



SAARC

Postharvest Management in Agriculture

SAARC Bibliographical Database



SAARC Agricultural Information Centre

Postharvest Management in Agriculture **SAARC Bibliographical Database**

A S Chandel and R M Kamal



SAARC Agricultural Information Centre (SAIC)

SAARC Agricultural Information Centre (SAIC)
BARC Complex, Farmgate, Dhaka 1215, Bangladesh

Published : 1995

Cover design : Mafruha Begum

Price : US\$ 5.00 for SAARC countries
US\$ 8.00 for other countries

Chandel, A S and Kamal, R M

Postharvest Management in Agriculture: SAARC bibliographical database.

Dhaka: SAARC Agricultural Information Centre, 1995.

ii, 231, xxxv p.

1. Postharvest technology, bibliography. 2. SAARC Agricultural Information Centre. i. Jt. Author.
ii. Title.

Published by : Director, SAARC Agricultural Information Centre (SAIC)

Printed at : Panir Printers, 9 Nilkhet, Dhaka 1205

CONTENTS

<i>Preface</i>	i
<i>Introduction</i>	ii
POSTHARVEST EQUIPMENTS	1
PACKING MATERIALS	14
AGRICULTURAL PRODUCE	25
CEREAL GRAINS	27
WHEAT	31
SORGHUM	35
MAIZE	36
BARLEY	38
MILLETS	38
RICE	39
SOYBEANS	60
VIGNA	62
LENTILS	66
STARCH CROPS	66
CASSAVAS	68
TOBACCO	70
COFFEE AND TEA	71
GARLICS	72
GINGERS	73
TURMERIC	75
SPICES	76
OILS	77
FRUITS	78
APPLES	83
PEARS	89
APRICOTS	90
PEACHES	91
PLUMS	92
PRUNUS DOMESTICA	94
CHERRIES	94
LITCHI CHINENSIS	94
CITRUS	95
ORANGES	97
KINNOWS	98
LEMONS	101

GUAVAS	102
SAPOTA	105
MANGOES	107
NUTS	115
COCONUTS	116
DATES	117
POMEGRANATES	118
PAPAYAS	118
JACKFRUITS	119
AEGLE MARMELOS	120
AMLA	121
BERRIES	121
BANANAS	122
PINEAPPLES	126
ZIZIPHUS MAURITIANA	126
GRAPES	128
VEGETABLES	133
CARROTS	136
POTATOES	138
ONIONS	144
CAULIFLOWERS	151
TOMATOES	151
BRINJALS	156
PEAS	157
GROUNDNUTS	159
MUSHROOMS	162
OTHER VEGETABLES	163
FLORICULTURE	164
DAIRY SCIENCE	166
FOOD TECHNOLOGY	191
JUICES	205
WINE AND BEVERAGES	211
SEED TECHNOLOGY	213

Term Index

i

Author Index

xvi

FRUITS

Preservation

563 ROY, SK; JAIN, AP; VILASACHANDRAN, T. 1982. Cryogenic freezing and answer to preservation of colour, flavour and texture sensitive fruits. *The 8th National Symposium on Cryogenics*. (NPL, New Delhi: 1982: 27-29 Jan).

564 VIJAY, S. 1989. Appropriate low cost technology for preservation of fruits and vegetables. *Training for the nominees of BARC, Dhaka in the field of management of research station farm*. Madacor, Philippines under World Bank founded project held at Division of Agronomy, IARI, New Delhi.

565 VIJAY, S. 1994. Low cost technology for preservation of fruits and vegetables. *Research Bulletin*, Division of Fruits and Horticultural Technology, IARI, New Delhi-110012.

566 VIJAY, S. 1989. Preservation of fruits and vegetables by chemical additives. Trainers training course on low cost preservation of fruits and vegetables, held on september 4-6th, 1989. Training manual, PHT Division of Fruits and Horticultural Technology, IARI, New Delhi-12. p. 99-102.

567 VIJAY, S. 1990. Prospects of indigenous fruits and vegetables for preserve industry. *Proceedings of National Seminar on Production, Processing, Marketing and Export of Fruits and Vegetables*. (IARI, New Delhi: 1990: 7th April).

Postharvest handling

568 BABB, T; PETERS, CW [et al.]. 1982. Project identification study of fruit and vegetable production and marketing in the Northwest Frontier Province of Pakistan. *GTS Report, Post Harvest Institute for Perishables, University of Idaho*, No. 82-04, 32 p.

The report examines the agronomic features of the Province's agricultural system, as well as its transport, credit, marketing, and input facilities and current output. Constraints to agricultural development and the potential for growth in the fruit and vegetable industry are assessed. A project to help the Province's newly created Fruit and Vegetable Development Board implement fruit and vegetable production and marketing activities is proposed, and a work plan for a project design team is described, along with the expertise re-

quired by members of the team and the key issues facing it. Discussion is briefly given to the need for a comprehensive water resources study if similar efforts are to succeed in Baluchistan Province. Appendices include a strategy for improving vegetable yields in the Northwest Frontier Province; a report on the potential for tree fruit production; a report on Baluchistan Province's Quetta region; a marketing report on fruit and vegetables in Pakistan; and bibliography.

569 BRUINSMA, J; GEELLEN, TAM; KNEGT, E; VARGA, A; VERMEER, E. 1990. Post-harvest development of climacteric fruit. *Proceedings of the International Congress of Plant Physiology*. V. 2. (New Delhi: 1988: 15-20 February)/edited by SK Sinha; PV Sane; SC Bhargava; PK Agrawal. New Delhi: Society for Plant Physiology and Biochemistry, p. 1385-1391; 20 ref.

The postharvest quality and longevity of fruits is largely determined by the onset and rate of ripening. Ways in which ripening processes can be studied are discussed. Preclimacteric respiration, the regulation of autocatalytic ethylene production and the role of polygalacturonase isoenzymes in fruit softening are examined with reference to a range of climacteric fruits but principally to tomatoes, *Annona muricata* and mangoes.

570 CHOPRA, SK. 1991. Recent advances in the understanding of gene expression in ripening fruit - a review. *Agricultural Reviews*, 12: 2, 55-65; 79 ref.

The subject is reviewed, particularly concerning the study of polygalacturonase synthesis, ACC synthase and mutants. Roles for molecular and recombinant DNA techniques are anticipated in the course of modifying genetic information and achieving precise control of fruit ripening.

571 DEFENCE RESEARCH LABORATORY, TEZPUR, ASSAM. 1987. *Symposium on Himalayan horticulture in the context of defence supplies*. 78 p.

Proceedings of this symposium, held at Defence Research Laboratory, Tezpur, Assam, India on 28-30 Oct. 1987, are summarized as abstracts in the following sections: I, services [to military and paramilitary personnel] and horticulture products pp. 1-7; II, recent advances in horticulture pp. 11-19; III, vegetable crops pp. 23-44; IV, fruit crops pp. 47-63; and V, post-harvest technology pp. 67-78. Abstracts noted separately may be traced in the subject index under Conferences.

572 DESAI, BB; SALUNKHE, DK. 1985. *Post-harvest biotechnology of fruits and vegetables* -

prospects and perspectives. *Maharashtra Journal of Horticulture*, 2: 1, 27-36; 42 ref.

The following aspects are reviewed and discussed: production technology; quality at harvest; improved storage environment; chemical conservation; direct post-harvest application of nutrient solutions; irradiation; innovations in packaging and containerization; and newer processing technology.

573 JAIKUMAR, R. 1982. Fruit and vegetable processing industry in India - challenges and opportunities. *Foreign Trade Review*, 16: 4, 444-459; OE.

The article discusses the size and structure of the food processing industry in India. There are some 1300 processing units of which only 167 are large-scale; they are located mainly in the urban centres. Annual production of processed fruit and vegetables is around 60 000 t, valued at nearly Rs 330 million. Figures are given for specific amounts of fruits and vegetables produced. The main problem areas in the food processing industry in India are seen as: sluggish domestic demand; absence of publicity and promotion; rising production and packing costs; packaging practices; the non-availability of cans and finance. There is a need for well conceived marketing strategies. The product range of exports should be widened, the 'credibility gap' should be bridged, packaging must appeal to consumers, prices must be competitive especially when introducing 'exotic' ranges to conservative customers, and finally health and sanitary regulations should be tightened up.

574 KHAN, AH; DAS, SR. 1986. Rapid micro-IHA test with FACL-SRBCs in the serodiagnosis of amoebiasis. *Indian Journal of Medical Research*, 83: April, 377-379; 5 ref.

A rapid micro-IHAT using glutaraldehyde fixed, antigen coated, lyophilized sheep red blood cells (SRBC) was developed for the immunodiagnosis of amoebiasis. The new antigen preparation, when used either fresh or after preservation at -20°C for 90 days, gave similar titres to those obtained using fresh SRBC in clinically diagnosed amoebiasis patients.

575 KHURDIYA, DS; ROY, SK. 1986. Solar drying of fruits and vegetables. *Indian Food Packer*, 40: 4, 28-39.

576 LAL-KAUSHAL, BB; KAUSHAL, BBL. 1987. Post-harvest handling of horticultural produce. *Indian Horticulture*, 32: 1, 40-42.

Topics covered include grading, curing, degreening, precooling, washing, waxing and packaging.

577 MAINI, SB; VISISHTHA, SC; ANAND, JC. 1983. Removal of field heat of horticultural produce by evaporative cooling system. *Indian Horticulture*, 28: 3, 13-15.

578 MENINI, UG. 1990. Development of temperate zone fruits in hilly and mountainous regions of the tropics: issues and constraints. *Acta Horticulturae*, No. 279, 53-56.

An outlook is presented on the possibilities of developing temperate zone fruits in mountainous regions of the tropics. Improvements need to be made which include: terracing; the evolution of traditional agro-pastoral systems; diversification; agricultural revitalization with regard to improved technology, modernization, increased productivity and improved returns to farming; recognition of the social importance of hill farming; and development that encourages a more specialized and more profitable hill farming structure. This could include the production of high value exotic crops and the cultivation of temperate tree crops such as apples, pears, peaches, walnuts, almonds, etc. These tree crops can be grown on slopes along contour lines and help to reduce top soil erosion. Their products are durable, damage resistant in the case of nuts, and lend themselves to drying or pickling. There is a need for further research into growing technologies. To disseminate information, intergovernmental cooperation is required to transmit the positive aspects of temperate fruit production evident in, for example, Zimbabwe, Ethiopia, Kashmir and Nepal, to those agricultural communities in hill and mountainous regions of different tropical countries in need of diversification and improvement.

579 ROY, SK. 1987. An approach to post harvest technology of fruits and vegetables. *Journal of the IARI post graduate school*, 10: 2, 34-38.

580 ROY, SK. 1992. Appropriate PHT of fruits and vegetables. *SAARC Workshop on Development of Small and Medium Scale Agro-Industries*. (1992: 28-31 Oct).

581 ROY, SK. 1993. Development needs of post-harvest handling, storage and transportation of fresh fruits and vegetables. *Proceedings of 3rd International Food Convention*. (Mysore: 1993: 7-12 Sept).

582 ROY, SK. 1985. Post-harvest handling of fresh fruits. *Fruits of India tropical and subtropical* edited by Prof. T.K. Bose; Naya, Prakash. Calcutta, India.

583 ROY, SK. 1983. Post-harvest technologist of arid zone fruits. *The workshop on Arid Zone fruits at Udaipur*. 1983: 8-10 July.

584 ROY, SK; DEWAR, H. 1990. Potassium and post harvest quality of fruit and vegetable crops. *Proceedings of Group Discussion*. (IARI, New Delhi: 1989: 2 Dec). p. 72.

585 ROY, SK; PAL, RK. [1991] Research achievement of Indo-USAID sub-project on post harvest technology of fruits and vegetables, October 1985 to March, 1991.

586 ROY, SK. 1989. Role of post harvest technology of horticultural crops in India. *Trends in food science and technology: Proceedings of the Second International Food Convention*. (Mysore: 1988: 18-23 Feb. Mysore: Association of Food Scientists and Technologists, p. 349-356; 20 ref.

About 6.7% of the gross cropped area of 173 million hectares in India is used for the cultivation of fruits, vegetables, ornamental plants, roots, tubers, plantation crops and medicinal/aromatic plants. These contribute 18% of the gross value of agricultural output and 52% of export earnings from agricultural produce. Despite the commercial potential of fruits and vegetables, inadequate postharvest management systems result in 20-40% losses/year. Developments in packing and cooling systems for horticultural crops, and new approaches for preserving fruits, such as solar drying, pickling, fermentation and the use of preservatives of plant origin, are discussed.

587 ROY, SK; PAL, RK; KAUR, C; GUPTA, S. 1994. Selected references of mango, banana, citrus, guava, onion, potato and tomato. Div. of Fruit & Hort. Technology, IARI, New Delhi

588 SALUNKHE, DK; KADAM, SS; DESAI, BB. 1984. Advances in postharvest biotechnology of fruits and vegetables. *Journal of Maharashtra Agricultural Universities*, 9: 2, 198-203; 33 ref.

Fruits and vegetables are perishable commodities. Several methods such as control of environmental conditions surrounding the products, ionizing radiation, use of solar energy, canning, preservation by food additives/preservatives and freezing are employed to prevent postharvest losses. Recent developments in these areas of research, feasibility of employing these methods in developing countries like India and further research strategies to overcome these problems are discussed.

Storage

589 PAL, RK; BUESCHER, RW. 1993. Respiration and ethylene evolution of certain fruits and vegetables in response to carbon dioxide in controlled atmosphere storage. *Journal of Food Science and Technology - Mysore*, 30: 1, 29-32.

Respiration was depressed by 10-30% CO₂ in ripening bananas, pink tomatoes and pickling cucumbers; increased by 20-30% in carrot roots and unaffected by CO₂ exposure in guava, orange and onion bulb. Changes in respiration seldom coincided with changes in C₂H₄ evolution. Evolution of C₂H₄ from guavas and tomatoes was substantially reduced by all levels of CO₂. However, 30% CO₂, accelerated C₂H₄ evolution in bananas, carrot roots, cucumbers, onions and potatoes which may have been due to an early injury response.

590 ROY, SK. 1984. Post harvest storage of fruits and vegetables in a specially designed built in space. *Proceeding International workshop on energy conservation in building*. (Roorkee, India: 1984: 2-7 April). Central Building research Institute, Roorkee, India.

591 ROY, SK. 1992. Refrigeration - an integral part of scientific preservation of perishable horticultural crops. *Agricultural Marketing*, Division of Fruit & Hort. Technology, Indian Agricultural Research Institute, New Delhi-110012. p. 52-55.

592 ROY, SK. 1983. Technology for storing fruit and vegetables under rural condition. *The National Seminar on "Design and Management of Rural Godowns"*. New Delhi: National Productivity Council at India International Centres.

593 SATYAN, SH; PATWARDHAN, MV. 1983. Organic acid metabolism during ripening of fruits. *Indian Journal of Biochemistry and Biophysics*, 20: 5, 311-314; 12 ref.

The pulp of freshly harvested mangoes (cv. Badami), apples (cv. Red Delicious), bananas (cv. Dwarf Cavendish) and mandarins (cv. Coorg) was injected with either ¹⁴C-labelled malic, citric, succinic or aspartic acid in mannitol. During ripening in storage, the amount of label incorporated into CO₂ in apples and mandarins increased, whereas in mangoes and bananas this decreased. Mangoes converted organic acids mainly into sugars during ripening. On injection into mandarins much of the organic acid label was incorporated into sugars which decreased only slightly with ripening. Utilization of organic acids decreased in ripening

bananas. This was indicated by a marked increase in the proportion of labelled organic acids during storage.

594 VIJAY, S; ANAND, JC. 1983. Microbiology of frozen fruits and vegetables. Proceedings National Symposium on Frozen Foods. 1983: 12-13th Noveber). New Delhi:

Storage decay

595 ASLAM, M; KHAN, AH. 1983. Post-harvest loss reduction in fruits and vegetables: a review with special reference to Pakistan through improved understanding of spoilage mechanism and control measures. 89p.; 32 ref.

Knowledge on postharvest systems of perishable crops is reviewed with particular reference to its relevance and application in developing countries, especially Pakistan, to reduce wastage. Chapters deal with basic physiology of fruits and vegetables, physiological disorders in harvested fruits and vegetables, microbial diseases, environmental control, control of postharvest diseases, packaging, transportation and cold stores.

596 CHANDRA, S. 1986. Post-harvest microbial spoilage of fruits. Review of tropical plant pathology. Volume 2. /edited by WH Heywood; J McNeil. New Delhi: Today and Tomorrow's Printers and Publishers, p. 365-388.

The extent and type of loss, mode of infection and pathogenesis, factors influencing infection and spread and control of postharvest decay of tropical, subtropical and temperate fruits are reviewed.

597 PRAKASH, P; MANOHARACHARY, C. 1987. Changes of amino acids and sugars in infected fruits and vegetables. Revue Roumaine de Biochimie, 24: 4, 331-336; 15 ref.

Results are presented of alterations in 20 amino acids and 9 sugars in 9 fruits or vegetables infected by *Sclerotium* [*Corticium*] *rolfsii*, *Alternaria alternata*, *Aspergillus niger* or *Colletotrichum gloeosporioides* [*Glomerella cingulata*] after harvest. The data obtained clearly show the losses of nutrients due to post-harvest infection by pathogenic fungi.

598 RAO, VG. 1986. Some post-harvest diseases of fruits and vegetables from Maharashtra. Biovigyanam, 12: 1, 14-16; 6 ref.

Among the diseases recorded from 13 host plants, those new to Maharashtra include *Aspergillus niger* causing dry rot of arecanut, *A. fumigatus* and *Aspergillus terreus*

(dry rot of coconut), *Colletotrichum dematium* (blossom end rot) and *Phoma cucurbitacearum* (soft rot) on cucumber, *P. cucurbitacearum* and *Botryodiplodia theobromae* on bitter gourd (*Momordica charantia*) fruits, *B. theobromae* on pods of *Moringa oleifera*, *Memnoniella echinata* causing skin spot of banana, *Geotrichum candidum* waxy rot of *Phyllanthus emblica* fruits, and *Aspergillus niger* on aubergine.

599 ROY, AN; SHARMA, RB; SINHA, HP. 1983. Post harvest decay of fruits. Indian Journal of Mycology and Plant Pathology, 13: 1, 66; 4 ref.

Trichoderma viride caused soft rot of injured *Prunus bukharensis* fruits; *Rhizopus oryzae* a blackish soft rot on injured *Artocarpus lakoocha* fruits; and *Aspergillus niger* and *A. flavus* were involved in rotting pawpaw fruits.

600 ROY, SK. 1982. Ways and means of reducing postharvest losses of perishable horticultural produce ideal for the development countries. The International Conference on Warehousing. 1982: 3-6 Nov. Division of Fruit & Hort. Technology, Indian Agricultural Research Institute, New Delhi-110012. Vigyan Bhawan, New Delhi:

601 SETHI, V; MAINI, SB. 1989. Appropriate technology for reducing post-harvest losses in fruits and vegetables. Indian Food Packer, 42: 2, 42-56.

602 SHARMA, RB; ROY, AN; AGRAWAL, RK. 1983. Some new post harvest diseases of fruits. Indian Journal of Mycology and Plant Pathology, 13: 1, 65; 6 ref.

Brief accounts are given of a soft rot of *Ziziphus jujuba* caused by *Chaetomium globosum* and of *Pyrus sinensis* by *Fusarium solani* in an Agra market.

603 SUMBALI, G; MEHROTRA, RS. 1983. Control of post-harvest diseases of temperate fruits by chemicals and treated wrappers. Indian Phytopathology, 36: 2, 270-273; 4 ref.

Iodine-potassium iodide wraps, mercuric chloride and sodium bicarbonate dip treatments provided effective control of *Aspergillus niger*, *Gliocladium roseum* and *Sclerotium rolfsii* rots of peaches, apples and pears, respectively.

604 SUMBALI, GEETA; BADYAL, KUSUM. 1991. Relationship between fungal air-spora of fruit shops and incidence of fruit rots. Indian Phytopathology, 44: 2, 214-218; 4 ref.

Samples of 22 kinds of diseased fruits were collected from markets in Jammu and Kashmir, India. The causal fungi of postharvest fruit rots were identified and the air spora above the fruits was investigated. A definite cyclic relationship was observed between the fungal air spora in the markets and the prevalence of market fruit diseases.

605 VIJAY, S. 1993. **Prevention of post harvest losses fruits and vegetables by low cost technologies bulletin horticulture crops-pre and post harvest package.** *Nat. Hort. Board*, 5:109, 66-9.

606 WADIA, KDR; MANOHARACHARY, C; PRAKASH, P. 1986. **Effect of temperature and relative humidity on post-harvest diseases of certain fruits and vegetables.** *Indian Phytopathology*, 39: 4, 568-573; 19 ref.

These 2 factors had pronounced effects on the rate of disease progress in 10 different rots (5 hosts). None of the test fungi caused appreciable amounts of rot at 10-15°C but rotting by all of them was severe at 25-30°. The higher the RH the more severe the fruit rot, accounting for maximum spoilage during July-Nov. when the RH was 80-100%.

Packaging

607 MAINI, SB; LAL, BB; ANAND, JC. 1993. **Packaging of fruit crops.** *Advances in Fruit crop. vol. IV*/edited by KL Chandha and OP Pareek. New Delhi: Malhotra Pubalishes House, p. 1967-92.

608 MAINI, SB. 1986. **Packaging of fruits and vegetables.** *Packaging of food products pub. by Indian Institute of Packaging.* Bombay: pp. 75-87.

609 PURUSHOTTAM, V; MAHADEVIAH, M; GOWRAMMA, RV; NARESH, R. 1992. **Packaging of some fruit and vegetable products in glass containers.** *Journal of Food Science and Technology - Mysore*, 29: 6, 368-370.

Suitability of indigenously available glass containers has been studied for packing mango juice, banana puree, tomato puree and processed peas. Reduction in beta-carotene was round to be less in amber coloured bottles compared to colourless bottles. Corrosive products like banana and tomato puree could be safely packed in glass bottles. Acidification of brine was found essential for packing processed peas in glass bottles.

610 ROY, SK. 1966. **Pre-packaging minimises spoilage of fresh fruits and vegetables.** *Perfectpac*, 6:7.

611 ROY, SK. 1986. **Status paper on packaging of fruits and vegetables.** *The Regional Committee No. 1 - Meeting of ICAR.* (1986: 11-12 Sept).

Marketing

612 CHAUHAN, KS; SANDOOJA, JK; SHARMA, RK; SINGHROT, RS. 1987. **A note of assessment of certain prevailing practices for marketing of commercial fruit.** *Haryana Journal of Horticultural Sciences*, 16: 3-4, 229-232; 3 ref.

To reduce post-harvest losses, currently estimated to range between 25 and 80%, a survey was carried out on the methods of harvesting, transporting and packaging, and on decay losses. Data are tabulated for the following crops: mangoes, peaches, guavas, mandarins and lemons.

613 ROY, SK. 1991. **Development of infrastructural facilities to boost the export of fresh and processed horticultural produce.** *Ind. Fd. Packr.*, 44: 5, 13-18.

614 ROY, SK. 1992. **Need for efficient distribution system for the development of domestic and export of fresh horticultural produce.** *National Seminar on challenges to the Indian Food Industry.* (AFST, Bombay: 1992: 29-30 May).

615 ROY, SK. 1990. **Proceeding of national seminar on production, processing, marketing and export of untapped indigenous fruits and vegetables.** *Association of food scientists and technologists (India).* New Delhi:

616 SETHI, V; MAINI, SB; ANAND, JC. 1987. **Reducing post-harvest wastage of fruits and vegetables for proper marketing.** *Beverage and Fd. World*, 14: 4, 35.

617 SINGH, A; SINGH, Y. 1992. **Damage of fruits during transportation.** *Agricultural Reviews (India)*, 13: 2, 102-106.

618 VIJAY, S; SINGH, A. 1994. **Export prospects for processed products from indigenous fruits and vegetables.** *Export of Agricultural commodities.* New Delhi, Bangalore, Bombay, Calcuta: Wiley Eastern Limited. p. 83-89.

619 VIJAY, S. 1987. Low cost technology for processing horticulture produce under Indian conditions. *Bev. Fd. World*, 14: 1, 67.

620 VIJAY, S. 1993. Prospects and constraint for export of indigenous fruits and vegetables products. *Indian Food Packer*, 47: 5, 37-44.

APPLES

Postharvest handling

621 BARWAL, VS. 1993. Effect of harvesting time and handling period on quality of apple. *Journal of Food Science and Technology - Mysore*, 30: 1, 42-43.

Fruits from 4 promising cultivars ('Hardeman', 'Red Spur Delicious', 'Topred' and Vance Delicious) were picked on 3 dates between 110 and 125 days after full bloom and their physical and organoleptic characteristics were studied upto 21 days of handling period under ambient conditions. Harvesting dates had no significant effect on the diameter of fruits of 'Hardeman', 'Red Spur Delicious' and 'Topred'. There was significant increase in organoleptic acceptability of fruits of all cultivars. Decrease in firmness and physiological weight loss (PWL) was found in late harvesting. During handling, organoleptic acceptability was at par upto 14 days in all the cultivars excepting 'Vance Delicious'.

622 LAL, BB; SHARMA, PC. 1994. Apples. *Handbook of World Fruits; Cultivation, Storage and Processing* edited by DK Salunkhe; SS Kadam. USA: Marcel Deckers.

623 LAL, BB; RANA, RS; KLOCHHAR, HL; CHADHA, TR; MAINI, SB. 1988. Packaging and transportation of apples a study on commercial aspects. *Production and Conservation of Forestry* edited by PK Khosla; DK Khurana; Atul. Solan, (H.P.), India: Indian Society of Tree Sciences, p. 79-86.

624 MAINI, SB; DIWAN, B; LAL, BB; ANAND, JC. 1994. Post harvest management of apples. *Indian Horticulture*, 29: 3, 51-54.

625 MAINI, SB; DIWAN, B; LAL, BB; ANAND, JC. 1982. Studies on packaging, transport and storage of apples in different wooden containers. *Indian Fd. Packer*, 36: 3, 34-37.

Storage

626 GUPTA, OP; KAUL, RK; HAFIZA. 1989. Studies on the shelf-life of Kashmir apple cv. Red Delicious in relation to its picking maturity for cold storage. *Agricultural Science Digest Karnal*, 9: 4, 188-190; 4 ref.

Fruits of Red Delicious were harvested 140, 155 or 170 days after full bloom (on 13 Sep., 28 Sep. and 13 Oct., respectively). They were packed in conventional wooden boxes lined with paper and, within 24 h, placed in a cold store at 0-1°C and 85-90% RH. On 15 Apr. they were removed from storage and transported. After 3, 10, 17 and 24 days at 22.4-36.5° and 52.3% RH (early summer climatic conditions of Jammu) they were assessed for fruit firmness and contents of TSS, total sugars, non-reducing sugars and % acidity. Fruits harvested 140 or 155 days after full bloom maintained their shelf-life and quality for 17-24 days after storage, compared with only 3-10 days for fruits harvested after 170 days.

627 MAHAJA, BVC; CHOPRA, SK. 1992. Effect of pre-harvest application of ethylene inhibitors on polygalacturonase, cellulase and malic-dehydrogenase enzyme activities of apple during cold storage. *Indian Journal of Plant Physiology*, 35: 4, 305-310.

628 MAHAJAN, BVC. 1994. Biochemical and enzymatic changes in apple during cold storage. *Journal of Food Science and Technology - Mysore*, 31: 2, 142-144.

Biochemical and enzymatic changes in apple during cold storage were studied. Total soluble solids, total sugars and soluble protein contents increased upto 150 days of storage and thereafter declined. In contrast, titratable acidity, total phenols and pectin contents followed a linear declining trend throughout the storage period of 7 months. The activity of polygalacturonase and cellulase increased upto 150 days of storage, thereby leading to softening of apple. The activities of thaw enzymes declined thereafter.

629 MAINI, SB; DIWAN, B; LAL, BB; ANAND, JC. 1985. Fruit firmness as a simple index of quality of stored apples. *Indian J. Agric. Sci.*, 55: 1, 60-61.

630 MAINI, SB; DIWAN, B; LAL, BB; ANAND, JC. 1985. Physicochemical characteristics in relation to market quality of apples during storage. *Indian Fd. Packer*, 39: 1, 51-54.