such as weight of crop, package size, number of macro-perforations etc.

D. TRANSFER OF TECHNOLOGY

Field Demonstration on Food Processing under Farmers Participatory Action Research Programme

RK Gupta, Mukund Narayan, VK Saharan and Jitender Singh

Under this project demonstration of food processing, polyhouses and plastic mulching was approved for four dis-advantaged districts namely Hoshiarpur (Punjab), Karauli (Rajasthan), Champawati (Uttanchal) and Chamba (HP). The project is funded by Central Water Commission, Ministry of Water Resources, GOI, New Delhi. The demonstration of food processing and plastic mulching was conducted in Hoshiarpur (Punjab) and Karauli (Rajasthan) districts.

Field Demonstration on Plastic Mulching Technology in Hoshiarpur (Punjab)

The demonstration of plastic mulching was conducted in Adimpur Mohatia and Changarwa villages of Talwara Block under Dasua Tehsil of the district. The total population of these villages is 500-600 and 2500-3000 respectively. Cultivated area of Adimpur Mohatia and Changarwa is 600 ha and 1250 ha respectively. In these villages, majority of

farmers have small holdings. Field demonstration on Plastic Mulching Technology to conserve the moisture was carried out in two selected farmers of each village (Table 1)

Field Demonstration on Food Processing in Karauli District of Rajasthan

The Badurpur, Khera and Mannauj (Todabhim) villages are situated in Karauli district of Southern and Eastern part of Rajasthan. The total population of these villages was 200-250, 2500-3000 and 2000-2500, respectively. The cultivated area of these villages is 600, 1500 and 1250 ha respectively and majority of land holdings are small. The main occupation of people is not agriculture due to lack of agricultural resources (irrigation water and infertile land). Root level survey was done and village profile was prepared and contacted the Women Shelf Help Group (WSHG). This group is governed by CDPO, Karauli. This WSHG was not much aware about food processing activities, hence, Food Processing Demonstrations were arranged. These demonstrations were conducted with the cooperation of KVK, Karauli. The details regarding participation and products demonstrated are presented in Table 2. The demonstrations are depicted in Figs. 1 to 3.

Table 1 Field demonstration of plastic mulching

Sr. No.	Farmers Name	Village Name	Crops in which mulching was done
1.	Sh.Gauri Shanker s/o Sh. Joginder Singh	Adimpur Mohatia	Cauliflower
2.	Sh. Gurubachan Singh	Adimpur Mohatia	Cauliflower
3.	Sh. Brijmohan Sing s/o Sh. Yaduvir Singh	Changarwa	Tomato
4.	Sh. Gurdial Singh s/o Sh. Jagat Ram	Changarwa	Mango

Sr. No.	Name of the village	Tehsil	No. of Participants	Products prepared
1.	Badurpur	Hindaun city	52	Jam (Mixed), tomato sauce, lemon, pomegranate and mango squash and lemon pickles
2.	Khera	Hindaun city	67	Jam (Mixed), tomato sauce, lemon, pomegranate and mango squash and lemon pickles
3.	Mannauj	Todabhim	74	Jam (Mixed), tomato sauce, lemon, pomegranate and mango squash and lemon pickles



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