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EFFECTS OF PACKINGHOUSE OPERATIONS ON SOME VEGETABLES PRIOR TO STORAGE IN COLD ROOMS OF HUMIFRESH REFRIGERATION SYSTEM

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RINGKASAN

Kesesuaian operasi rumah pembungkusan terhadap sayur-sayuran sawi, kacang panjang, kubis, kubis Cina dan tomato, sebelum penyimpanan di dalam bilik sejuk bersistem penyejukan 'Humifresh' telah diuji. Operasi rumah pembungkusan seperti pemilihan, pemotongan, pengelapan dengan kain lembab, pembasuhan, pengeringan selepas pembasuhan dan pra-penyejukan telah dicuba dan didapati sangat berfaedah terhadap setengah sayur-sayuran bagi mengurangkan kerosakan semasa penyimpanan. Dengan operasi rumah pembungkusan yang sesuai, sayur-sayuran di atas dapat disimpan masing-masing selama 1, 2, 8, 3 dan 2 minggu, di mana kira-kira 70% hasilan masih diterima dan sesuai untuk keperluan manusia. Kehilangan adalah berpunca dari penyejatan air, kerosakan fisiologi dan penyakit seperti kelayuan, penguningan, kecederaan suhu dingin, reput-busuk bakteria dan penyakit bintik berpusar.

INTRODUCTION

The present practices in handling of vegetables from farms to retail outlets need to be improved. It was estimated that the losses of vegetables between harvesting and retail sale ranged from 20% to 40%, which amounted to about M$26 million annually (ANON, 1981). Some of the main causes of post-harvest losses include improper harvesting practices, improper handling and transportation, and inappropriate storage methods. After harvesting, the preparation of the produce for the market should be done in the field or at any shaded location nearby. A packing shed or packinghouse may be simple or elaborate. The Federal Agricultural Marketing Authority (FAMA) has 24 packinghouse and cold room complexes throughout Peninsular Malaysia. The Tangkak Packinghouse Complex has six walk-in cold rooms using the Defensor humidification system, whereas the other complexes, including the Dengkil Packinghouse Complex use the Humifresh humidity and cooling system. In the Humifresh System the concept of 'direct contact heat transfer', by counter flow circulation of the air and chilled water over an efficient packing called the Filacell (trade mark) is followed.

Packinghouse complexes serve as a transit area where horticultural produce are subjected to packinghouse operations and stored for a considerable period prior to marketing. The basic packinghouse operations are sorting, sizing, grading and packing; however, it can also include trimming, degreening, curing, washing, drying after washing, hot water treatment, chemical treatment, fumigation, waxing and precooling (AKAMINE, KITAGAWA, SUBRAMANYAM and LONG, 1975). Sorting is done to remove parts which are unsuitable for sale. Washing removes foreign matters such as dirt, grit, trash, dust or visible traces of chemicals, moulds and other organisms and larvae on the surface of the produce (AKAMINE *et al.*, 1975; BAUTISTA and PANTASTICO, 1975; RYALL and LIPTON, 1972; FREY, WRIGHT and HOEHIN, 1974; ROBINSON, WRIGHT, HOEHIN and GEERING, 1977). However, not all vegetables can economically be washed since washing may affect the physiological changes of the produce. ABD. SHUKOR, ROHAYA and AB. AZIZ (1981) recommended that brinjal, long beans, chillies and tomatoes should only be washed if they are heavily contaminated with field residues. However, on the contrary, FELLERS and PFLUG (1967) found that washing of cucumber may reduce the storage life to half that of unwashed fruit. Furthermore, AKAMINE *et al.*, (1975) reported that field washed tomatoes may

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have an increased incidence of bacterial soft rot and necrosis.

An important factor prior to storage is precooling. The faster the produce is cooled to the storage temperature the longer they can be kept in good marketable conditions during storage. BAUTISTA and PANTASTICO (1975) reported that a 10°C reduction in temperature decreased the rate of respiration by half and doubled the keeping period of produce. ABD. SHUKOR *et al.* (1981) stressed the necessity of rapid cooling to reduce the rate of respiration, since the field heat of local vegetables have been recorded in the range of 28°C to 33° Centigrade. They further conducted several trials to study the suitability of packinghouse operations on seven types of lowland vegetables namely mustard, okra, brinjal, long beans, cucumber, tomatoes and chillies. They found that suitable packinghouse operations for brinjal, okra, long beans, cucumber, tomatoes and chillies were initial selection, sorting and precooling by half cooling time while washing, and drip drying after washing can be applied to mustard conducted in the Tangkak Packinghouse Complex. Hence, the need to study the suitability of packinghouse operations on some vegetables prior to storage in cold rooms of Humifresh system.

This paper reports several trials on packinghouse operations for some vegetables in the Dengkil Packinghouse Complex as representing cold rooms of the Humifresh refrigeration system.

MATERIALS AND METHODS

Vegetables

Five types of local vegetables namely mustard (*Brassica juncea*, local name 'Sawi'), long beans (*Vigna sesquipedalis*), cabbage (*Brassica oleracea* var *capitata*), Chinese cabbage (*Brassica chinensis* var *pekinensis*) and tomatoes (*Lycopersicon esculentum*) were used in the trials. Mustard and long beans were bought from Seremban while cabbage, Chinese cabbage and tomatoes were bought from Cameron Highlands. Harvesting were done by farmers at the commercial stage of maturation. Vegetables were transported to the Dengkil Packinghouse Complex using FAMA refrigerated truck.

Experiments

Vegetables obtained from farm were subjected to suitable packinghouse operations described by BAUTISTA and PANTASTICO (1975); and ABD. SHUKOR *et al.* (1981) as follows:

1. Mustard : Sorting, trimming, washing, drip drying after washing and precooling.
2. Long beans : Sorting and precooling.
3. Cabbage : Sorting, trimming and precooling.
4. Chinese cabbage : Sorting, trimming and precooling.
5. Tomatoes : i. Sorting, grading, washing, drip drying after washing and precooling.
   ii. Sorting, grading, wiping with moist cloth and precooling.

Vegetables were packed in medium size bamboo baskets of about 30 kg capacity and lined with paper. Tomatoes received were of mixed stages of maturity. In this trial, only turning and pink tomatoes were available for use. The produce were then covered with plastic sheet and arranged in front of the precooler unit situated inside the cold room set at 3°C–5°C and cooled by its half cooling time in one to two hours. Vegetables without any packinghouse operation were used as control.

The produce were stored at their nearest recommended storage temperature. Vegetables were stored in either 5°C or 10°C (± 2°C) since only two cold rooms were available at preset temperatures. Mustard, cabbage, Chinese cabbage and long beans were stored at 5°C, while tomatoes at 10° Centrigrade. Observations were carried out to determine the storage lives. Data were obtained on weight loss due to evaporation, damage and rotting; and acceptability after storage. Upon removal from cold rooms,

vegetables were kept at ambient condition for about 24 hours to simulate retail display.

RESULTS AND DISCUSSION

The effects of packinghouse operations prior to storage in cold rooms of the Humifresh refrigeration system for mustard, long beans, cabbage, Chinese cabbage and tomatoes are presented in *Tables 1* to *5* respectively. Generally, losses were mainly due to the loss of water, physiological damage and rotting. Water loss due to transpiration was accompanied by shrivelling and wilting. However, in the Humifresh system, the high relative humidity of about 90%–95% may reduce the rate of transpiration. Physiological damage and rotting were the major causes of losses and short storage lives of vegetables in Humifresh system.

Vegetables that showed symptoms of chilling injury (watery soaked sunken spots, colour turned dull and darker), wilting, yellowing, anthracnose (diseased spots or patches of dark brown and black colour) and soft rot (diseased areas which are soft and smelly) were observed at the end of the storage periods. Deterioration may be due to the improper packinghouse operations and storage conditions for certain vegetables. As observed by PANTASTICO, CHATTOPADHYAY and SUBRAMANYAM (1975); RYALL and LIPTON (1972); ABD. SHUKOR and LAM, (1980); ABD. SHUKOR *et al.* (1981); MOHD. SALLEH and LAM (1983) the optimum storage temperature for leafy vegetables such as mustard, cabbage and Chinese cabbage was close to 0°C with a relative humidity of about 90%–95%, while for non-leafy vegetables such as long beans and tomatoes were between 5°C–12°C with a relative humidity of about 85%–90 per cent. Disorders and diseases may increase as the storage conditions were not at their optimum (RYALL and LIPTON, 1972). However, ABD. SHUKOR *et al.* (1981) also suggested that leafy and non-leafy vegetables can generally be stored at temperatures ranging from 0°C–5°C and 8°C–12°C respectively, but the storage life may be shorter as compared with the produce stored at optimum condition.

The basic packinghouse operations for mustard are sorting, trimming, washing, drip drying after washing, and precooling. There were no marked differences in weight loss due to transpiration, but the above operations showed a lower percentage in damage as compared to the control *(Table 1)*. Disorders were mainly due to yellowing and rotting. Yellowing was observed particularly on exposed surfaces. This may be caused by ethylene gas produced by other commodities in the same cold room (PANTASTICO *et al.*, 1975). Bacterial soft rot caused by *Erwinia carotovora* can also affect wet produce (ECKERT, 1977). Mustard leaves used in this experiment were not completely dried after washing.

Table 1. The percentage losses in weight after one and two weeks storage of mustard* at 5°C ± 2°C in Humifresh refrigeration system

Treatment	Storage period (weeks)	Weight loss (%) of mustard	
		Transpiration	Damage
Packinghouse operation**	1	4.0	28***
	2	8.0	57***
Control	1	5.0	46
	2	7.0	81

*Average of four replicates @ about 15 kg per sample
**Sorting, trimming, washing, drip drying and precooling
***Significant difference at P = 0.01

After two weeks storage, only about 40% mustard were still acceptable, while the rest were totally unfit for human consumption *(Table 1)*. Therefore, the suitable keeping period was about one week, where about 70% mustard were still edible even after about one day exposure at ambient condition.

Long beans obtained from field were almost clean and free from any foreign matter hence washing was not essential (ABD. SHUKOR *et al.*, 1981). Therefore, the sufficient packinghouse operations for long beans are sorting and precooling. However, there were no marked differences in both weight losses due to transpiration and damage between treated and untreated beans. This could be due to the good quality samples received from farm, because farmers usually presorted the beans manually during harvesting. The damages occurred during storage were mainly due to chilling injury and diseases. Beans were reported to be susceptible to chilling injury when stored at temperatures below 5°C (PANTASTICO *et al.*, 1975; ABD. SHUKOR and LAM, 1980). The diseases appeared as deep black spots and watery soft rot which may be caused by *Colletotrichum lindemuthianum* and *Sclerotinia sclerotiorum* respectively (ECKERT, RUBIO, MATTO and THOMPSON, 1975). The above disorders resulted in 30% and 75% weight loss of beans after 2 and 2½ weeks storage respectively *(Table 2)*. Hence, the maximum keeping period is about two weeks at 5°C in cold room of Humifresh system with allowable exposure period of about one day at ambient condition.

The suitable packinghouse operations for cabbages are sorting, trimming and precooling. The results showed that water loss was slightly higher in both treatments as compared with other vegetables, although relative humidity in the room was in the range of 85%–90% *(Table 3)*. The same result was observed by PARSONS (1959), especially when cabbages were packed in unlined containers even though the relative humidity was about 92 per cent. The losses were about 14% after eight weeks in storage. High moisture loss resulted in wilting and shrinkage especially on the outer leaves. Hence, it is suggested that one or two outer leaves which are slightly damaged (by mechanical means) should remain after trimming so as to prevent deterioration on edible layers. Damages were significantly less when cabbages were treated with proper packinghouse operations. They were mainly due to wilting, shrinkage, yellowing, sprouting and rotting. Sprouting which might be caused by the high moisture in the room, started from the internal head, growing slowly until the head cracked and burst. Black rot caused by *Xanthomonas campestris* is the most serious market disease of cabbage (ECKERT *et al.*, 1975). The base of the stem and the outer head leaves become soft due to secondary invasion by bacterial soft rot. Trimming improved the appearance and consumer's acceptability of the remaining edible portion. About 74% and 64% cabbages were still edible after eight and 10 weeks storage respectively, when they were subjected to packinghouse operations. The acceptability remained unchanged even after one or two days exposure to ambient condition.

Table 2. The percentage losses in weight after 2 and 2½ weeks storage of long beans* at 5°C ± 2°C in Humifresh refrigeration system

Treatment	Storage period (weeks)	Weight loss (%) of long beans	
		Transpiration	Damage
Sorting and precooling	2	16	14
	2½	19	56
Control	2	18	18
	2½	21	57

*Average of three replicates @ about 15 kg per sample

Table 3. The percentage losses in weight after 8 and 10 weeks storage of cabbage* at 5°C ± 2°C in Humifresh refrigeration system

Treatment	Storage period (weeks)	Weight loss (%) of cabbage	
		Transpiration	Damage
Sorting, trimming and precooling	8	14	12**
	10	17	20**
Control	8	15	29
	10	18	35

**Significant difference at P = 0.05

*Average of three replicates @ about 24–28 kg per sample

Chinese cabbages were subjected to the same packinghouse operations as performed on cabbages. Although there were no marked differences in weight losses, the treated cabbages were slightly higher in remaining edible leaves and better in appearance at the end of storage period *(Table 4)*. The insignificant differences may be due to the sample received, where almost all were already trimmed and ready for the markets. For the purpose of this trial, trimming prior to storage was only done on one or two layers which were bruised or damaged during transportation. Water loss was relatively low at less than 10% in both treatments. Hence, wilting is not the major cause of losses. Deterioration was mainly caused by yellowing and diseases. The disease which can be observed as black specks, occurred in almost all leaves especially on the outer. The specks resembled early stages of alternaria spot which is more common on outer leaves of cabbages (RYALL and LIPTON, 1972). About 73% and 58% edible cabbages remained after three and four weeks storage with proper packinghouse operations. One to two days exposure at ambient condition after cold storage did not affect their appearance and acceptability.

There were no significant differences in any form of losses among the three treatments for tomatoes *(Table 5)*. However, the wiped tomatoes showed slightly higher acceptability in terms of better appearance. The insignificant losses may be due to the samples used, which were apparently clean and in good marketable condition. Damages were mainly due to shrinkage, over ripe and rotting. Anthracnose caused by *Colletotrichum phomoides* could be seen as small lesions on the skin and finally became a watery rot (ECKERT *et al.*, 1975). Bacterial soft rot caused by *Erwinia carotovora* occurred particularly on damaged fruits

Table 4. The percentage losses in weight after 3 and 4 weeks storage of Chinese cabbage* at 5°C ± 2°C in Humifresh refrigeration system

Treatment	Storage period (weeks)	Weight loss (%) of Chinese cabbage	
		Transpiration	Damage
Sorting, trimming and precooling	3	6	21
	4	8	34
Control	3	7	28
	4	10	37

*Average of four replicates @ about 50 kg per sample

Table 5. The percentage losses in weight after 2 and 2½ weeks storage of turning and pink tomatoes* at 10°C ± 2°C in Humifresh refrigeration system

Treatment	Storage period (weeks)	Weight loss (%) of tomatoes	
		Transpiration	Damage
Sorting, washing, drip drying and precooling	2	2	28
	2½	3	76
Sorting, wiping and precooling	2	2	24
	2½	4	69
Control	2	2	27
	2½	2	71

*Average of three replicates @ about 20 kg per sample

either during handling, preparing or storage (RYALL and LIPTON, 1972). The above diseases were easily observed on washed tomatoes due to the moist and bruised skin after washing. It is suggested that if washing is very essential because of heavy field residue contaminations, then the fruits should be sufficiently dried. The longest storage life in FAMA cold room was found to be about two weeks where more than 70% tomatoes were still acceptable. Even when exposed about one day at ambient after removal from cold room, the fruits were still edible and in good condition.

CONCLUSION

Vegetables should be subjected to proper packinghouse operations as presented in *Table 6*. Although the benefits of some operations were not significant in some vegetables during the trials, the data showed a tendency towards better appearance and a reduction in losses. The factors affecting the quality and storage life of vegetables when stored in the FAMA Humifresh cold rooms were not only due to improper market preparation prior to storage, but also due to the unoptimum

Table 6. Storage lives and acceptability when vegetables were subjected to proper packinghouse operations and cold storage in Humifresh refrigeration system

Vegetable	Storage life (weeks)	Acceptability after storage (%)	Cold room used*	Packinghouse operations
Mustard	1	68	Precooler/ Storage	Sorting, trimming, washing, drying after washing and precooling.
Long beans	2	71	"	Sorting and precooling.
Cabbage	8	74	"	Sorting, trimming and precooling.
Chinese cabbage	3	74	"	"
Tomato	2	74	Storage	Sorting, wiping with moist cloth/ towel, and precooling.

*Precooler/storage room – Temperature 5°C ± 2°C
Relative humidity 85% – 90%

Storage room – Temperature 10°C ± 2°C
Relative humidity 80% – 85%

storage conditions of the cold rooms for certain vegetables. Some vegetables, especially leafy vegetables deteriorated very fast because the rooms were also storing other produce including ethylene producing fruits and vegetables. The quality as well as storage life were not at the optimum as obtained by other researchers. However, with suitable packinghouse operations, the produce were still marketable after a few weeks in cold storage and can be exposed at ambient condition in shaded areas for about 24 hours.

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SUMMARY

The suitability of packinghouse operations on vegetables namely mustard, long beans, cabbage, Chinese cabbage and tomatoes prior to storage in cold rooms of the Humifresh refrigeration system were tested. Packinghouse operations such as sorting, trimming, wiping with moist cloth, washing, drip drying after washing, and precooling were tried and found to be very useful for some vegetables in reducing deterioration during storage. With proper packinghouse operations, the above vegetables could be kept for 1, 2, 8, 3 and 2 weeks respectively, where about 70% (w/w) produce were still acceptable for human consumption. Losses were mainly due to water evaporation, physiological damage, wilting, yellowing, chilling injury, bacterial soft rot and anthracnose.

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