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POST HARVEST LOSSES IN VEGETABLES

A. Waheed*, M.Z. Iqbal** and F.H. Shah

PCSIR Laboratories, Lahore-16

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Post-harvest losses in vegetables have been studied. The maximum (52%) quantitative loss was recorded in spinach of which 25% was at retailers' shop. Proximate analysis of vegetables at different maturity stages indicated that the nutritional composition of vegetables were species specific and maturity dependent. Protein contents of leafy vegetables were high (25-46%) at immature stage while roots and tubers indicated high (6.9-13.7%) protein contents at over mature stage. Leafy vegetables accumulated more sodium and potassium as compared to the rest of the vegetables. Vitamin contents of all the vegetables were high at mature stage and indicated significant losses during storage.

INTRODUCTION

Pakistan is producing 2,453,000 tonnes of vegetables per annum [1]. The vegetables commonly grown in Pakistan included roots and tubers, leafy vegetables and immature green legumes. In view of increase in population of the country and the growing demand for vegetables, greater extension and intensification of agriculture is of prime importance for the increased production of vegetables. An alternative to increased vegetables production is provided by improved storage and conservation. Good conservation of fresh produce is especially important because the proportions of vegetables which are processed is much lower. It has been reported [2] that post harvest losses of 20-50% of perishables are not unusual in tropical countries like Pakistan, where storage facilities are not available and appropriate chemical treatments are not used.

In addition to quantitative losses quality of the produce has also been reported [3-10] to be affected during transportation and storage.

Muccio [11] reported a considerable loss in vitamin contents of vegetables during storage for 12 to 14 days at 5°. Sirtautaite [12] and Dokl investigated the changes in carrot during storage. It was observed that 12-13% of the carotene and 34.2% sugars were lost during storage. Sucrose decreased while invert sugars were observed to increase. Scholottmann *et al* [13] studied the loss of nutritive values of vegetables and fruits between harvest and consumption. Moisture, total and proteinous nitrogen, total sugars, ascorbic acids and amount of carotenes decreased during storage for 4 to 7 days. Emura [7] studied the effect of storage temperature on Chinese cabbage stored at O° and 5°.

*Chemistry Department; Government F.C. College, Lahore.

**Institute of Chemistry, University of Punjab, Lahore.

Ogata *et al* [14] studied changes in the ascorbic acid content of Okra during maturation and storage. El-Sayed [15] studied the changes in keeping quality of tomato. Treatment with gamma radiation was reported to increase the shelf-life upto 13 days without affecting vitamin C content. The present studies were aimed on assessing the post-harvest losses in vegetables commonly grown in Pakistan.

MATERIAL AND METHODS

Production statistics of vegetables: The production statistics of vegetables were taken from the *Statistical Year Book* published by the Government of Pakistan, Ministry of Food, Agriculture and Cooperatives, Food and Agriculture Division [1].

The post-harvest losses in quantity of various vegetables from the field to consumer were collected through questionnaire (Appendix 1) from the personnel involved in the production and distribution of the vegetables.

Vegetables: Vegetables for quality analysis were purchased fresh from the field and were divided into three categories: immature, mature and overmature. These three categories were stored in the Laboratories at ambient temperature (20-31°) and relative humidity (50-79°%) for a period of 72 hr. Four replicates of each commodity were taken.

EXPERIMENTAL

Moisture, proteins, fats, ash, fibre and carbohydrates were determined according to A.O.A.C. methods [16]. Vitamin C was determined according to the method described by Jagota and Dani [17] Vitamin A was determined

by the colorimetric method as proposed by Graig *et al* [18] Vitamin B_1 was determined [19] with iodobismuthic acid. Vitamin B_2 was determined by the method of Roy *et al* [20] Flame photometric method was used to determine sodium, potassium and calcium as described in A.O.A.C. [16] Magnesium was determined with EDTA [12]. Iron was determined by the colorimetric method [22]. Phosphorus was determined by spectrophotometric method [23].

RESULTS AND DISCUSSION

Production of vegetables in Pakistan: The production statistics of selected vegetables are presented in Table 1. The estimates are based on the information contained in the *Statistical Year Book* published by the Ministry of Food and Agricultural [1] and are based only on the commercial scale production in Pakistan.

Post-harvest losses: The post-harvest losses in vegetables during transportation, marketing and storage are reported in Table 2. Maximum losses observed in spinach, tomatoes and salad were 52, 51 and 37 % respectively and were mostly at the retailers' shop where these commodities are retained for more than 24 hr. Losses during harvesting and in the whole-sale market in the case of leafy vegetables were almost uniform. The minimum losses (11.8-18.0 %) were observed in radish. Losses in the field were upto 4 % which were due to over-maturing and physical damage during harvesting or transportation.

Proximate composition: Proximate analysis of the selected vegetables is reported in Table 3. This table indicates that proteins, lipids and ash contents of almost all the vegetables were high at the immature stage and decreased with the maturing process and were minimum at the overmature stage.

Fibre contents of all the vegetables were lower in the immature vegetables and increased on maturing. It was maximum in the overmature vegetables. Leafy vegetables contained higher protein contents than the other vegetables. Roots and tubers were rich in carbohydrates and contained lesser amount of proteins, lipids, fibre and ash (Table 3). Vegetables such as bitter gourd, cauliflower, peas and tomatoes contained higher amounts of protein and lesser amount of carbohydrates as compared to roots and tubers. Immature vegetables contained higher moisture content which decreased with maturity. Mineral contents are reported in Table 4. It is evident from the Table that mineral contents decreased with increase in maturity of the vegetables. Among the minerals, calcium, magnesium and phosphorus were found to be greater m quantity than sodium and potassium. Spinach contained the maximum amount of calcium, magnesium and phosphorus, while sodium, potassium and iron were comparatively low. These minerals were lower in roots and tubers but were found to be maximum in bitter gourd, cauliflower, peas and tomatoes. Ash contents of salad and spinach ranged from 6.8 to 21% which appear to be due to insoluble matter, i.e. silica as plants have been reported [24] to contain considerable amounts of silica in their tissues. High ash contents (18-25-8 %) of leafy vegetables have also been reported [25] by other workers. Roots and tubers showed no significant variations in their ash contents.

Vitamin contents of the vegetables are reported in Table 5. Leafy vegetables contained higher contents of ascorbic acid as compared to roots and tubers. Bitter gourd contained the maximum 900 mg/100 g ascorbic acid among all the vegetables. Tomatoes contained 650 mg/100 g at the immature stage while at the over mature stage vitamin C

Table 1. Production of vegetables in Pakistan.

Vegetables	Area under cultivation in '000' Hectares	Production in '000' Tonnes
Leafy Vegetables		
1. Cabbage (*Brassica oleracea*)	8.00	71.70
2. Salad (*Pisonia alba*)	–	–
3. Spinach (*Spinacia oleracea*)	3.00	161.80
Roots and Tubers		
1. Beet Root (*Beta vulgaris*)	12.50	360.40
2. Carrot (*Daucus carota*)	7.00	148.00
3. Onion (*Allium Cepa*)	43.40	451.80
4. Radish (*Raphanus sativum*)	6.50	70.50
5. Potatoes (*Solanum tuberosum*)	45.30	476.60
Other Vegetables		
1. Bitter gourd (*Momordica charantia*)	4.00	40.80
2. Caulflower (*Brassica oleracea*)	8.00	123.60
3. Okra (*Hibiscus esculentus*)	5.00	46.00
4. Peas (*Pisum sativum*)	176.90	80.90
5. Tomato (*Lycopersicon esculentum*)	8.20	101.50
6. Cucumber (*Cucumis sativus*)		

Table 2. Post-harvest losses in vegetables.

Vegetables	Percentage Loss During					
	Harvesting	Storage in the field	Loading and transportation to wholesale market	Wholesale market	Retailer's shop	Total loss
1	2	3	4	5	6	7
Leafy Vegetable						
1. Cabbage (*Brassica oleracea*)	2.5 – 4.0	1.0 – 2.0	1.8 – 2.0	1.3 – 2.0	10.0 – 15.0	16.6 – 25.0
2. Salad (*Pisonia alba*)	3.0 – 4.0	1.0 – 2.0	1.0 – 2.0	2.0 – 3.0	25.0 – 26.0	31.0 – 37.0
3. Spinach (*Spinacia oleracea*)	6.0 – 8.0	5.0 – 6.0	4.0 – 5.0	6.0 – 8.0	23.0 – 25.0	44.0 – 52.0
Roots and Tubers						
1. Beet Root (*Beta vulgaris*)	6.0 – 8.0	2.0 – 3.0	2.0 – 3.0	3.0 – 4.0	10.0 – 13.0	23.0 – 31.0
2. Carrot (*Daucus cerota*)	5.0 – 7.0	1.0 – 2.0	2.0 – 3.0	3.0 – 4.0	15.0 – 20.0	26.0 – 36.0
3. Onion (*Allium Cepa*)	3.0 – 4.0	2.0 – 3.0	1.0 – 1.5	2.0 – 3.0	7.0 – 10.0	15.0 – 21.5
4. Radish (*Raphanus sativum*)	2.5 – 4.0	0.5 – 1.0	1.3 – 2.0	2.5 – 4.0	5.0 – 7.0	11.8 – 18.0
5. Potatoes (*Solanum tuberosum*)	2.0 – 4.0	1.0 – 2.0	2.0 – 3.0	2.0 – 3.0	6.0 – 8.0	13.0 – 20.0
Other Vegetables						
1. Bitter gourd (*Momordica charantia*)	2.2 – 4.0	2.0 – 3.0	1.5 – 2.0	3.0 – 5.0	15.0 – 20.0	22.7 – 32.0
2. Cauliflower (*Brassica oleracea*)	2.0 – 3.0	0.6 – 1.0	1.5 – 2.0	1.5 – 2.0	15.0 – 20.0	20.6 – 28.0
3. Cucumber (*Cucumis sativus*)	2.0 – 3.0	1.0 – 2.0	2.0 – 2.5	2.0 – 3.0	15.0 – 20.0	22.0 – 30.5
4. Okra (*Hibiscus esculentus*)	8.5 – 10.0	2.5 – 4.0	5.0 – 6.0	3.0 – 4.0	10.0 – 15.0	29.0 – 39.0
5. Peas (*Pisum sativum*)	5.0 – 6.0	1.0 – 2.0	3.0 – 4.0	4.0 – 4.5	10.0 – 11.0	23.5 – 27.5
6. Tomato (*Lycopersicon esculentum*)	10.0 – 12.0	3.0 – 4.0	6.5 – 7.5	9.5 – 10.0	15.0 – 18.0	44.0 – 51.5

Table 3. Proximate analysis* of vegetables.

Name of Vegetables	Immature						Mature						Over Mature					
	Dry Wt. %	Protein %	Lipids %	Fibre %	Ash %	Carbo-hydrate %	Dry Wt. %	Protein %	Lipids %	Fibre %	Ash %	Carbo-hydrate %	Dry Wt. %	Protein %	Lipids %	Fibre %	Ash %	Carbo-hydrate %
Leafy Vegetables																		
1. Cabbage (*Brassica oleracea*)	7.0	25.0	1.2	7.0	6.8	60.0	8.0	21.5	1.0	10.0	6.0	61.5	10.0	19.0	1.0	12.0	5.8	62.2
2. Salad (*Pisonia alba*)	8.0	46.0	1.8	7.0	14.0	31.2	8.8	45.0	1.7	8.0	13.6	31.7	12.0	44.0	1.8	10.0	14.0	30.2
3. Spinach (*Spinacia oleracea*)	7.0	32.0	7.5	6.0	21.0	33.5	7.5	30.5	8.1	8.0	20.0	33.4	9.0	28.0	8.0	10.5	23.0	30.5
Roots and Tubers																		
1. Beet root (*Beta Vulgaris*)	10.0	13.0	1.0	5.2	6.0	74.8	13.0	13.8	1.5	6.1	5.8	72.8	15.0	13.7	1.1	10.4	6.0	68.8
2. Carrot (*Daucus carota*)	10.0	10.2	1.0	7.5	7.0	74.3	13.0	10.1	1.2	10.5	7.6	70.6	15.0	12.5	1.3	10.0	7.8	68.4
3. Onion (*Allium Cepa*)	10.1	7.8	1.2	3.0	5.0	83.0	13.1	7.6	1.3	3.5	5.5	82.1	14.0	8.2	1.4	4.0	6.0	80.4
4. Potatoes (*Solanum tuberosum*)	20.0	6.0	1.0	1.1	2.0	89.9	24.0	6.3	1.2	1.8	2.6	88.1	28.0	7.0	1.3	2.0	3.0	86.7
5. Radish (*Rephanus sativum*)	5.0	7.5	1.0	9.0	9.3	73.2	7.0	7.1	1.6	10.7	9.3	71.3	8.0	6.9	2.0	10.8	9.0	71.3
Other Vegetables																		
1. Bitter gourd (*Momordica charantia*)	8.0	16.0	2.4	8.0	7.6	66.0	10.0	15.8	2.5	10.0	7.5	64.2	9.1	16.1	2.8	11.0	7.4	62.7
2. Cauliflower (*Brassica oleracea*)	8.0	24.0	1.8	7.2	6.8	60.2	11.0	22.7	1.8	8.3	6.8	60.4	12.0	14.3	13.6	10.5	6.5	55.1
3. Cucumber (*Cucumis sativus*)	4.0	13.0	2.0	5.2	7.8	72.0	5.6	12.5	1.8	8.9	7.3	69.5	10.1	12.5	2.0	10.0	7.0	68.5
4. Okra (*Hibiscus esculentus*)	8.0	20.0	2.1	7.2	8.1	62.6	10.0	18.0	2.0	10.0	8.0	62.0	20.0	18.0	2.5	15.0	8.5	56.0
5. Peas (*Pisum sativum*)	25.0	26.8	2.8	5.0	3.5	61.9	28.0	24.0	1.5	5.5	3.2	65.8	32.0	22.0	1.1	8.0	3.5	65.4
6. Tomato (*Lycopersicon esculentum*)	6.0	25.0	7.0	1.5	1.5	65.0	5.0	20.0	6.0	1.2	1.2	71.6	5.5	21.0	6.5	1.0	1.5	70.0

*Results calculated on dry weight basis.

Table 4. Mineral contents (mg/100 g dry wt.) of vegetables.

Name of Vegetables	Immature						Mature						Over Mature					
	Na mg	K mg	Ca mg	Mg mg	Fa mg	P mg	Na mg	K mg	Ca mg	Mg mg	Fa mg	P mg	Na mg	K mg	Ca mg	Mg mg	Fa mg	P mg
Leafy Vegetables																		
1. Cabbage (*Brassica oleracea*)	20.0	10.0	575.0	500.0	6.25	375.0	21.0	11.0	450.0	420.0	6.25	900.0	17.0	9.0	600.0	550.0	6.00	400.0
2. Salad (*Pisonia alba*)	15.0	9.0	250.0	200.0	6.25	284.0	20.0	10.0	200.0	150.0	6.00	200.0	13.0	8.0	300.0	240.0	6.30	300.0
3. Spinach (*Spinacia oleracea*)	13.0	12.0	1066.6	900.0	40.00	733.0	15.0	13.0	950.0	750.0	30.0	600.00	10.0	10.0	1100.0	1000.0	42.00	800.0
Roots and Tubers																		
1. Beet root (*Beta Vulgaris*)	10.0	8.0	207.6	180.0	7.69	330.76	12.0	8.0	150.0	150.0	6.0	225.0	8.0	6.0	240.0	200.0	8.0	350.0
2. Carrot (*Daucus carota*)	12.0	9.0	300.0	225.0	6.15	284.60	20.0	10.0	180.0	180.0	5.0	210.0	9.0	5.0	350.0	250.0	7.0	300.0
3. Onion (*Allium Cepa*)	6.0	5.0	1030.5	780.0	6.79	183.20	6.0	7.0	840.0	650.0	5.0	150.0	4.0	4.5	1100.0	900.0	7.5	200.0
4. Potatoes (*Solanum tuberosum*)	5.0	4.0	45.83	70.0	2.91	233.30	6.0	6.0	40.0	15.0	1.0	200.0	3.0	2.0	80.0	40.0	3.0	250.0
5. Radish (*Raphanus sativum*)	4.0	3.0	528.5	40.0	14.28	442.80	6.0	4.0	450.0	28.0	10.0	410.0	2.0	1.8	600.0	60.0	15.1	450.0
Other Vegetables																		
1. Bitter gourd (*Momordica charantia*)	8.0	3.0	200.0	150.0	13.0	700.0	9.0	4.0	175.0	120.0	10.0	600.0	5.0	1.5	250.0	200.0	13.0	750.0
2. Cauliflower (*Brassica oleracea*)	7.0	2.0	200.0	151.0	10.0	654.50	8.0	4.0	150.0	119.0	7.0	555.0	5.0	1.5	240.0	180.0	12.0	700.0
3. Cucumber (*Cucumis sativus*)	8.0	2.0	178.5	150.0	5.75	775.0	10.0	3.0	150.0	140.0	2.0	650.0	4.0	1.5	200.0	180.0	6.0	800.0
4. Okra (*Hibiscus esculentus*)	7.0	1.0	820.0	720.0	7.0	620.0	10.0	2.0	750.0	650.0	4.0	520.0	3.0	1.2	250.0	800.0	8.0	700.0
5. Peas (*Pisum sativum*)	5.0	2.0	203.50	150.0	16.78	1385.70	8.0	3.0	158.0	100.0	15.0	1100.0	3.0	1.2	250.0	250.0	17.0	1400.0
6. Tomato (*Lycopersicon esculentum*)	10.0	3.0	220.0	200.0	12.0	540.0	15.0	4.0	170.0	110.0	9.0	450.0	8.0	1.6	250.0	250.0	15.0	600.0

Table 5. Vitamin contents (per 100 grams dry wt.) of vegetables.

Name of Vegetables	Immature				Mature				Over Mature			
	A mg	B_1 mg	B_2 mg	Ascrobic acid mg	A mg	B_1 mg	B_2 mg	Ascorbic acid mg	A mg	B_1 mg	B_2 mg	Ascrobic acid mg
Leafy Vegetables												
1. Cabbage (*Brassica oleracea*)	0.35	0.81	1.25	450.0	0.36	0.84	1.26	475.0	0.28	0.80	1.50	470.0
2. Salad (*Pisonia alba*)	10.0	0.35	1.20	250.0	10.09	0.38	1.14	325.5	9.80	0.30	1.50	315.0
3. Spinach (*Spinacia oleracea*)	64.50	0.45	3.38	300.0	65.40	0.48	4.10	333.3	63.00	0.40	3.35	330.0
Roots and Tubers												
1. Beet root (*Beta Vulgaris*)	0.06	0.10	0.60	80.0	0.08	0.15	0.69	86.92	0.65	0.19	0.70	76.0
2. Carrot (*Daucus carota*)	13.20	0.28	0.10	40.0	14.54	0.31	0.15	42.46	14.10	0.35	0.18	38.0
3. Onion (*Allium cepa*)	–	0.51	0.71	80.10	–	0.60	0.77	86.92	–	0.55	0.80	72.0
4. Potatoes (*Solanum tuberosum*)	0.1	0.38	0.02	73.0	0.13	0.42	0.04	76.83	0.10	0.40	0.39	71.0
5. Radish (*Raphanus sativum*)	0.02	0.65	0.20	220.0	0.04	0.71	0.28	225.28	0.01	0.66	0.27	216.0
Other Vegetables												
1. Bitter gourd (*Momordica charantia*)	1.30	0.71	1.20	900.0	1.35	0.80	1.30	920.0	1.01	0.80	0.80	850.0
2. Cauliflower (*Brassica oleracea*)	0.36	0.33	1.21	550.0	0.39	0.36	1.79	570.0	0.35	0.34	1.52	500.0
3. Cucumber (*Cucumia sativus*)	0.28	0.39	0.19	80.0	0.30	0.40	0.20	89.28	0.20	0.30	0.16	75.0
4. Okra (*Hibiscus esculentus*)	0.59	0.91	1.20	158.0	0.60	0.89	1.1	160.0	0.43	0.75	0.75	150.0
5. Peas (*Pisum sativum*)	0.35	0.89	0.04	69.0	0.38	0.99	0.045	74.28	0.37	0.95	0.040	64.0
6. Tomato (*Lycopersicon esculentum*)	4.0	2.0	0.21	650.0	4.2	2.2	0.30	700.0	3.68	1.68	0.28	680.0

contents was 680 mg/100 g. Vitamin A,B_1 and B_2 were also found in greater proportions in the leafy vegetables as compared to roots and tubers. Vitamin B_2 was higher in bitter gourd, cauliflower, cucumber, okra, peas and tomatoes as compared to roots and tubers. Maturity had a significant effect on vitamin contents of almost all the veget-

Table 6. Post-harvest vitamin losses in mature vegetables during storage.

Name of Vegetables	One Day Storage				Two Days Storage				Three Days Storage			
	A %	B_1 %	B_2 %	C %	A %	B_1 %	B_2 %	C %	A %	B_1 %	B_2 %	C %
Leafy Vegetables												
1. Cabbage (*Brassica oleracea*)	32.0	10.5	13.0	35.0	38.0	14.3	17.0	44.0	43.5	24.8	23.0	63.0
2. Salad (*Pisonia alba*)	20.0	14.3	15.5	40.0	24.0	18.5	20.0	48.0	30.0	24.5	22.3	70.0
3. Spinach (*Spinacia oleracea*)	45.0	20.0	18.0	50.0	55.0	20.0	22.5	63.0	50.0	25.0	26.8	75.0
Roots and Tubers												
1. Beet root (*Beta Vulgaris*)	30.0	16.0	20.0	45.0	35.0	19.6	23.0	58.0	40.0	24.3	29.0	69.5
2. Carrot (*Daucus carota*)	35.0	18.0	20.5	45.0	45.0	20.0	24.0	60.0	50.0	24.8	30.0	72.0
3. Onion (*Allium Cepa*)	–	10.0	8.0	30.0	–	15.0	12.0	39.0	–	20.0	18.0	44.0
4. Potatoes (*Solanum tuberosum*)	14.0	5.0	7.0	40.0	16.5	7.5	8.3	49.5	20.0	10.0	12.6	60.6
5. Radish (*Rephanus sativum*)	21.0	10.0	9.0	48.0	24.0	15.0	14.0	62.0	29.0	18.0	17.8	73.5
Other Vegetables												
1. Bitter gourd (*Momordica charantia*)	35.5	25.0	27.0	45.0	47.0	30.5	32.5	58.0	51.5	35.0	38.0	71.0
2. Cauliflower (*Brassica oleracea*)	30.0	20.0	21.0	42.0	35.0	26.6	23.0	52.0	45.5	32.0	29.0	68.0
3. Cucumber (*Cucumis sativus*)	30.5	19.5	18.0	40.0	35.0	22.0	22.0	51.0	45.0	30.0	31.0	65.0
4. Okra (*Hibiscus esculentus*)	35.0	22.0	21.0	42.0	45.0	24.0	23.0	55.0	48.0	29.0	30.0	63.0
5. Peas (*Pisum sativum*)	30.0	18.0	19.5	40.0	40.0	23.0	25.0	50.0	49.0	25.0	27.0	60.0
6. Tomato (*Lycopersicon esculentum*)	40.0	23.0	20.0	46.0	46.0	26.0	23.0	58.0	50.0	30.0	27.0	70.0

ables. Vitamin contents increased with the maturity but decreased at the overmature stage. These results are supported by the findings of Sirtautaite [12] and Dokl who studied the changes in chemical composition of carrots and observed an increase in nutritional components during early days of storage which decreased thereafter. The changes in vitamins with the maturity could be attributed to the physicological changes occurring during maturity. At overmature stage the synthetic process ceases and degenerative processes start which result in decrease in nutritional value.

Vitamins Losses in Vegetables: Post-harvest vitamins losses in vegetables during storage are reported in Table 6. Vegetables were analysed for vitamins after storage at ambient temperature (20-31°) and relative humidity (50-79 %) for one, two and three days. In leafy vegetables vitamin C losses were 35-50 % after one day storage. It was 44-63 % after two days and 63-75 % after three days. Among roots and tubers, loss of vitamin C was 45-48 %, 58-62 % and 69-73 % after one, two and three day storage respectively. In bitter gourd the loss of vitamin C was upto 71.0 % after storage for three days. A similar trend was observed in other vegetables. Vitamin A,B_1 and B_2 contents of vegetables also decreased during storage (Table 6). Highest losses of these vitamins in various vegetables were noted after three day storage. Maximum losses in vitamin A (51.5 %), B_1 (30.0 %) and B_2 (38.0 %) were observed in the bitter gourd while potato tubers indicated the minimum losses of these vitamins i.e. 20.0, 10.0 and 12.6 % respectively. Variations in the losses of these vitamins in vegetables seem to depend upon the nature, maturity storage of vegetables, temperature, relative humidity and duration of storage as these factors have been reported to exercise pronounced effect on losses of these vitamins in vegetables. Muccio [11] recorded a significant loss in vitamin A, thiamine, riboflavin and ascorbic acid in carrots during storage at 5° for 12 to 14 days. Similar results have been reported by Sirtautaite and Dokl [12]. Dry weight was also observed to decrease to a considerable extent (6.5-28.7 %). Immature roots showed even the higher losses.

APPENDIX I

Questionnaire regarding losses at various stages

1. Mode of harvesting.
2. Losses during harvesting.
3. Time lag between harvesting and transportation.

4. Mode of transportation.
5. Losses during transportation.
6. Time taken for transportation.
7. Holding time at the whole sale market.
8. Losses at the whole sale market.
9. Commodities retained at retailer's shop.
10. Losses at retailer's shop.
11. Total losses.

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