Technical Bulletin No.41

POST HARVEST LOSSES IN SELECTED FRUITS AND VEGETABLES IN INDIA

(A Compilation)

Indian Institute of Horticultural Research
Hesaraghatta Lake post
Bengaluru-560 089,Karnataka,India

PHL at Wholesale Market

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INDIAN INSTITUTE OF HORTICULTURAL RESEARCH
HESARAGHATTA LAKE (PO)
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FOREWORD

Fruits and vegetables play most significant role in nutritional security in India. And, the country has unprecedented growth and is first in production of mango, banana, papaya and okra while, second in brinjal, cauliflower, onion, potato and tomato in the world. Post-harvest losses cause sudden fluctuation in prices of some of the horticultural crops. Lack of reliable database for planning suitable strategies to better utilize the horticultural produce is a major challenge.

It is appreciable that the Horticulture Division of ICAR along with Ministry of Food Processing Industries has come out with this informative Technical Bulletin on ***Post-Harvest Losses in Selected Fruits and Vegetables in India,*** which would give a holistic view of post-harvest losses in economically important fruits and vegetables. I hope, the information provided in this bulletin will help in working out future plans for effective post-harvest management of horticultural produce.

(S. Ayyappan)

Dated the 26th August, 2013
New Delhi

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PREFACE

During the last few decades, horticultural sector has made commendable progress in increasing the production and productivity of horticultural crops. At the same time post harvest losses in many horticultural crops has been a matter of concern. As per a Press Release by ASSOCHAM on Tuesday, the 13th August, 2013, the Post Harvest Losses in fruit and vegetables in India in terms of money was ₹ 2.13 lakh crore during 2011-12 which may cross ₹ 2.50 lakh crore during 2013-14. Availability of information on Post Harvest Losses in important crops would be of help in formulating policies and implementing programmes in minimizing such losses. The finding of earlier studies during eighties and nineties on Assessment of Post Harvest Losses of Fruit and Vegetable crops remained scattered in reports and were neither available to public nor policy makers. The first comprehensive and systematic effort made by AICRP on PHT, CIPHET (ICAR), Ludhiana on *Estimation of Harvest and Post Harvest Losses of Major Agricultural Produce in India* is a very useful ready reference.

As per the *Vision 2050* documents published by ICAR recently, we have to produce more from less for more. Efforts are therefore, needed to minimize the Post Harvest Losses which will directly add to increased availability for consumption and export. Over the years, India has made significant progress in production and availability of fruit and vegetables for consumption and export. However, we need not be complacent with these achievements as the situation in future far more challenging than ever before. The nature of Post Harvest Losses varies with crop, season and region, hence constant and repeated monitoring is essential. Therefore, it was felt that before we launch upon another mission to document the post harvest losses in fruits and vegetables, it would be wise to take stock of the information available on selected crops. A meeting of all the concerned research workers was called on 19th July 2013 at the Division of Horticulture, ICAR, New Delhi and various issues discussed. It was unanimously decided to re-visit the issue of post harvest losses of fruits and vegetables and develop a database on all the horticultural crops. As a prelude to that it was also decided to compile the available information on important fruit and vegetable crops.

I complement the efforts made by the concerned scientists of Institutes under the Horticulture Division of the Indian Council of Agricultural Research in putting the information together in the shortest time available. I also extend honest appreciations to the scientists of Division of Agricultural Engineering and Director, NHRDF, Nasik for their cooperation in this effort. I believe that this publication will be helpful to the all concerned with minimization of Post Harvest Losses in fruits and vegetables.

Date: August, 26, 2013
New Delhi

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CONTENT

INTRODUCTION

FAO's report on Food Losses and Food Waste, defined food losses as those that take place at production, post harvest and processing stages in the food supply chain and food wastes are that occur at the end of the food chain i.e. retail and final consumption (Gustavsson *et al*, 2011; Parfitt *et al*., 2010). In horticultural commodities, the stages at which post harvest losses occur can be divided into five such as production/harvest, post harvest handling and storage, processing, distribution and consumption. Post harvest losses represent a waste of resources used in production such as land, water, energy and inputs.

Producing food that is consumed leads to unnecessary CO_2 emissions in addition to loss of economic value of the food produced. It is not possible to give exact amount of post harvest losses as these commodities move through several supply chain networks. The topic of loss reduction in fruits and vegetables draws larger attention because it significantly affects the inflation curve. When ways of breaking the production barriers are exhausted, the challenge to meet the future food requirements stare at the scientists and policy makers alike. It is at such a juncture that a dire need is felt to arrest the issues of losses of food produced. The FAO report state that roughly one-third of the edible parts of food produced for human consumption gets lost or wasted globally, which is about 1.3 billion tonnes per year. The food losses are more in low income countries, the food wastages are more in high and middle income countries. Food losses in industrialized countries are as high as in developing countries, but in later more than 40% of the food losses occur at post harvest and processing levels, while in former, more than 40% of the food losses occur at retail and consumer levels (Gustavsson *et al*, 2011).

It is heartening to notice that despite growing urbanization, the area under fruits and vegetables in India increased from 9.08 million hectares in 1991 to 15.644 million hectares in 2012 (NHB, 2012). At the same time it is depressing to observe that the post harvest losses also increased.

India ushered into an era of Golden Revolution during 11th Five Year Plan with unprecedented increase in area, productivity and production. India harvested 260.06 million tonnes of horticultural produce from 23.54 million hectares of land during 2012of which fruits and vegetables contributed 232.75 million tonnes from 16.09 million hectares . This was possible due to the constant research efforts and improved production and protection technologies developed by the scientists and adopted by farmers. Paradoxically, an increasing amount of these perishables also were lost after harvest due to inadequate post-production infrastructure and improper handling and marketing system. India did not witness consonant improvement in post harvest management system matching with long strides made in increased production and productivity. Till mid 1980s, the researches on food items including the post harvest aspects of fruits and vegetables were being carried out at CFTRI, Mysore. During 1980's

realizing the deficiency of post harvest research in India, the Indo-USAID subproject on Post Harvest Technology of Fruits and Vegetables was sanctioned by ICAR during VIIth Five Year Plan with an idea to intensify research efforts on Post Harvest Technology of seven commercially important crops viz., mango, banana, citrus, guava, potato, onion and tomato. After the training of deployed staff in USA, the project supported the post harvest research in their respective laboratories in India. As part of this project an effort was made at four ICAR institutes viz. IARI, New Delhi; IIHR, Bangalore ; CIHNP (now CISH), Lucknow and NRC for Citrus, Nagpur to estimate the post harvest losses in these fruits and vegetables under the guidance of US experts with whom they worked in the USA. After the closure of the Indo-USAID scheme in 1991, the activities of this project continued in AICRP on PHT of horticultural crops till 2002 with its Coordinating centre at IARI, New Delhi.

Collection of data on post harvest losses of fruit and vegetables is a Herculean task and making a sense out of this data using appropriate statistical tools is another giant step ahead as the losses differ in various varieties, production seasons and regions. In fruits and vegetables, quantitative loss is always accompanied by qualitative changes which affects marketability and consumption. In addition to internal bio-chemical composition, the post harvest life in fruits and vegetables are influenced by several factors like temperature, humidity, stage of harvest, packaging, transportation facilities, handling practices, etc., which differ in various seasons, regions and varieties. Accordingly, it becomes essential to relate the survey data with experimental data under simulated conditions to ensure that the loss estimates are closer to the real values.

The Parliamentary Standing Committee on Agriculture (PSCA) during the month of May 2005 urged the ICAR to collect authentic data on post harvest losses of products from agrarian and allied sectors on All India basis. Accordingly, the AICRP on PHT at CIPHET, Ludhiana undertook the task of Estimation of Harvest and Post Harvest Losses of Major Agricultural Produce in India (including important fruits and vegetables during October 2005 to February 2007. The results of this study was published in 2010. The data published in this report pertaining to fruits and vegetables is reproduced here for ready reference (Table 1, 2 & 3).

Before this report, an ICAR funded Network Project Report was submitted in 2003 which covered data on post harvest losses at different stages of harvest/handling and marketing like farm , wholesalers' and retailers' level in important fruits and vegetables viz., mango, banana, guava, grapes, mandarin, mosambi, kinnow, acid lime, pineapple, apple, aonla, potato, onion, tomato, cabbage, cauliflower and chilli . National Horticultural Research and Development Foundation (NHRDF), Nasik also collected country wide data on post harvest losses of onion during 2001-2003 under NATP.

Table 1. Harvest and Post harvest Losses (%) of Fruits at National Level in India

Sl. No.	Crop	Harvesting	Collection	Sorting/ grading	Packaging	Transportation	Totalloss in farm operations	Farm level storage	Godown/ cold storage	Wholesaler level storage	Retailer level storage	Processing unit level storage	*Total loss in storage	Overall Total Loss
1	Apple	4.56± 1.41	0.42± 1.03	4.79± 1.51	0.10± 0.08	1.19± 0.22	**11.06**± 1.08	2.26± 0.99 (0.04± 0.02)	1.47± 1.21 (0.12± 0.10)	0.99± 0.63 (0.52± 0.32)	1.10± 0.49 (0.23± 0.10)	1.70± 4.24 (0.29± 0.73)	1.20± 0.81	12.26± 1.05
2	Banana	1.33± 8.59	0.36± 0.54	0.93± 0.35	0.44± 0.46	1.14± 1.29	**4.18**± 5.08	1.60± 1.02 (0.04± 0.03)	3.34± 0.11 (0.16± 0.01)	2.39± 1.06 (1.85± 0.82)	2.44± 1.51 (0.36± 0.23)	0.26± 0.16 (0.01± 0.00)	2.42± 0.85	6.60± 3.43
3	Citrus	0.92± 1.39	0.48± 1.01	1.79± 1.16	0.35± 0.94	1.30± 1.67	**4.84**± 1.30	1.94± 2.96 (0.03± 0.07)	0.00± 0.00 (0.00± 0.00)	1.28± 0.64 (0.69± 0.35)	2.29± 0.79 (0.77± 0.27)	0.21± 0.26 (0.01± 0.02)	1.54± 0.45	6.38± 1.15
4	Grapes	0.94± 1.94	0.24± 1.10	3.21± 1.26	0.26± 0.98	1.93± 1.13	**6.57**± 1.39	5.54± 0.56 (0.02± 0.00)	-	1.61± 0.84 (0.54± 0.28)	2.17± 0.74 (0.84± 0.29)	2.69± 1.03 (0.30± 0.12)	1.73± 0.42	8.30± 1.00
5	Guava	4.36± 1.53	1.20± 1.05	4.64± 1.18	0.94± 0.69	2.77± 0.73	**13.92**± 1.17	2.10± 1.27 (0.41± 0.26)	-	5.91± 1.09 (1.83± 0.34)	3.79± 1.57 (1.80± 0.75)	5.71± 0.66 (0.06± 0.01)	4.13± 0.86	18.05± 1.12
6	Mango	4.11± 2.37	0.68± 0.71	2.80± 1.54	0.51± 0.54	2.53± 2.49	**10.64**± 1.89	1.50± 0.59 (0.06± 0.03)	-	2.50± 1.14 (0.92± 0.42)	2.67± 1.70 (0.93± 0.59)	0.87± 0.39 (0.19± 0.09)	2.11± 0.73	12.74± 1.57
7	Papaya	1.45± 1.56	0.28± 0.26	1.97± 0.92	0.23± 0.20	1.13± 1.35	**5.06**± 1.08	2.10± 3.34 (0.08± 0.12)	0.00± 0.00 (0.00± 0.00)	2.28± 1.48 (1.02± 0.66)	2.39± 1.28 (1.20± 0.64)	0.03± 0.03 (0.00± 0.00)	2.28± 0.92	7.36± 1.04
8	Sapota	1.53± 1.14	0.23± 0.52	1.43± 0.83	0.08± 0.51	1.06± 0.67	**4.31**± 0.89	0.84± 0.13 (0.02± 0.00)	-	1.74± 0.58 (0.75± 0.25)	1.71± 0.76 (0.73± 0.32)	-	1.46± 0.40	5.77± 0.69

Figures in parentheses show contribution of storage % in relation to total production.

* Sum of the loss as % of the total produce from all storage channels (i.e. sum of the figures in parentheses).

Table 2. Harvest and Post Harvest Losses (%) of Vegetables at National Level in India

Sl. No.	Crop	Harve-sting	Colle-ction	Sorting/ grading	Packaging	Transpor tation	Totalloss in farm operations	Farm level storage	Godown/ cold storage	Wholesaler level storage	Retailer level storage	Processing unit level storage	*Total loss in storage	Overall Total Loss
1	Cabbage	1.08± 2.84	0.30± 0.39	1.64± 2.10	0.27± 0.64	1.32± 0.79	4.61± 1.71	2.10± 2.09 (0.14± 0.15)	1.11± 0.83 (0.06± 0.04)	2.20± 0.68 (0.88± 0.27)	2.62± 0.84 (1.21± 0.39)	2.31± 1.68 (0.03± 0.02)	2.33± 0.50	6.94± 1.51
2	Cauliflower	0.84± 1.78	0.27± 0.45	1.66± 2.30	0.18± 0.35	1.91± 1.13	4.85± 1.38	1.52± 1.30 (0.08± 0.07)	0.47± 0.12 (0.04± 0.01)	2.17± 1.69 (1.00± 0.78)	2.31± 1.60 (0.89± 0.63)	-	2.03± 1.01	6.88± 1.32
3	Green Pea	3.46± 2.63	1.08± 1.07	3.30± 2.22	0.23± 0.50	0.50± 0.54	8.58± 1.78	1.18± 1.77 (0.06± 0.09)	0.30± 0.16 (0.01± 0.00)	1.32± 1.93 (0.72± 1.05)	2.44± 0.66 (0.92± 0.25)	-	1.70± 1.08	10.28± 1.67
4	Mushroom	1.37± 2.45	1.77± 3.08	4.26± 4.59	1.64± 2.10	2.00± 0.85	11.03± 2.96	-	-	-	1.73± 0.89 (1.51± 0.78)	-	1.51± 0.78	12.54± 1.40
5	Onion	2.70± 2.54	0.23± 0.49	1.64± 1.37	0.14± 0.56	0.44± 0.58	5.17± 1.47	2.67± 1.98 (0.54± 0.40)	2.18± 0.93 (0.40± 0.17)	2.19± 0.53 (0.83± 0.20)	2.57± 0.98 (0.57± 0.22)	0.09± 0.07 (0.01± 0.00)	2.34± 0.53	7.51± 1.09
6	Potato	3.18± 4.02	0.69± 0.23	2.23± 3.41	0.10± 0.14	0.54± 0.36	6.73± 2.53	3.88± 2.10 (0.35± 0.19)	1.36± 0.64 (0.76± 0.35)	3.87± 0.61 (0.96± 0.15)	2.41± 0.65 (0.19± 0.05)	0.43± 0.11 (0.01± 0.00)	2.26± 0.43	8.99± 1.87
7	Tomato	1.73± 1.26	1.06± 0.49	3.24± 0.98	0.77± 0.53	3.14± 1.20	9.94± 1.03	4.62± 2.75 (1.22± 0.72)	1.57± 0.60 (0.01± 0.00)	2.66± 0.72 (1.06± 0.29)	2.27± 1.16 (0.58± 0.30)	2.00± 1.65 (0.17± 0.14)	3.04± 0.84	12.98± 1.00
8	Tapioca	3.61± 2.77	0.51± 0.62	1.54± 1.52	0.53± 1.08	1.28± 0.78	7.47± 1.79	4.13± 4.19	- (0.17± 0.17)	1.47± 0.75	1.70± 1.04 (0.68± 0.35)	2.34± 0.66 (0.74± 0.46)	1.72± 0.60 (0.74± 0.46)	9.19± 1.52

Figures in parentheses show contribution of storage % in relation to total production.

* Sum of the loss as % of the total produce from all storage channels (i.e. sum of the figures in parentheses).

Table 3. Harvest and Post Harvest Losses (%) of Plantation Crops and Spices at National Level in India.

Sl. No.	Crop	Harve-sting	Colle-ction	Thre shing	Sorting/ grading	Winn-owing/ cleaning	Drying staling	Packa ging	Transpor tation	Totalloss in farm operations	Farm level storage	Godown/ cold storage	Whole saler level storage	Retailer level storage	Proces-sing unit level storage	*Total loss in storage	Overall Total Loss
1	Arecanut	1.90± 0.37	0.16± 0.16	3.32± 0.83	0.39± 0.59	0.41± 0.20	0.19± 0.37	0.06± 0.04	0.19± 0.09	6.62± 0.32	1.53± 0.91 (0.03± 0.01)	0.00± 0.00 (0.00± 0.00)	1.24± 0.18 (0.88± 0.13)	1.85± 0.12 (0.27± 0.02)	0.74± 0.13 (0.12± 0.02)	1.26± 0.13	7.87± 0.34
2	Cashew	0.16± 0.09	0.14± 0.45	0.37± 0.11	-	-	0.21± 0.95	0.00± 0.00	0.01± 0.05	0.89± 0.26	0.13± 0.12 (0.01± 0.00)	0.00± 0.00 (0.00± 0.00)	0.22± 0.07 (0.06± 0.02)	0.36± 0.18 (0.02± 0.01)	0.24± 0.11 (0.14± 0.07)	0.23± 0.07	1.12± 0.23
3	Coconut	1.57± 0.47	0.22± 0.26	-	1.36± 1.77	-	0.66± 0.51	0.13± 0.22	0.17± 0.16	4.10± 0.87	1.94± 0.76 (0.14± 0.05)	0.21± 0.16 (0.02± 0.02)	1.08± 0.29 (0.46± 0.12)	2.09± 0.79 (0.32± 0.12)	1.37± 0.29 (0.36± 0.07)	1.27± 0.19	5.36± 0.71
4	Sugarcane	2.78± 1.75	0.86± 0.61	-	0.31± 6.55	-	3.52± 0.62	0.09± 0.29	0.22± 0.63	7.79± 1.85	0.83± 2.62 (0.08± 0.23)	-	-	0.14± 0.15 (0.01± 0.01)	1.16± 1.08 (0.81± 0.72)	0.90± 0.76	8.64± 1.82
5	Black Pepper	0.71± 0.33	0.16± 0.11	0.46± 0.70	-	0.83± 0.49	0.92± 0.58	0.24± 0.19	0.31± 0.41	3.60± 0.49	0.28± 0.41 (0.01± 0.02)	0.00± 0.00 (0.00± 0.00)	0.57± 0.09 (0.19± 0.02)	0.50± 0.09 (0.10± 0.02)	0.03± 0.02 (0.00± 0.01)	0.27± 0.03	3.86± 0.41
6	Chilli	1.64± 1.05	0.71± 0.58		-	0.67± 0.85	0.56± 0.29	0.12± 0.22	0.13± 0.47	3.95± 0.70	0.90± 1.32 (0.03± 0.04)	0.61± 0.26 (0.03± 0.01)	1.78± 0.79 (1.19± 0.52)	1.96± 0.88 (0.36± 0.15)	0.99± 0.79 (0.09± 0.06)	1.66± 0.55	5.60± 0.66
7	Coriander	2.19± 1.36	0.68± 0.68	3.10± 1.66	-	0.21± 0.57	.37± 00.30	0.16± 0.22	0.20± 0.19	6.81± 1.03	1.89± 0.65 (0.09± 0.03)	0.00± 0.00 (0.00± 0.00)	0.52± 0.12 (0.31± 0.08)	0.40± 0.27 (0.10± 0.07)	0.00± 0.00 (0.00± 0.00)	0.51± 0.11	7.31± 0.66
8	Turmeric	3.66± 6.47	0.77± 0.99	-	0.67± 1.93	1.14± 1.46	0.12± 0.07	0.13± 0.34	0.22± 0.59	6.72± 3.34	1.32± 1.08	(0.18± 0.13)	-	0.95± 0.29 (0.43± 0.14)	0.76± 0.84 (0.08± 0.08)	0.66± 0.20	7.37± 2.53

Figures in parentheses show contribution of storage % in relation to total production.

* Sum of the loss as % of the total produce from all storage channels (i.e. sum of the figures in parentheses).

Prior to that, the report of work done under AICRP on PHT of horticultural crops from 1991 to 2002 was available for *Official Purpose* but not in public domain. The assessment of post harvest losses of important fruits and vegetables were carried out under Indo-USAID Sub Project on Post Harvest Technology of fruits and vegetables during the VII Five Year Plan (1985-1991). This study was carried out by team consisting of economist and plant pathologist at Four important Institutes viz., IARI, New Delhi, IIHR, Bangalore, CISH (erstwhile CIHNP), Lucknow and NRC for Citrus, Nagpur during 1986 – 1990 to assess the post harvest losses in mango, banana, guava, orange, potato, onion & tomato.

Though the efforts made in the past had their own merits and limitations, nevertheless these reports provided baseline data which serve as milestone for the way ahead. In a developing country with complex socio-economic situations like India, the improvements can not occur all at once but definitely it is evolving. Therefore, the change has to be monitored regularly to see and understand where we are heading to. With this agenda in mind, there is a need to look back the way we treaded and readjust our pace to reach the goal.

An effort has been made to collate/collect these reports/publications from different Institutes / NRCs, and summarize the findings that help us to understand progressive developments which took place in Assessment of Post Harvest Losses in selected fruits and vegetables during the last two to three decades.

Post Harvest Losses in fruits

1. Mango

Mango occupies a prime position among the fruit crops as it has originated in India. It is reported to have been cultivated in India for over 4000 years in the past. Though the systematic collection of data on area and production started quite late in India, the available literature shows that in 1978-79 mango was cultivated in an area of 9.43 lakh hectares with a production of 8.22 million tonnes. In the subsequent three decades this increased to 24.64 lakh hectares area and 15.19 million tonnes production by 2012 (NHB, 2012).

Nanda *et al* (2010) reported an overall total post harvest losses of 12.74% in mango. The highest loss (10.64%) was found in farm operations like harvesting (4.11%), sorting & grading (2.80%) and transportation (2.53%). As the data were mainly collected for quantitative losses, with inclusion of the quality loss, these aggregate figures could be much more.

The post harvest losses depended greatly on the cultivars, stage of harvest, stage of handling and marketing. Murthy *et al* (2002) assessed the post-harvest losses in Banganapalli mango at different stages of marketing in Andhra Pradesh. The average post-harvest loss at the farm level was 15.6%. The major post harvest loss at the farm level was due to the harvest of

immature and small fruits, which account for about 66 % of the total loss at farm level. Loss at whole sale market level was virtually zero. The post harvest losses during storage and ripening were estimated as 8.8%. The loss at the retail marketing was found to be 5.25%. The major cause for the loss was pressing injury, which caused about 51% of the fruit damage. The other factors for loss were black spot (31%) and injury due to mechanical and physical causes. The total post-harvest loss in Banganapalli mango from the production to consumption was estimated to be 29.65% in Andhra Pradesh.

Table- 4: Assessment of post-harvest losses in Banganapalli mango at different stages (Murthy *et al*, 2002)

Stages	Loss (%)
Orchard/field level	15.60
Storage and ripening	8.80
Retail level	5.25
Total	**29.65**

(Murthy *et al*., 2012)

Srinivas *et al* (1997) conducted a survey to assess post harvest losses of 'Totapuri (Bangalora)' and 'Alphonso' (Badami)' mangoes in Karnataka. A total post harvest loss of 17.9% (3.5% orchard/field level, 4.9% during transportation, 4.1% at storage and 5.4% at retail level) and 14.4% (1.9% at orchard/field, 3.7% during transportation, 3.5% at storage and 5.3% retail level), respectively were observed in Totapuri and Alphonso mango. The major causes of losses in the order of their occurrence were mechanical injuries, spoilage, either over mature / shriveling, or immature/ unmarketable sizes, pilferage, and damage by birds/hailstorms.

Table- 5: Post-harvest losses (%) of mangoes in Karnataka (Srinivas *et al*,1997)

Stages	'Totapuri (Bangalora)	'Alphonso'(Badami)
Orchard/field	3.5	1.9
Transportation	4.9	3.7
Storage	4.1	3.5
Retail level	5.4	5.3
Total	**17.9**	**14.4**

(Srinivas *et al*., 1997)

A survey on post harvest losses on mango was conducted during 1988 & 1989 at Division of Fruits and Horticultural Technology, IARI, New Delhi. The results revealed that average total physical loss at market level was 16.09%. It varied from 7.28% in Dashehari to 10.44% in

Chausa variety at wholesale level. The retail level average loss for Dashehari, Chausa, Safeda, Sarhauli, Langra and Sindhuri varieties was 5.25%. The total physical loss was 21.34%.

A similar survey by IIHR, Bangalore in Tamil Nadu, Andhra Pradesh and Karnataka carried out during that period to study the then existing packaging methods and losses of mangoes (Totapuri, Banganapalli and Neelum) during transportation, storage (at farm, wholesale and retail levels) and processing revealed that during the peak harvesting months of May, June and July there was 20-30% fruit loss in Totapuri, Banganapalli and Neelum varieties.

A more detailed study was carried out in Uttar Pradesh at CISH, Lucknow where at the surveys for assessment of post harvest losses in mangoes was made at different levels in the marketing channel during 1987 through 1990. The main area surveyed comprised of Lucknow, Hardoi, Sitapur, Barabanki and Kanpur districts. The pre and post harvest operational flow chart of handling mangoes was identified. It was observed that the harvesting was usually done during the early hours of the day. The rest of the day was devoted to sorting, packaging and transportation to market place. The marketing channels for small, medium, large orchards were also identified. As a result of sorting, farmer could get 95.46 per cent sound fruits which could be sold at prevailing market rates. The ? fruits comprised of 1.37 per cent and the fruits which were damaged in varying proportions accounted for 3.17 per cent. However, only 1.51 per cent were complete discards. The aggregate loss due to insects, diseases and injury was 0.86, 0.43 and 0.51 per cent respectively. Whereas, the first two types of losses were due to pre harvest factors, the last one involved bruising and cracking sustained during harvesting operations. Following loss causing insect pests and diseases were recorded at this level.

Insect pest

i. Fruit fly

Diseases

i. Anthracnose (*Colletotrichum gloesporioides*).

ii. Stem end rot (*Diplodia natalensis*)

iii. Bacterial canker (Xanthomonas campestris pv. mangiferaeindicae)

iv. Sooty mould (*Capnodium mangiferae*)

When the orchards were neglected and had high incidence of hopper, the honey dew secreted by them got deposited on the fruits. This in turn attracted sooty mould making the fruits unattractive and fetched lesser price. The maximum post harvest loss was observed at wholesaler level. At this stage the fruits were ripened artificially with the help of calcium carbide.

The latent infections passed on from the field were the main cause for the losses at this stage. Besides the stem end rot and Anthracnose, Black rot (*Aspergillus niger*) and rhizopus rot (*Rhizopus sp*) were also identified as the causes for loss. Sorting after ripening indicated that 5.12 per cent fruits had 10 per cent damaged area, 4.81 per cent had between 10 to 50 per cent damage and 3.56 per cent were complete discards. Only 77.57 per cent fruits were sound and could be marketed at prevailing wholesale rates. The retailer did informal grading of fruits before disposing them off. While the aggregate losses were least in case of Safeda variety i.e., 1.70 per cent, it was maximum in case of Dashehari i.e. 2.46 per cent followed by Chausa and Langra. An aggregate loss of 2.37 per cent for all varieties was observed at retailers' level. The losses could mainly be attributed to over-ripening and rotting. With a view to have an overall estimate of losses over all the stages, the above results were pooled and the final estimates were worked out (Table 6). Considering physiological loss in weight of 8.81 per cent also as a loss, the total loss during the entire channel was 35.40 per cent and therefore, of the initial harvest only 64.60 per cent fruits were finally marketed. Another 20.48 per cent fruit (13.48 per cent having less than 10 per cent damaged area and 6.99 per cent having 10 to 50 per cent damaged area), were marketed at reduced prices. The aggregate loss was worked out as 19.78 per cent.

Table- 6: Mean post harvest losses (%) in mangoes at different levels

Level	Post harvest losses					
	% Sound	10% D	10-50% D	Discards %	Total %	Aggregate %
Farm	93.42	4.93	0.65	1.00	6.58	1.83
Ripening	69.51	6.08	5.50	3.52	15.10	6.88
PLW	64.60	2.48	0.84	1.59	4.91	2.26
Total	**64.60**	**13.49**	**6.99**	**6.11**	**35.40**	**19.78**

D= Damage; PLW=Physiological loss in weight (%) (Anon, 1992)

Considering the prices that prevailed then, the economic loss was also worked out at retailer level (Table 7.). While maximum economic loss of 8.94 per cent was observed in case of Chausa, Dashehari had reported the least i.e. 5.69 per cent. The economic loss over all the varieties was 7.01 per cent.

Table-7: Post harvest economic loss at retailer level (₹)

Variety	Expected value	Realised value	Per cent loss
Dashehari	630.53	594.63	5.69
Langra	305.18	283.14	7.22
Chausa	398.74	363.08	8.94
All varieties	444.82	413.62	7.01

(Anon, 1992)

Losses during transportation and processing of mangoes were also studied by this team. The fruit processing firms in Bareilly and Lucknow area were also surveyed to assess post harvest losses during processing. The main processing variety was Totapuri. It was contracted from the assembly market in Nagpur and was delivered at the factory head by truck. On arrival the fruits were sorted. This resulted in 10 per cent discards (Table.8 & Fig.1) which could be attributed to transportation losses. The sorted fruits were kept for ripening after which they were again sorted. At this stage 10 per cent rotten fruits were discarded. The ripened fruits were sent into processing line. During the process, 50 per cent waste by- product (35 per cent peel and 15 per cent stone) was generated and only 50 per cent pulp was recovered. The pulp was either stored for future use or used for preparing RTS beverages.

Table-8: Some physical changes in ripening Dashehari mangoes of different size grades

Grade	Av. Wt (g)	Ripening (%) on day			Marketability (%) on day			
		5th	7th	9th	5th	7th	9th	10th
Grade A	210.59.4	38.4	98.3	100	100	100	90	50
Grade B	167.67.2	57.2	99.2	100	100	80	60	40
Grade C	130.96.8	76.3	100.0	100	100	50	40	Unmarketable

(Anon, 1992)

An investigation was conducted to study the effect of long distance truck transportation on green and ripened mangoes. The sample mango boxes were loaded at Lucknow in different layers, i.e. top, middle and bottom, in different positions. The observations on green fruits which were ripened under warehouse conditions, revealed that in top layers maximum amount of 40.60 per cent fruits were in sound conditions (Table 9.). The aggregate loss in this layer was 12.02 per cent. In middle and bottom layers, due to pressure from top and thrust from bottom, only 13.44 and 16.19 per cent fruits were in sound conditions, respectively. Maximum amount of discards due to excessive press marks and rotting were observed in bottom layers. The aggregate loss in these layers was observed as 18.70 and 19.82 per cent, respectively.

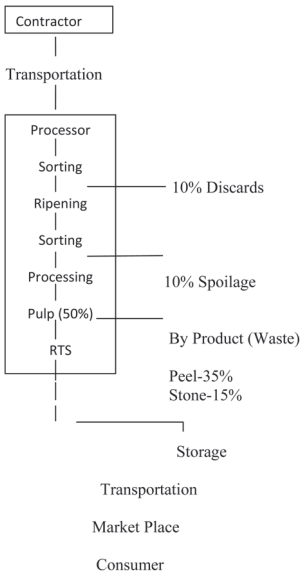
Table.9: Layer wise post harvest losses* in green mangoes manifested during ripening, after truck transportation (in per cent)

Layers in the truck	Sound fruits	Up to 10% Damage	10-50% Damage	Discards	Aggregate
Top	40.60	39.08	11.16	2.53	12.02
Middle	13.44	63.44	21.50	1.61	18.70
Bottom	16.19	59.09	18.18	4.81	19.82
Overall	23.41	53.87	16.95	2.98	16.85

(Anon, 1992)

* Mainly due to press marks and to a minor extent rotting due to infection with *Diplopia, Aspergillus* and anthracnose.

Fig. 1: Losses during transportation and processing of mango Cv. Totapari



2. Banana

Banana (*Musa* sp), is consumed both as a fruit and vegetable. The sweet desert cultivar are generally called bananas and the starchy cooking types are called plantains. It is an important food crop throughout the tropics. Being a tropical climacteric fruit, banana too is highly perishable after ripening.

Qualitative loss in banana is much higher in countries like India where the post harvest handling system is still quite primitive. It is one of the main reasons for India being not able to compete in the international markets. Banana is a crop in which the area and production increased by several folds during last three decades. It was grown in an area of 2.36 lakh hectares in 1980 with a production of 3.45 million tonnes (Dass, 1980). The area expanded to 7.71 lakh hectares and production to 27.05 million tonnes in 2012 (NHB, 2012). Nanda *et al* (2010) reported an overall post harvest loss of 6.60% in banana. Within this the loss at harvesting stage was 1.33%, transportation was 1.14% and storage losses were 2.42%.

Sreenivasa Murthy *et al* (2007) studied the marketing losses and their Impact on Marketing Margins of banana in Karnataka. They identified three stages, viz. field , transit and wholesale and retail marketing level. Simple averages and percentages were used for estimation of post harvest losses at these stages. The study was conducted in Bangalore rural district (). They observed losses of 5.53% at the field and assembly level, 6.65% at the wholesale and 16.66% at the retail level in wholesale marketing system whereas, in the co-operative marketing system, the losses were 7.82, 1.77 and 8.72% respectively in the corresponding stages.

Table-10: Post harvest losses (%) and their impact on marketing margins of banana in Karnataka

Stages	Wholesale marketing system	Co-operative marketing
Field and Assembling	5.53	7.82
wholesale	6.65	1.77
Retail	16.66	8.72

(Sreenivasa Murthy *et. al.*, 2007)

Gajanana, *et al* (2002) conducted a survey in two districts of Tamil Nadu to estimate the post harvest loss of banana (Poovan) in the local market. They observed a loss of 3.9% at farm level sorting. The loss during transport ranged from 2.19 to 2.52%. The main reason for the higher loss in transport was due to long distance. At wholesale and retail market storage, the losses were 2.52% and 7.5%, respectively. The needs to improve packing for long distance transportation through boxes were suggested.

Table-11: Assessment of post harvest losses (%) in banana in Tamil Nadu

Stages	Loss (%) Poovan variety
Farm level	3.90
Transportation	2.35
Whole sale	0.52
Retail market	7.50

(Gajanana *et al,* 2002)

Table-12: Post harvest losses in banana at different stage in the country

Region	Variety	Channel	Field level	Whole sale market level		Sub total	Retail level	Grand total
				Transit	Ripening/ storage			
Karnataka	Ney Poovan	Wholesale	5.53			6.65	16.66	28.84
		Cooperative	7.82			1.77	8.72	18.31
Andhra Pradesh	Tella Chakka-rikeli	Channel I	1.09			2.32	0.59	4.00
		Channel II	0.97			2.00	0.59	3.56
Tamil Nadu	Poovan	Channel I	3.90	5.22	2.19	7.41	7.45	18.76
		Channel II	3.90	7.21	2.52	9.73	7.55	21.18
Bihar			4.00			7.50	11.00	22.5
		Hazipur	3.00			6.00	10.00	19.00
Assam			3.50			6.50	13.00	23.00
West Bengal			5.00			7.00	13.00	25.00

Channel-I = Local market ; Channel-II = Distant market (Anon, 2003)

As per the reports of Network Project and AICRP on PHT of horticultural crops the losses in banana across the states ranged from 4.00% to 28.84% with an average of 18.42% during 1994 – 2002 (Anon, 1992 & Anon, 2002).

The first systematic study on estimation of post harvest losses in banana was done in 1989 under Indo-USAID project. Survey of the existing packaging methods and post harvest losses of banana during transportation, storage (at farm, wholesale and retail levels) and processing were carried out at the Division of Fruits and Horticultural Technology, IARI, New Delhi and IIHR, Bangalore. The area and market surveyed were purposely selected while the random sampling technique was used for selecting the samples. They surveyed the Jalgaon district of Maharashtra for losses of banana at farm level in 1990 and market level in 1989 and 1990. The results revealed that farm level losses were 3% only. However, on an average the total post harvest physical loss from farm to retail level was found to be 16.64%. The average economic loss at market level was 12.63%.

Simultaneously scientists of IIHR, Bangalore surveyed Tamil Nadu, Andhra Pradesh, Maharashtra and Karnataka states to assess the post harvest losses in two important varieties viz. Dwarf Cavendish and Robusta. Their results showed that nearly 9-15% of post harvest loss took place in Cavendish and Robusta varieties of banana harvested across these states. Maximum loss of 4.7% recorded after ripening was mainly due to the wrong post harvest handling techniques (Anon, 1992).

Table-13: Causes of post-harvest losses in banana

Sl. No.	Post-harvest handling operations	Causes of losses
1	Harvesting and preparation for market	1. Maturity at harvest. 2. Mechanical damage due to improper harvesting methods. 3. Failure to protect the commodity from sun. 4. Virtual absence of packaging practice.
2	Transport	1. Inadequacy and delay in transport. 2. Transportation by head-load and bullock-cart before loaded into the truck due to the absence of feeder roads up to the field. 3. No ventilation during long distance transport by truck and train. 4. Rough handling and improper stacking in the transport vehicle cause increased mechanical injury. 5. Bulk transport without container.
3	Handling at destination	1. Rough handling during loading and unloading i.e., throw and catch practice. 2. Improper ripening and storage methods.
4	Retailing	1. Absence of grading 2. Exposure to sun and other unfavourable environments. 3. Absence of consumer package system.

(Anon, 1992)

3. Guava

Guava is a highly nutritious fruit and very popular as poor man's apple. It has assumed special significance because of its hardy nature and prolific bearing even on marginal soils where other fruit crops fail badly. Though guava is native to tropical America, after its introduction to India in 17th Century by Portuguese it widely adapted to Indian conditions.

During the last two decades its cultivation increased in India from 0.94 lakh hectares to 2.33 lakh hectares. Though there was no significant increase in its productivity, the production increased from 1.09 million tonnes in 1991 to 2.69 million tonnes in 2012. Owing to its delicate peel and high amount of polyphenols, it is highly perishable. Guava like mango is received in raw stage at wholesale level. It is ripened at this level either in box or baskets.

Nanda et al (2010) reported an overall post harvest losses of 18.05 per cent in guava. About 13.92% of this loss was during the farm operations and among that harvesting losses were 4.36%.

During 2000-2002, the surveys conducted for estimation of post harvest losses of guava at different levels under Net Work project in Kaushambi- Allahabad region of Uttar Pradesh showed an aggregate loss of 5.17 per cent. The highest loss was at retailers level (3.99%) and lowest at traders level (0.3%). However, total damaged fruits (with 10 to 50% damages) were (Table-14) as high as14.48 per cent (Anon, 2003).

Table 14: Pooled post harvest losses in marketing system of guava (in per cent)

Sl.No.	Levels	Sound fruits	Damage Intensity			Total damaged	Aggregate Loss
1.	Farm	100.00	2.12	0.99	0.18	3.29	0.88
2.	Trader	96.71	3.01	-	-	3.01	0.30
3.	Retailer	93.70	2.29	4.27	1.62	8.18	3.99
	Total	**85.52**	**7.42**	**5.26**	**1.80**	**14.48**	**5.17**

(Anon, 1992)

Surveys were carried out by the scientists of IARI, New Delhi and CISH, Lucknow to assess the post harvest losses in guava between 1986-1988. In surveys in and around Delhi for retail level physical and economic losses of winter season guava in 1986-87, it was found that these loses were 2.14% and 2.81%, respectively. On the other hand average total physical and economic losses of rainy season guava at market level (1988 survey) was 14.5% and 21.38%, respectively.

The survey to assess post harvest losses in guava was also undertaken in Lucknow, Unnao, Kanpur and Allahabad districts during monsoon and winter seasons. The data were pooled

over all the regions to work out the final estimates. It was observed that, in general, the losses at farm level were more in the monsoon season as compared to winter season. At farm level, about 15.47 and 4.13 per cent fruits were affected by varying degree of infestation during monsoon and winter seasons, respectively (Table-15). The aggregate loss was worked out as 1.71 and 1.75 per cent during above seasons, respectively. Hence, on an average only 84.53% sound fruits could be recovered and marketed during monsoon season as compared to 94.87 per cent in winter. The losses due to faulty harvesting technique were negligible in both the seasons and were due mostly to pre-harvest factor i.e., inherent infections prevalent in the orchard itself. While the loss in monsoon season was mostly due to fruit fly, anthracnose (*C. psidi* and *C. gloesporiodes*) and Phytophthora rot (*P. parasitica*), while, it was due to fruit borer, peel cracking and bird damage during winter season.

Table-15: Post harvest losses in guava at farm level in different seasons (in per cent)

Season	Sound fruits	Post harvest losses			
		Up to 10% damage	10-50% damage	Discards	Aggregate loss
Monsoon	84.53	5.89	2.91	6.67	8.71
Winter	94.87	2.11	0.96	1.06	1.75

4. Citrus

The most important commercial citrus fruit in India is mandarin orange followed by sweet orange, lemon and acid lime. Citrus fruits are used for fresh juices, processing into squashes and marmalades. Its essential oils extracted from peel are widely used in flavouring, perfumery and cosmetic industry. Over 1980 the area under citrus fruits in India increased from 1.47 lakh hectares to 10.39 lakh hectares in 2012 and production from 1.58 million tonnes to 9.44 million tonnes. The post harvest losses in citrus fruits are mainly due to diseases and injuries caused by insects, thorns and rough handling.

(a) Oranges

Nanda *et al* (2010) reported an overall post harvest loss of 6.38% in citrus fruits of which 4.84% was at farm level and 1.54% was in storage.

Harvesting injury and insect damage are the important causes of loss in mandarin reported at farm level. The total losses reported in mandarins were 3% in Sikkim and 6.15% in Assam from farm to retail level (Anon, 2003).

Survey of the existing packaging methods and post harvest losses of oranges during transportation, storage (at farm, wholesale and retail levels) and processing were assessed at IARI, New Delhi; IIHR, Bangalore and NRC Citrus, Nagpur during 1988 to 1990. A survey in 1989 on physical and economic losses of Nagpur orange by the scientists of IARI revealed

that these losses at market level were 17.10% and 18.36%, respectively. Both physical as well as economic losses at retail was more as compared to wholesale level.

Surveys were conducted in Karnataka at IIHR, Bangalore to assess the post harvest losses in Coorg Mandarin which showed that nearly 3.5% of the total market arrival were discarded, while another 37% were sorted out and sold at 80% reduced price. The details of this survey from the Final Report of Indo-USAID project is reproduced in Table-16.

Table-16: Losses at the market level in Coorg mandarin (1990)

Information collected	Wholesale	Retail
Size of sample	15 (Traders)	31 (Retailers)
Sample quantity in no./truck loads	33 loads*	40.400 Fruits
Percentage	60	-
Discard Percentage	1.5	2.0
Quantity sorted out in no. (Partially damaged)	9.0 loads	4,242.0
Percentages	27.2	10.5
Lowered price per fruit	Rs.13.50 per/100 nos.	Rs.0.20/fruit
Percentage price deductions	80.92	80.0

* One Load = ~ 60,000. (Anon, 1992)

Simultaneously a detailed survey was conducted at NRC Citrus, Nagpur for the assessment of post harvest losses during the commodity flow in Nagpur Mandarin from farm level to consumer level. The areas surveyed were Nagpur, Amravati and Wardha. It was reported that *Mrig bahar* is the major crop of the region which contributes to 70-80% of the produce from early January to mid April. The marketing of the produce is mainly organised by pre-harvest contractors and the farmers who send the produce by both by truck and train to local and distant markets like Azadpur market in Delhi. In majority of the cases, full truck load was assessed to determine the losses due to diseases and mechanical damage. The consignments were followed up to Azadpur market, New Delhi for the assessment of losses by both the mode of transport i.e., road and rail. The road transport carried 70-80% of produce. A truck carried 550-699 boxes (50 x 33 x 33 cm) whereas, a train wagon accommodated about 700-750 wooden boxes. The road transport took 60-70 hours from Nagpur to Delhi while the same distance was covered by train in 120-130 hours. The losses from farm level to local market were assessed to be up to 8.39 per cent. In market packed fruit, losses ranged from 18.34% to 23.48% when transported by truck and 21.95% to 24.59% by train up to Delhi market. The reasons for high losses were i) rough and about 20 times handling of fruit and ii) about 6-7 days of retention after harvest (Table.17). The losses in farm house packed fruit were 15.6% to 20.73% by truck and 19.21% to 21.85% by train transport up to Delhi. These fruits were handled 12 times, hence the losses were comparatively low (Table-18).

Seven commodity flow channels were recognised during the survey and out of them three main channels have been traced out for loss assessment studies at different levels.

Table-17: Total range of post-harvest losses of Nagpur mandarin from farm to Delhi market while packed at market

Causes	Per cent losses			
	Range		Mean	
	Truck	Train	Truck	Train
1.Diseases*				
i) Stem end rot	3.07-7.5	4.80-4.98	5.55	4.89
ii) Anthracnose	0.59-0.59	0.59-0.59	0.59	0.59
iii) Sour rot	2.26-3.1	3.48-3.55	2.71	3.52
iv) *Penicillium* rot	0.115-0.00	0.44-1.08	0.06	0.91
v) *Aspergillus* rot	0.07-0.09	0.64-1.08	0.08	0.86
2. Others				
i) Injuries	4.15-4.59	4.45-5.46	4.37	4.95
ii) Sunburn	0.96-0.96	0.96-0.96	0.96	0.96
iii) Fruit moth	0.00-0.00	0.00-0.00	0.00	0.00
iv) Culled fruit	6.59-6.59	6.59-6.59	6.59	6.59
Total	**18.34-23.48**	**21.95-24.59**	**20.906**	**23.27**

(Anon, 1992)

* Stem end rot: (*Collectotrichum gloeosporioides, Botryodiploidia theobromae and Phomopsis citri),* Sour rot*: (Geotrichum* sp.),. Anthracnose: (*Coll2ectotrichum gloeosporioides),*. Penicillium rot: (*Penicillium digitatum),* Aspergillus rot: (*Aspergillus niger).*

(b) Acid Lime

The surveys were conducted in Nagpur and Akola market to assess post harvest losses in acid lime under Network Project. The losses in Nagpur were reported as 8.21% at farm , 8.58% at wholesaler and 20.50% at retailers' level, aggregating to 37.29%. Similarly in Akola region the losses at farm were reported as 5.47%, wholesale 7.04% and at retail level loss was 10.50%, thus aggregating to 23.41%. In Ahmednagar region, the aggregate loss was only 10.00% (Table-19). At the farm level, fruits are sorted for removing the rotten, bruised, cracked, wind scarred, fruits with thorn injury and very small fruits. The fruits harvested in summer have less sorting losses (2-3%) and those in rainy season it could be up to 6%. As the 'Ambia' crop of acid lime matures in rainy season in these areas, the losses are high (Anon, 2003). In Andhra Pradesh, the crop is harvested four times a year and the losses are relatively low compared to Maharashtra (Anon, 2003).

Table-18: Total range of post harvest losses of Nagpur Mandarin from farm to Delhi market while packed at farm house

Causes	Per cent losses			
	Range		Mean	
	Truck	Train	Truck	Train
1.Diseases*				
i) Stem end rot	3.34-7.23	4.53-4.72	5.28	4.62
ii) Anthracnose	0.65-0.65	0.65-0.65	0.65	0.65
iii) Sour rot	1.36-2.27	2.54-2.65	1.81	2.62
iv) *Penicillium* rot	0.11-0.12	0.44-1.38	0.06	0.91
v) *Aspergillus* rot	0.76-0.07	0.64-1.08	0.08	0.86
2. Others				
i) Injuries	4.15-4.59	4.45-5.46	4.38	4.96
ii) Sun burn	0.58-0.58	0.58-0.58	0.58	0.58
iii) Fruit moth	0.33-0.33	0.33-0.33	0.33	0.33
iv) Culled fruit	5.00-5.00	5.00-5.00	5.00	5.00
Total	15.60-20.74	19.21-21.85	18.17	20.53

(Anon, 1992)

* Stem end rot: (*C. gloeosporioides, Botryodiploidia theobromae and Phomopsis citri),* Anthracnose: (*C. Gloeosporioides).* Sour rot: (*Geotrichum.* sp), *Penicillium* rot: (*P. digitatum), Aspergillus* rot: (*A.Niger).*

Table-19: Post harvest losses in acid lime at different levels

State	Region	Loss (%) at different levels			Aggregate Loss (%)
		Field level	Wholesale	Retail	
Maharashtra	Nagpur	8.21	8.58	20.5	37.29
	Akola	5.47	7.44	10.5	23.41
	Ahmednagar	4.00	1.00	5.00	10.00
Andhra Pradesh	Hyderabad	0.69	0.87	2.52	4.08
	Gudur	0.64	0.82	2.43	3.89

(Anon, 2003)

6. Grape

Among all the horticultural crops, grape has received a special importance in view of its value addition into raisins. Fresh grapes are one of the important export commodity from India to European Union. There has been tremendous expansion of area under grapes in India during the last 3 ½ decades. It increased from 9.35 thousand ha in 1976-77 to 32.4 thousand ha in 1991 and 1.15 lakh ha during 2011. Similarly production increased from 1.50 lakh tonnes in 1976-77 to 25.19 lakh tonnes in 2012 (Jindal, 1986; NHB, 2012). The main causes of post harvest losses in grapes at farm level were reported to be due to water berries, berry shattering, and loose berries at retailers' level. During storage or long distance transportation, spoilages due to molds and shriveling due to moisture loss contribute to losses.

Nanda *et al* (2010) had reported an overall post harvest loss of 8.30 per cent in grapes. Of this, 3.21% was during sorting and grading, 1.93% during transportation and 5.54% at farm level storage.

Under Network project, based on the data collected from Andhra Pradesh on Thompson Seedless grapes, the post harvest losses was reported to be 7.96 per cent in domestic market. Out of this 3.40 per cent was at field level and 4.56 per cent at retail level. While in export market, the loss at field level was reported as eight per cent and at cold storage level 11.13 per cent aggregating to 19.13 per cent (Anon, 2003). For the same Thompson Seedless variety in Karnataka total losses in local market was 14.40%, which comprised a field level loss of 7.31%, transit and wholesale market level loss of 4.24% and retail level loss of 2.85%.

A study was conducted by Ladaniya *et al* (2005) in 2000-2001 in Nashik and Sangli districts of Maharashtra, which produces 70% total grapes in the state. Four major commercial varieties, Thompson seedless, Sonaka, Tas-e-Ganesh and Sharad seedless (Black) comprised 90% of the grape produced in the studied area.

Mumbai, Pune and Nagpur markets were studied for wholesale and retail level losses. They observed 1.00 to 1.25% losses at farm level, 5.5 to 8.65% at wholesale level and 12.25 to 16% at retailers level when grapes were packed in boxes. The aggregate loss ranged from 19% to 30.9%. However, those arriving in bamboo basket in Mumbai market had an average loss of 24.19 per cent due to rupturing, rotting and shattering of berries. The economic value of this loss has been reported as Rs.434 crores.

7. Papaya

Papaya is an important fruit of tropical and subtropical regions of the world. From being a plant in the home gardens where green papaya is also used as a vegetable, it became a crop of high commercial importance during the last two decades. The area under papaya cultivation in India increased from 0.45 lakh ha in 1991 to 1.29 lakh ha in 2011 and the production from 0.80 million tonnes in 1991 to 5.19 million tonnes in 2012 (NHB, 2012).

Table-20: Post harvest losses in grapes at different stages in Maharashtra

Stage of handling / marketing	Causes of loss	Loss (%) (Pimpalgaon-Nashik)		Loss (%) (Tasgaon-Sangli)	
Farm level	1.Small and mummified berries	0.80	-	1.01	-
	2. Rotting	0.20	-	0.24	-
	3.Bruises / Splitting	0.00	-	0.00	
	Total	**1.00**	**-**	**1.25**	-
Wholesale level		Mumbai	Pune	Nagpur	
	1. Rotting	0.00	0.00	-	0.00
	2. Shattered berries	5.50	6.00	-	8.65
	3.Any Other	0.00	0.00	-	0.00
	Total	**5.50**	**6.00**	**-**	**8.65**
Retail	1. Rotting	2.50	3.00	-	3.15
	2. Softened berries	2.50	2.50	-	3.60
	3. Shattered berries	7.25	7.50	-	9.25
	4.Any other	0.00	0.00	-	0.00
	Total	**12.50**	**13.00**	**-**	**16.00**

(Ladaniya *et al.*, 2005)

Note: Average losses at farms at Pimpalgaon and Tasgaon. In a channel of producer-Wholesaler-Retailer

Table-21: Losses of grapes in bamboo basket at wholesale market in Mumbai

Causes of losses	Loss (%)		
	Minimum	Maximum	Average
1. Ruptured and Pressed	1.14	11.64	6.54
2. Rotting	1.65	5.64	3.64
3. Shattered	8.16	19.86	14.01
Total	**11.25**	**37.14**	**24.19**

(Ladaniya *et al*, 2005)

Nanda *et al* (2010) reported an overall post harvest losses of 7.36% in papaya, out of which 5.06% was at farm level and 2.28% was storage losses.

The studies conducted by Gajanana *et al* (2010) revealed that the total post harvest loss in papaya cv. Taiwan 786 produced in Ananthpur district of Andhra Pradesh and marketed in Bangalore was 25.49% consisting of 1.66% at field level, transit loss of 4.12% and ripening loss of 8.22% at the market level and 11.49% at the retail level. At the field level, the losses were mainly due to immature and small size of fruits, malformation and harvesting injury. At

the market level, bruises and pressing injury caused market loss. Anthracnose and fruit rot due to *Alternaria* and *Phytophthora* were the main causes of loss during ripening.

Scientists at CISH, Lucknow conducted a study under AICRP on PHT of horticultural crops in 1996-97 to quantify the post harvest losses of papaya in Farukhabad and Kanpur region. They reported a farm level loss of 6.30 per cent due to cracking and bird damage and a further loss of 11.47 per cent during ripening. The aggregate loss in the papaya marketing system was reported as 24.97 per cent and additionally physiological loss in weight of 9.00 per cent. The data presented in the AICRP worker meet in 1996-97 is reproduced below.

Table-22: Post harvest losses in papaya at farm level in Farrukhabad and Kanpur region

Type of loss	Total Proportion	Damage intensity			Aggregate loss (%)
		Less than 10	10-50	Discards	
Sound fruits	90.00	-	-	-	-
Pre-harvest bird damage	2.00	0.63	0.24	1.13	1.31
Harvest damage (cracking)	8.00	2.53	1.71	4.00	4.99
Total	**100.00**	**3.16**	**1.71**	**5.13**	**6.30**

(Anon, 1998)

Table-23: Losses in papaya during ripening operation in Farrukhabad and Kanpur region

Type of loss	Total Proportion	Damage intensity			Aggregate loss (%)
		Less than 10	10-50	Discards	
Sound fruits	90.00	-	-	-	-
Discards					
Rotting	18.30	6.55	5.75	6.00	9.53
Over ripe	6.80	3.65	3.15	-	1.94
Total	**25.10**	**10.20**	**8.90**	**6.00**	**11.47**

(Anon, 1998)

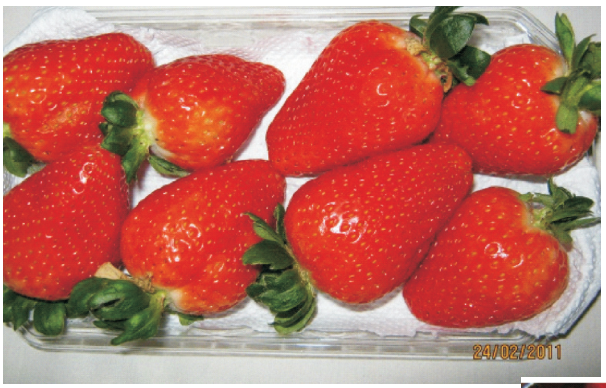
Table-24: Losses in papaya at retailer level in Farrukhabad and Kanpur region

Type of loss	Total Proportion	Damage intensity			Aggregate loss
		Less than 10	10-50	Discards	
Rotting	6.40	0.60	2.40	3.40	4.66
Over ripe	4.55	0.85	2.50	1.20	2.54
Total	**10.95**	**1.45**	**4.90**	**4.60**	**7.20**

(Anon, 1998)

8. Strawberry

Strawberry is one of the high value fruit crops grown in an area of 2200 ha with an annual production of 30,000 tons. The average productivity is 12 tons/ha. Now it is being grown in Shimla, Solan, Bilaspur, Kangra, Kullu, Palampur (H.P.); Dehradun, Saharanpur (Uttaranchal); Muzaffarnagar, Ghaziabad (UP); Hoshiarpur, Ludhiana, Jalandhar, Patiala (Punjab); Gurgaon, Hisar, Karna (Haryana); Bangalore, Coorg (Karnataka); Kodaikanal, Palani hills and Servoy hills (TN); Pune, Mahabalweshwar (Maharashtra), Jammu, Kathua, Samba (J&K). Strawberry fruit are very delicate and easily damaged. Since the harvest crew is responsible for grading, packing, and gentle handling, their training is critical to packing a quality product. There are six different channels of marketing strawberry, including pick your own berries concept, where the postharvest losses are minimum. There is no systematic study about the post-harvest loss estimation in this crop in our country. Disease is the greatest cause of postharvest losses. The most common decay is Botrytis rot, also called Gray Mold, caused by Botrytis cinerea. Mechanical damage/ bruises /abrasions caused during harvest also lead to development of fungal pathogen in the transit / storage. According to one of the studies conducted in USA the consumer- level loss for strawberry –(The proposed loss percentages are calculated by subtracting food consumption estimates from food purchase or availability estimates) is around 20 per cent. Supermarket loss estimates for fresh fruit is around 9.5 per cent.



Post Harvest Losses in Vegetables

Post harvest losses in vegetables are a major problem in the supply chain from production in the field to the consumers table. Post harvest losses vary greatly among commodities and production areas and seasons. In India, the losses of fresh vegetables are estimated to range from two to 23 per cent, depending on the commodity, with an overall average of about 12 per cent between production and consumption.

9. Potato

In India potato is a very important crop contributing 26.53% to the total vegetable production and occupying 21.24 per cent of total vegetable area. During 2012, about 41.09 million tonnes of potato was produced from 19 lakh hectares in India mainly from seven states like Uttar Pradesh, Bihar, West Bengal, Punjab, Karnataka, Assam and Madhya Pradesh. Among vegetables, potato is a crop most widely cold stored in the production catchment areas (NHB, 2011).

Nanda *et al* (2010) reported 6.73 per cent post harvest losses at farm level and 2.26 per cent storage losses aggregating to 8.99 per cent.

The studies conducted under Network project during 2001-2003 in Bihar indicated 4.44 per cent loss at field , 12.41 per cent at wholesale and 4.92 per cent at retailers' level, thus aggregating to 21.77 per cent. In West Bengal these losses were estimated to be 26.5, 17.3 and 15.9 per cent respecitively at field , wholesale and retailers' level, aggregating to 59.7 per cent (Anon, 2003).

Table- 25: Post harvest losses in potato at different stages in different regions

State	Region	Loss at different levels(%)			Aggregate loss (%)
		Field level	Wholesale	Retail	
Bihar	Nalanda District	4.44	12.41	4.92	21.77
West Bengal	Cooch behar	26.5	17.3	15.9	59.7

(Anon, 1998)

Surveys were conducted by scientists of IARI, New Delhi and CISH, Lucknow in northern markets to assess the post harvest losses in potato under Indo-USAID project. During the survey on post harvest losses in northern region in 1989, it was observed that market level losses were 7.29, 6.33 and 10.25 per cent for UP plains, Haldwani and Punjab potatoes. The simple average total losses of potato at wholesale and retail level were 2.09 and 5.87 per cent, respectively. The average market level physical and economic losses were 7.96% and 14.49% respectively.

Simultaneously, surveys at farm level in Lucknow district of Uttar Pradesh indicated that 2.09 per cent potatoes got cut during digging of which 0.65 per cent were complete discard. The

aggregate loss due to digging operations was 0.97 per cent. The rest of the loss was due to greening and diseases caused during growing stages. The amount of sound potatoes was 96.56 per cent. At cold storage level, the farmer/user could get only 82.75 per cent sound potatoes at the end of storage period. The rest was damaged in varying degrees. The losses which could be attributed to cool storage in particular comprised of sprouting, shrinkage, insects/rodents damage and rotting. The other type of losses was passed on from the field. The data were pooled to work out the losses experienced during the entire marketing channel (Table-26). Only 74.10 per cent of potatoes reached consumer in sound condition and remaining was lost.

Table- 26: Mean post harvest losses in potatoes at different levels

Level	Post harvest losses (%)					
	% Sound Damage	Upto 10% Damage	10-50%	Discards	Total	Aggregate
Farm level	95.56	1.90	0.89	0.65	3.44	1.29
Cold storage	79.90	7.89	4.62	4.15	16.66	7.25
Trader/Retailer	74.10	1.43	0.83	3.54	5.80	4.10
Total	**74.10**	**11.22**	**6.34**	**8.34**	**25.90**	**12.64**

(Anon, 1992)

In 2000-2001, under AICRP on PHT of horticultural crops, surveys were conducted in Tamil Nadu by TNAU. They reported a loss of 2.2 per cent at wholesale level, one per cent at retailers' level and 0.3 per cent at consumers' level, aggregating to 3.5 per cent (Anon, 2002).

The surveys were conducted at CISH, Lucknow to assess the post harvest losses in potatoes at retailers' level in three different varieties which showed an aggregate loss of 4.22 per cent in Pahari, 4.02 per cent in White and 2.82per cent in Red varieties (Table 27).

Losses during processing of potatoes

The survey was undertaken in Hortico Factory, Hapur during the same period. The principal processing variety was Military Special as it contained less number of eyes and could be cut into desired segments without encountering much loss. The potatoes were sorted before sending to processing line. At this stage about 0.5 per cent loss due to rotting was observed. The sound potatoes were sent to peeler where some starch was also washed out and lost along with peel. Afterwards, the eyes from the potatoes were removed manually. The total waste at this stage was 4.6 per cent.

Table- 27: Post harvest losses in potatoes at retailer level (in kg)

Variety	Quantity Handled (kg)	Grade			Losses			Aggre-gate Loss (%)	Propor tional Loss (%)
		Top	Moderate	Low	Less than 10 %	10-50 %	Discard %		
Pahari	64.38	10.2	40.68	7.99	1.30	0.25	3.96	4.22	6.55
White	62.08	1.76	43.98	10.83	1.17	0.51	3.83	4.02	6.77
Red	39.47	1.05	22.32	7.37	0.89	0.21	2.63	2.82	7.14
Aggregate	165.93	13.01	111.98	26.19	3.36	0.97	10.42	11.24	6.77

(Anon, 1992)

10. Onion

India is a second largest producer of onion in the world after China, with a production of 16.65 million tonnes from an area of 9.92 lakh hectares. There are various kinds of losses in onion *viz*., those that are unmarketable, driage, spoilage, bruising, rotting, microbial decay, transportation, physiological weight loss, sprouting etc.

Gajanana *et al* (2011) reported 10.43 per cent post harvest loss in onion (Bellary Red) at field and 2.12 per cent at retailers' level in Karnataka. In Rose variety, the losses at field and wholesalers(Exporters)levels were 16.51 and 7.13 per cent, respectively and it aggregated to 23.64 per cent in Karnataka and Tamil Nadu.

Nanda *et al* (2010) reported 7.51 per cent overall post harvest losses in onion. Out of this the total losses in farm operations was 5.17 per cent followed by 2.34 per cent storage losses.

During 1987-1990, the work of post harvest loss assessment in onion was conducted at two centres *viz*. IARI, New Delhi and IIHR, Bengaluru under Indo-USAID project.

The study carried out by scientists of IARI, New Delhi under Indo-USAID project worked out average physical losses on the basis of Gujarat onion and local onion (from Rajasthan, Haryana and Punjab) during 1987-1990. It was observed that farm level losses were more in case of Gujarat onion compared to onion from local areas. The reason is that immediately after harvest, the small and double onion in Gujarat has least market demand. Therefore, this onion is not brought to the market for fear of extremely low price (even below marketing cost). The average total loss of onion at wholesale level was 4.18 per cent. The onion that is received at wholesale level, is sorted out for damaged ones many times during storage period. Even then total market level physical loss was 18.16 per cent. However, the loss of onion

from Nasik was lowest. The economic loss of onion at market level based on 1989-90 survey data from Gujarat and local onion was 10.62 per cent (Anon, 1992).

The scientists at IIHR, Bengaluru surveyed the states of Karnataka and Tamil Nadu to assess the post harvest losses in onion based on the then existing packaging methods and losses during transportation, storage (at farm, wholesale and retail levels) and processing. The ruling varieties studied were Bellary Red, Nasik Red, Pusa Red, Bangalore Rose and Podisu.

The estimated postharvest loss was around 13 per cent in varieties with small bulbs like Bangalore Rose and Padisu. While it was more than 30 per cent in varieties with big size bulbs from the rainfed areas of Karnataka. In Arka Nikethan and Arka Kalyan varieties the losses during the storage up to 5 months was 22.09 and 55.28 per cent, respectivley. The post harvest losses excluding the physiological loss in weight in rain fed onion was higher (19.27%) than irrigated one (12.76%).

National Horticultural Research and Development Foundation (NHRDF), Nasik conducted country wide studies to assess the post harvest losses in onion during 2001-2003 under NATP. The inputs from NHRDF are reproduced here.

Post harvest losses in *kharif* onion

In *kharif* onion the highest average unmarketable onion bulb percentage was recorded in Karnataka (13.8%) followed by Tamil Nadu (12.0%) and the lowest average unmarketable bulb percentage was recorded in Rajasthan (1.5%). In Maharashtra 4.86 per cent bulbs were found to be unmarketable in Lasalgaon area. Maximum percentage of losses due to drying were recorded in Andhra Pradesh (5.4) followed by Gujarat (4.25) while lowest was in Odisha (1.5%).

Table- 28: State wise average post harvest losses after harvest in *kharif* onion

Losses after harvest / State	Unmarketable	Driage	Spoilage	Others
Maharashtra				
Lasalgaon	4.86	2.21	2.00	1.36
Sinnar	4.00	3.50	-	0.71
Gujarat	4.13	4.25	0.88	3.50
Odisha	9.00	1.5	0	0
Tamil Nadu	12.00	1.66	5.00	3.17
Karnataka	13.80	3.80	3.40	1.20
Rajasthan	1.50	2.10	0.40	0
Andhra Pradesh	1.80	5.40	1.10	9.60
Average	**6.39**	**3.05**	**1.80**	**2.44**

Source: NHRDF

Maximum percentage of spoilage losses were recorded in Tamil Nadu (5.0%) followed by Karnataka (3.4%) while it was nil in Odisha due to immediate marketing after harvest.

Excluding the above mentioned losses some other losses were also reported, which ranged from zero to 3.5 per cent.

Post harvest losses in *rabi* onion

In *rabi* onion the highest average unmarketable onion bulb percentage was recorded in Rajkot area of Gujarat (22.2%), while it was 2.6 and 0.38 per cent in Odisha and Haryana, respectively.

Maximum percentage of driage losses were recorded in Mahuva area of Gujarat (7.5%) and minimum in Haryana (4.5%). The spoilage losses were reported in the range of 0.5-1.75 per cent. Haryana reported minimum (0.5%) while Mahuva area of Gujarat state showed maximum spoilage losses (1.75%).

In addition to above mentioned losses some other losses were also recorded which ranged from 0.6-3.0 per cent. Haryana reported minimum (0.6%) while Mahuva area of Gujarat had maximum losses (3.0%).

The reasons for higher losses after harvest are that farmers do not adopt field curing. Although some farmers follow curing but they do not follow 'windrow' method. Similarly, the growers rarely adopt shade curing. Also, the trend of applying frequent and excessive irrigations was observed by the growers as other reason. Some farmers applied excessive nitrogenous fertilizers which are also responsible for higher losses. The late season rainfall (Sep.-Oct.) also noticed to cause damage to the kharif onion at harvesting stage.

Besides these losses, there are further losses due to decay and damage during transport and losses at market level which are also variable with season.

Table- 29: State wise average post harvest losses in *rabi* onion

Losses after harvest / State		Unmarketable (%)	Driage (%)	Spoilage (%)	Others (%)
Gujarat	Mahuva	9.50	7.50	1.75	3.00
	Rajkot	22.20	6.00	1.20	2.60
Odisha		2.60	5.20	1.60	2.30
Haryana		0.38	4.50	0.50	0.60
Average		**8.67**	**5.80**	**1.26**	**2.13**

Source: NHRDF

Decay losses, damage during transport and losses at market level in *kharif* onion

Maximum average percentage of decay losses by pathogens was reported in Tamil Nadu (5.33%) followed by Odisha (3.0%) and Gujarat (2.0%). Other states reported negligible losses. Maximum percentage of damage in transport was reported in Rajasthan (5.1%), while both Gujarat and Odisha had 0.8 per cent damage. All other states had negligible damage in transport.

Table- 30: Average losses during transportation and at market level in kharif onion

Kind of loss / State	Decay losses by pathogen (%)	Damage in transport (%)	Losses at market level (%)
Maharashtra	Lasalgaon	Negligible	Negligible 3.50
	Sinnar	Negligible	Negligible 3.00
Gujarat	2.00	0.80	2.00
Orissa	3.00	0.80	Negligible
Tamilnadu	5.33	Negligible	Negligible
Karnataka	Negligible	Negligible	2.00
Rajasthan	0.40	5.10	2.00
Andhra Pradesh	-	Negligible	-

Source: NHRDF

The losses at market level ranged from negligible to 3.5 per cent. Lasalgaon and Sinnar area of Maharashtra had 3.5 and 3.0 per cent market level losses, respectively. States like Gujarat, Karnataka and Rajasthan had uniformly 2.0 per cent losses, while Odisha and Tamil Nadu had negligible.

Decay losses, damage during transport and losses at market level in rabi onion

The decay losses by microbial spoilage were found to be negligible in Gujarat, while in Odisha had 3.0 per cent losses. The damage in transport in Gujarat and Odisha was recorded at 0.9 and 0.8 per cent,respectively. The losses at market level were found to be negligible in both Gujarat and Odisha.

The farmers did not following proper curing practice as reported earlier. The storage of bulbs with higher moisture content without complete removal of field heat causes more decay losses. In most of areas *kharif* onions are stored for a short period and hence decay losses are negligible.

Table- 31: Average losses during transportation and at market level in *rabi* onion

Kind of loss / State	Decay losses by pathogen (%)	Damage in transport (%)	Losses at market level (%)
Gujarat (Mahuva)	Negligible	0.90	Negligible
Orissa	3.00	0.80	Negligible

In most of the areas bulbs are carried in bulk through tractor / bullock cart from farmer's field to market, while in some markets gunny bags / hessian bag packing is used. Hence, damage / losses during transport are almost negligible except in cases when onions are transported to distant markets that too in thickly woven jute bags where transport losses are higher. At the time of auction, some part of the produce brought for marketing by farmers is dropped on ground so that the traders can observe the quality, this causes bruising to the bulbs and increases losses. Also, when bulk weighingt is practiced, 2 kg weight general reduction is followed in some markets.

Losses in storage (5-6 months)

The study was conducted in conventional type of onion storage constructed by farmers in different states during the month of July to November. The summery of storage losses studied by NHRDF on its own (Not under NATP) are given below:-

Decay losses - 3-8%

Sprouting losses - 2-9%

Physiological Loss of Weight (PLW) – 10-25%

Note: - Losses vary from 35 to 40 per cent, which depends on period of storage and varieties used.

11. Tomato

In India, tomato is the second largest cultivated vegetable after potato. In India, it was cultivated in an area of 8.76 lakh hectares with a production of 17.84 million tonnes in 2012. It contributes 11.5% of total vegetable production in India with average productivity of 19.5 tonnes/ha (NHB, 2012).

Nanda *et al* (2010) indicated an aggregate post harvest loss of 12.98 per cent in tomato which comprised of 9.94 per cent at field and 3.04 per cent in storage. Gajanana *et al* (2006) observed total post harvest loss of 19 per cent in tomato in Karnataka which consisted of 9.43 per cent at field, four to five per cent at market and about five per cent at retail level.

In Andhra Pradesh the losses during local marketing of tomato was found to be 13.92 per cent consisting of 7.33 per cent at farm , 1.44 per cent at wholesalers' and 5.15 per cent at retailers' level (Anon, 2003).

During 2000-2001, a survey conducted in Tamil Nadu under AICRP on PHT of horticultural crops showed an aggregate post harvest loss of 22.08 per cent. During the same period, it was 25.69 per cent in West Bengal (Anon, 2002).

The survey of the then existing packaging methods and post harvest losses of tomato during transportation, storage at farm, wholesale and retail levels and; processing were conducted by scientists of IARI, New Delhi in central and northern part of India and IIHR, Bengaluru in Karnataka under Indo-USAID project. All F-1 Hybrids and Local varieties were covered under this study. On the basis survey during 1989-1990 the average total physical loss from farm to retailer level was 26.10 per cent. This included an average farm level loss of 9.60 per cent in Nasik (Maharashtra) and Solan (H.P.) districts. The losses were observed to be more in case of local tomato from Rajasthan, Haryana and Uttar Pradesh. At market level itself, the physical loss for local tomato was 25.56 per cent. The average economic loss of tomato at market level was 18.90 per cent.

Surveys conducted in Karnataka to assess the post harvest losses in tomato during 1987 indicated that the loss at farm was 3.25 per cent, at wholesalers' level 9 per cent and at retailers' level was 7.7 per cent aggregating to 19.95 per cent (Table- 32).

Table-32: Post-harvest loss (%) in tomato at different stages in Karnataka

Stages	Percentage loss
Loss at farm level	3.25
Loss at market level (Wholesale)	9
Loss at Retailer level	7.7
Total	**19.95**

(Anon, 1992)

12. Cauliflower

India was the leading producer of cauliflower in the world with a total production of 7.65 million tonnes from an area of 4.09 lakh hectares during 2012. It contributed 4.6 per cent to total vegetables produced in India.

Nanda *et al* (2010) reported an aggregate post harvest loss of 6.88 per cent in cauliflower. This included 4.85 per cent at farm and 2.03 per cent in storage.

The study under Network project reported an aggregate post harvest loss of 12.0 per cent in Varanasi, 12.5 per cent in Ranchi, 13 per cent each in Bhubaneshwar and Guwahati and 20.82 per cent in Coochbehar district of West Bengal. The losses (Table- 33) at field level at these places were in the range of 0.5 per cent to 5.02 per cent, at wholesalers' level 1.5 per cent to 8.09 per cent and at retailers' level five to 9.5 per cent (Anon, 2003).

Table-33: Post harvest losses in cauliflower at different levels of handling

State	Region	Loss at different levels (%)			Aggregate loss (%)
		Field level	Wholesale	Retail	
Uttar Pradesh	Varanasi	3.5	2.5	6.0	12.0
Bihar	Ranchi	1.5	1.5	9.5	12.5
	Patna	2.0	2.6	7.0	11.6
Orissa	Bhubneshwar	1.5	6.0	5.5	13.0
Assam	Guwahati	0.5	7.5	5.0	13.0
West Bengal	Coochbehar	5.02	8.09	7.71	20.82

(Anon, 2003)

In 2000-01, the total post harvest losses in cauliflower in Tamil Nadu was reported as 3.2 per cent (Anon, 2002). The main causes of post harvest losses in cauliflower was reported to be due to infestation of curds by insects, diseases, cracking and over-maturity adversely affecting the quality of curd.

13. Green Pea

The pea (*Pisum sativum* L.) is a very common nutritious vegetable grown in cool season throughout the world. In India, it is widely cultivated in Uttar Pradesh, Bihar, Haryana, Punjab, Himachal Pradesh, Odisha and Karnataka. During the year 2012, pea was cultivated in an area of 4.22 lakh hectares with a production of 3.86 million tonnes. Fresh green peas being high in moisture content and sugars are highly perishable under ambient conditions. However, the economic part being the seed, shell protects the peas to a great extent. After shelling, the peas undergo rapid deterioration if not refrigerated or frozen. The information on post harvest losses in green peas in India is very negligible.

Nanda *et al* (2010) reported an overall post harvest loss of 10.28 per cent in green peas. This included 8.58 per cent loss at farm operations and 1.70 per cent storage losses. As per the information from IIVR, Varanasi 4.87 per cent loss is reported at harvesting stage, 1.05 per cent at grading and packing stage, 3.7 per cent during handling and transportation and 0.44 per cent during marketing aggregating to 10.06 per cent.

Outlook

The details in the above part of the bulletin indicate a progressive change in data of post harvest losses of fruits and vegetables from mid 1980's to 2010. The trend is heartening to many, because that the post harvest losses have come down drastically from around 30 per cent and more to around 10 per cent or even less in the last eight to ten years between 2000 to 2010 but the cry in society and media is too loud and is disagreeing to buy the argument. Introspection on this issue compels us to re-look to see if we have erred somewhere.

From the foregone information it is evident that an attempt to arrive at a single figure for post harvest losses of fruits and vegetables for the whole nation may not give a realistic picture of the post harvest scenario as it has been found to vary from region to region, one season to another and one variety to another even within a region. Too wide values for the same variable (due to above said reasons) may vitiate the calculations. Repeatability and re-evaluation to ascertain any phenomenon is the bedrock on which scientific scrutiny stands. Therefore, when certain phenomena are dynamic or constantly changing, keeping a vigil and watch and constant monitoring is inevitable.

References

1. Anonymous. 2003. Consolidated Final Report. ICAR Network project on marketing and assessment of post harvest losses in fruits and vegetables in India.

2. Anonymous. 1992. Final Report of Indo-USAID Subproject on Post Harvest Technology of fruits and vegetables. Indian Council of Agricultural Research.

3. Anonymous. 2002. Group Workers Meeting of AICRP on PHT of horticultural crops. Trial Data of 2000-2001 presented in Workshop held at Konkan Krishi Vidyapeeth, Dapoli from 5th to 7th March 2002.

4. Anonymous. 1998. Group Workers Meeting of AICRP on PHT of horticultural crops. Trial Data of 1996-1997 presented in Workshop held at SKN College of Agriculture, Jobner, Rajasthan from 9th to 11th January 1998.

5. Anonymous. 1992. Final Report of Indo-USAID Subproject on Post Harvest Technology of fruits and vegetables, ICAR, New Delhi.

6. Jindal, P. C. 1985. Grape. In: Fruits of India: Tropical and Subtropical (Ed. T. K. Bose), Naya Prokash Publisher, Calcutta, India. Pp-241.

7. Ladaniya, M. S., Vinod Wanjari and Bipin Chandra Mahalle. 2005. Marketing of grapes and raisins and post-harvest losses of fresh grapes in Maharashtra. *Ind. J. Agril. Res.*, 39(3):167-176.

8. Gustavsson, Jenny., Cederberg, Christel., Sonesson, Ulf., Otterdijk, Robert van. and Meybeck, Alexandre. 2011. Global Food Losses and Food Waste. FAO Rome, Italy.

9. Parfitt, J., Barthel, M. & Macnaughton, S. 2010. Food waste within food supply chains: quantification and potential for change to 2050, *Phil. Trans. R. Soc.*, vol. 365, pp. 3065-3081.

10. NHB. 2011. Indian Horticulture Database - 2011., (Eds. Bijay Kumar, Mistry, N.C., Brijendra Singh and Chander P. Gandhi). Ministry of Agriculture, Government of India.

11. Srinivas, R.N., Venkatesha Reddy, T., Ravi, P.C., Lalitha Achoth and Chinnappa Reddy, B.V.1997. Post-harvest loss assessment in totapuri and alphonso mangoes, Journal of Food Science and Technology, 34(1):70-71.

12. Sreenivasa Murthy, D., Gajanana, T. M., Sudha, M and Dakshinamoorthy, V. 2007. Marketing losses and their impact on marketing margins: A case study of banana in Karnataka, Agricultural Economics Research Review, 20 (1): 47-60.

13. Murthy, S.D., Gajanana, T. M., Sudha, M and Subramanyam, K.V. 2002. Post harvest loss estimation in mangoes at different stages of marketing-A methodological perspective. Agricultural Economics Research Review. 15(2):188-200.

14. Nanda, S. K., Vishwakarma, R. K., Bathla, H.V.L., Anil Rai, and Chandra, P. 2010. Harvest and Post Harvest Losses of major crops and livestock produce in India. All India Coordinated Research Project on Post Harvest Technology (ICAR), Ludhiana.

15. Dass, H.C. 1980. Proceedings of National Seminar on Banana Production and Technology, Tamil Nadu Agricultural University, Coimbatore. Pp-5-13.

16. Gajanana, T. M., Sreenivasa Murthy, and Sudha, M. 2002. Marketing and post harvest loss assessment of banana var. Poovan in Tamil Nadu. Agricultural Economic Research Reviews, 15(1): 56-65.

17. Gajanana, T. M., Sudha, M., Saxena, A. K. and Dakshinamoorthy, V. 2010. Post Harvest Handling, Marketing and Assessment of Losses in Papaya. Proceedings of 2nd International Symposium on Papaya. (Eds. N. Kumar *et al*,), *Acta Hortic*. Vol.851: 519-525.

18. Gajanana, T. M., Sreenivasa Murthy, D., Sudha, M and Dakshinamoorthy, V. 2006. Marketing and estimation of post harvest losses of tomato crop in Karnataka. *Ind. J. Agril. Mark.*, 20(1): 1-10.

19. Gajanana, T. M., Sreenivasa Murthy and Sudha, M. 2011. Post harvest losses in fruits and vegetables in South India-A Review of concepts and quantification of losses. *Indian Food Packer*, 2011, Pp.178- 186.

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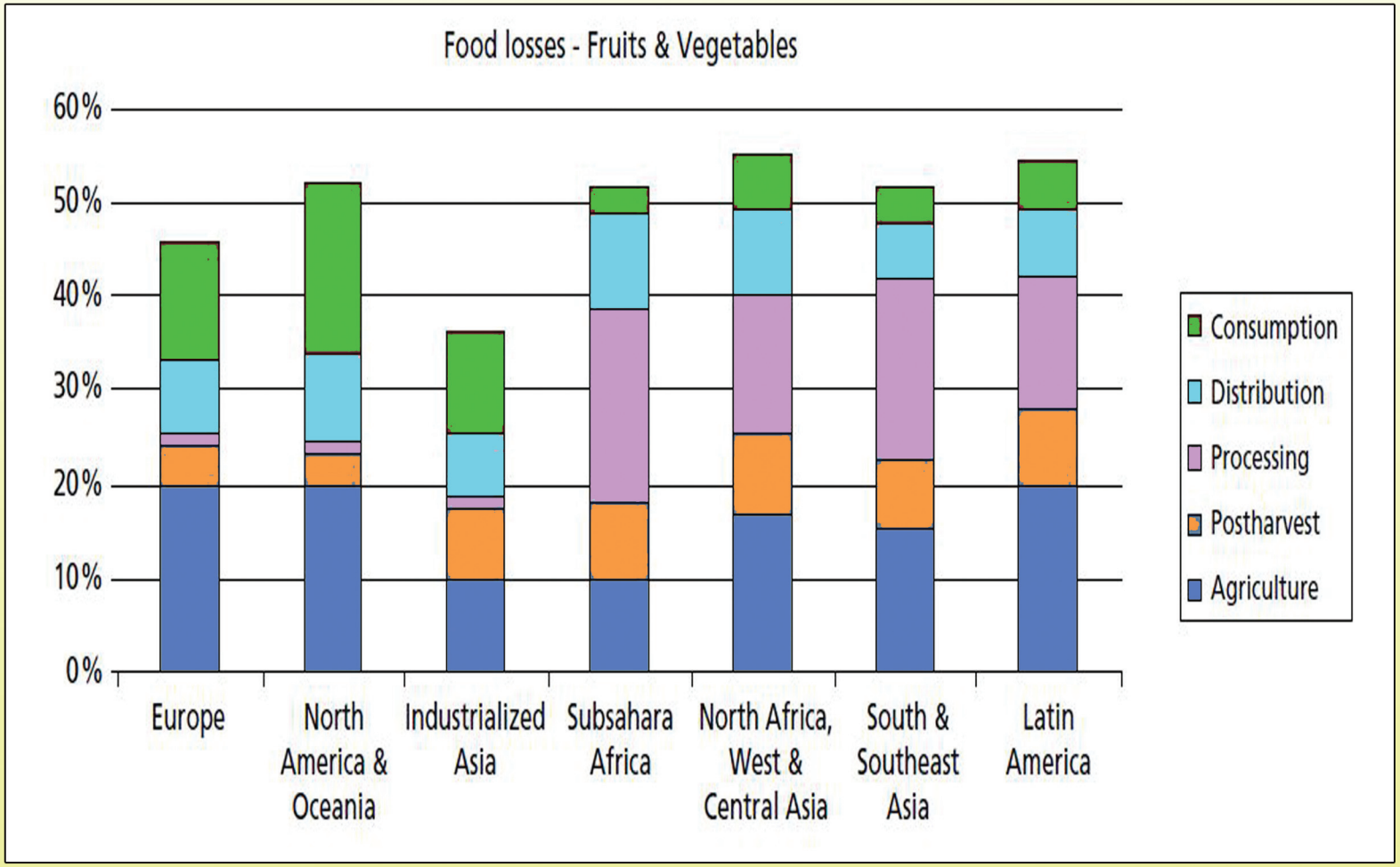
A WORLD SCENARIO



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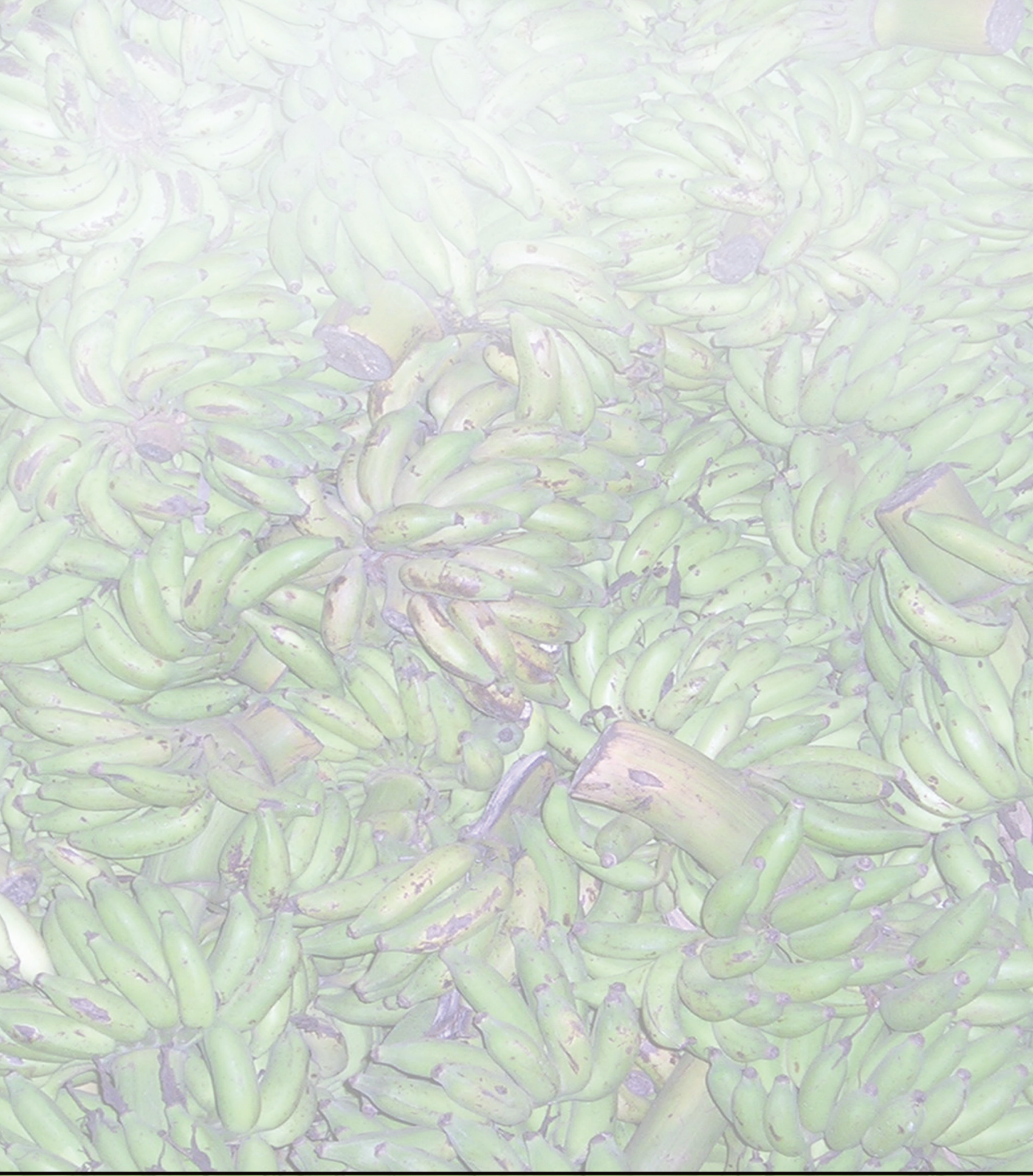

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