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Effect of packaging on the quality of minimally processed long bean (*Vigna sesquipedalis* L.)

(Kesan pembungkusan terhadap kualiti kacang panjang (*Vigna sesquipedalis* L.) yang diproses secara minimum)

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Key words: packaging types, minimally processed, quality changes, storage life

Abstract

Long beans (*Vigna sesquipedalis* L.) were cut into 3–4 cm long and packed in three different types of packaging namely 500 ml round-shaped polypropylene (PP), airtight polyvinyl chloride (aPVC) and non-airtight polyvinyl chloride (nPVC) containers. Samples were stored at 2 °C and evaluated every 3 days of the 14 days of storage. Quality observation was based on physical and chemical changes, rate of respiration and ethylene production. The shelf life of minimally processed (MP) long bean was 14 days at 2 °C. Changes in total titratable acidity (TTA), ascorbic acid (AA) content, CO_2 concentration and the rates of O_2 consumption and ethylene production of MP long bean were reduced significantly (p <0.05) when stored at 2 °C. There were significant (p <0.05) differences in the percentage of weight loss, pH and concentrations of O_2 and CO_2 among types of packaging used, but the TTA, AA content and the rate of ethylene production were not significantly (p >0.05) different.

The percentage of weight loss of MP long bean increased significantly (p <0.05) (1.34%) when packed in nPVC and stored at 2 °C and caused the samples to dehydrate. The symptom was not seen in samples packed in PP or aPVC containers. MP long bean softened and became soggy quickly. This might be due to condensation of water vapour as the by-product of the respiration process and reduction in O_2 concentration in packages that encouraged alcoholic fermentation. Microbiological analysis of MP long bean indicated the reduction in coliform contamination, but the count of yeast and mould increased during storage period. Therefore, for a commercial purpose, packing of MP long bean in PP container is a better choice and more suitable as compared to aPVC and nPVC, since the freshness of the product can be maintained for a longer period.

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Introduction

Long bean (*Vigna sesquipedalis* L.) belongs to Leguminaceae family. The fruit length measures between 50–80 cm depending on varieties. Long bean can be stored for 3–7 days at 10 °C (90% RH). The minimally processed long beans were partially prepared and served as a light meal during the peak season and was available in the market. Such a product no longer requires additional preparation before use (Watada and Ling 1999). Generally, the product is prepared for restaurants, dining commons, fast food outlets and occasionally for retail markets.

In recent years, the production and sale of ready-to-eat vegetables (washed, sliced or shredded, cut and trimmed, and packed) has increased tremendously. Minimal processing usually increases the degree of perishability, due to the disruption of cell/tissue and the breakdown of cell membranes; increases in the respiratory rate (Wong et al. 1994); ethylene production (Gordon 1992), surface dehydration and total moisture loss (Barry-Ryan and O'Beirne 1998) thus limiting the product's shelf life (Lownds et al. 1994).

Suitable storage temperature and types of packaging are important factors in maintaining the quality and extending the shelf life of MP vegetables (Osornio and Chaves 1998). Packaging can prevent the produce from drying or by creating an atmosphere with a high relative humidity and can modify the headspace atmosphere yielding high level of CO_2 and reducing the level of O_2. Packaging can also be used for showing the maturation of the fruits and vegetables and delaying changes in acidity, soluble solids, texture, colour and polygalacturonase (Nakhasi et al. 1991) and reducing water loss (Wall and Berghage 1996). Convenience and maintaining an attractive appearance of fresh vegetable or fruit products can be offered when using suitable packaging materials (Bussel and Kenigsberger 1975).

In this study attempts were carried out to evaluate the effect of packaging materials on quality of minimally processed long bean and also to decide the most suitable type of packaging for storing MP long bean. Temperature surrounding the products was also monitored to relate with any quality changes.

Materials and methods

Handling operations

Commercial maturity long beans (*Vigna sesquipedalis* L.) used in the study were bought fresh at a local market in Sungai Besi, Kuala Lumpur. Samples were brought to the Minimal Processing Laboratory (MPL) at MARDI Serdang, Selangor. Upon arrival at the laboratory, samples were sprayed and washed with 100 ppm chlorinated water to remove dirt and also to reduce the microbial loads prior to cutting.

Samples were sorted and selected to remove the physiological defects and/or off-cut pieces. Only samples that were free from mechanical injuries were used in this study. Samples were cut into 3–4 cm trimmed form and then immersed in chilled water containing 1% calcium chloride for about 1–2 min. Samples were drip-dried to free the excess water prior to packing. Samples were then packed using 500 ml round-shaped polypropylene (PP) container with lid. Each pack had an average net weight of 150 g. Samples were stored at 2 °C, 88–90% of relative humidity. Evaluations of the samples were conducted every three days by taking three containers from each type of packaging. The analyses were done in triplicates.

Physical and chemical analyses

Physical appearance based on colour, texture, taste and odour was observed visually on the evaluation day. The percentage of weight loss of the cut long bean sample was obtained by measuring the difference in weight before and after storage. Analyses of the chemical parameters were carried out on the same day after taking the weight loss. Samples for the chemical analyses were blended using a blender. The pH of samples was measured using an

Origon digital pH meter (Model SA 520) and total titratable acidity was determined by titrating the known volume of homogenates solution with 0.1 N NaOH to an end point of pH 8.1 using digital burette (Shaw et al. 1987). The AA content was determined by titrating with 2, 6-dichlorophenolindophenol (Ranganna 1977). Analyses were carried out in triplicates.

Gases in the package

Measurements of gases, carbon dioxide (CO_2) and ethylene (C_2H_4) were taken according to the day the sample was removed from the storage room. The gas samples were measured using a closed system. A syringe through a septum in the package was used to draw the gases.

One milliliter (1,000 µl) of the C_2H_4 gas sample was injected into a Perkin Elmer Auto System_XL gas chromatography fitted with flame ionization detector (FID) and a stainless steel column packed with Porapak T of 100/120-mesh size. Simultaneously, CO_2 was detected using a different detector (thermal conductivity detector; TCD) with a stainless steel column packed with Porapak R of 80/100-mesh size. The flow rate of the purified helium gas was 30 ml/min and the column oven was operated at 50 °C and 100 °C for CO_2 and C_2H_4, respectively. Helium was also used as a carrier gas at a same flow rate and the injector temperature was 35 °C. Three replicates of sample were analysed.

The same amount of O_2 gas sample was detected using a TCD gas chromatograph (Varian 1420) fitted with a 1,500 mm x 3 mm stainless steel column packed with Porapak R of 80/100-mesh size. Helium was also used as a carrier gas at a same flow rate and the injector temperature was 35 °C. Three replications were used for each analysis.

Microbiological analysis

Standard microbiological procedures were used for the analysis of the samples (ICMSF 1978). A sample of 10 g of randomly sampled long bean was homogenised with 90 ml Ringers solution using a Seward Stomacher Lab Blender 400 for 1 min. Suspension was held for 30 min to allow the larger particles to settle. Appropriate serial dilutions were made and 1 ml volume of appropriate decimal dilutions was poured on plate using total plate count agar (TPCA) and potato dextrose agar (PDA) to determine total viable count, yeast and mould count, respectively. Microbial colony was counted after 48 h of incubation at 37 °C. For detection of coliform and *E. coli*, the Multiple Tube Dilution Method was used by using MacConkey Broth as a medium. Most Probable Number (MPN table) was used to examine the positive tube for the various dilutions. All media were from Difco (Difco Laboratories, Detroit MI).

Statistical analysis

Experiment was designed by using completely randomised design (CRD). For data analyses, the SAS (Statistical Analysis System) program was used (SAS Inst. 1985). The values obtained were subjected to analysis of variance (ANOVA) and tested using Least Significant Difference (LSD) for different types of packaging and storage periods (Gomez and Gomez 1984).

Results and discussion

The percentage of weight loss of minimally processed (MP) long bean packed with different types of packaging was significantly different ($p < 0.05$) during storage at 2 °C *(Table 1)*. Weight loss of MP long bean packed with airtight containers (PP and aPVC) was only 0.09% and 0.12%, respectively during 14 days of storage at 2 °C, whereas samples packed in nPVC container showed higher weight loss (1.27%) resulting in surface dessication after 6 days of storage at 2 °C *(Figure 1)*. Similar observation was reported by Bussel and Kenigsberger (1975) on green bell peppers. Kays (1991) indicated that the maximum acceptable moisture loss (%) of chilli is

Table 1. Changes in physical, chemical and rate of respiration and ethylene production of minimally processed long bean packed in different types of packaging and stored at 2 °C for 14 days

Types of packaging	Weight loss (%)	pH	Total titratable acidity (%)	Ascorbic acid (mg/100 g)	O_2 consumption (%)	CO_2 concentration (%)	C_2H_4 production rate (µl/kg/h)
PP	0.09b	5.17b	0.153a	3.37a	12.38a	1.90b	0.436a
aPVC	0.12b	5.27a	0.149a	3.17a	8.40b	4.15a	0.434a
nPVC	1.27a	5.19b	0.158a	3.48a	10.69ab	0.69b	0.516a

PP = Polypropylene
aPVC = Airtight polyvinly chloride
nPVC = Non-airtight Polyvinyl chloride
Each value was the mean of three replicates. Means with the same letter are not significantly different at 5% level (p <0.05*)*

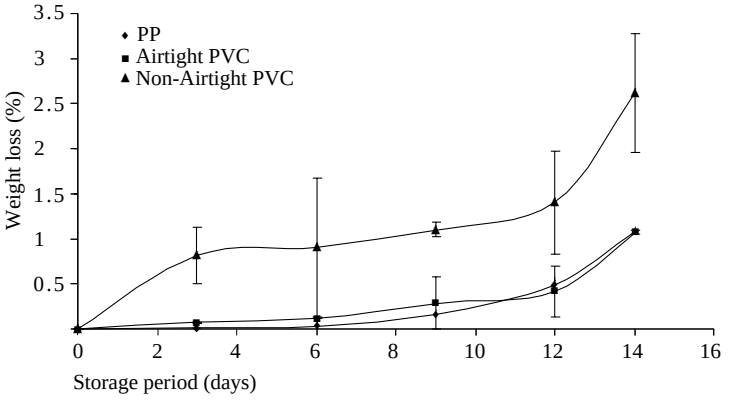

Figure 1. Effects of different types of packaging on percentage of weight loss of minimally processed long bean stored at 2 °C for 14 days

about 12.2%. According to Lownds et al. (1994), packaging material can reduce water loss rate up to 20 times or more at each storage temperature. Thus, air-tightness of containers affected permeability and water loss of sample. The occurrence of water condensation in nPVC provides condition for faster decay development (wilted, shriveled, brown, inedible) compared to other packages.

There was no significant difference (p >0.05) in the total titratable acidity (TTA) of MP long bean packed in the different packing materials during storage at 2 °C *(Table 1)*. The TTA value ranged between 0.15% (aPVC, PP) and 0.16% (nPVC). The reduction of TTA was gradual from 0.15% (day 0) to 0.13% (day 14) in PP and nPVC but rapid from 0.15% (day 0) to 0.12% (day 14) in aPVC packages *(Figure 2)*. Visually, this reduction is parallel with production of fermented aroma and softening of the MP long bean. In most cases, the concentrations of TTA tend to decline during postharvest storage of horticulture produce (Wills et al. 1981; Kays 1991). The increase in TTA of MP long bean during storage was probably due to the increase in CO_2 inside the packages.

In dark storage with high CO_2, at least two mechanisms can increase the TTA value:
(1) Pyruvic acid that can be converted to malic acid by enzyme, and
(2) Phosphoenolpyruvate carboxylase that is capable to catalyse phosphoenolpyruvate to oxalicacetic acid (Kays 1991).

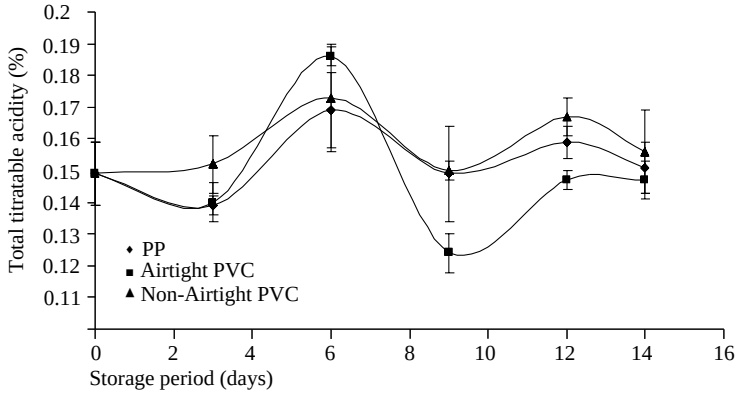

Figure 2. Effects of different types of packaging on total titratable acidity of minimally processed long bean stored at 2 °C for 14 days

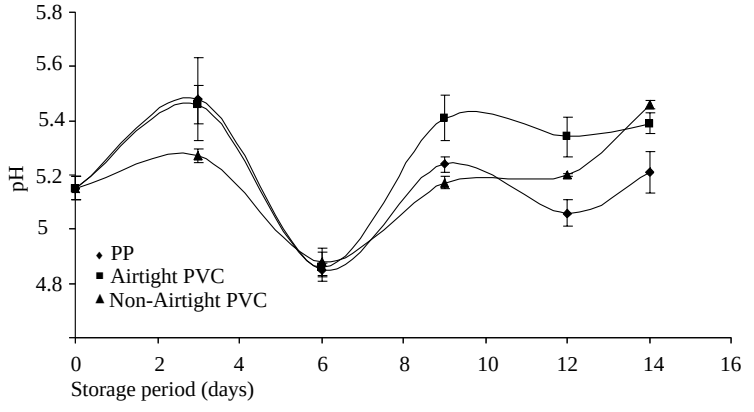

Figure 3. Effects of different types of packaging on pH of minimally processed long bean stored at 2 °C for 14 days

This is due to the much larger improvements obtained by small reduction of storage temperature. The pH value of MP long bean packed in different packing systems had shown significant difference (p <0.05) during the period of storage at 2 °C *(Figure 3)*. The pH value of MP long bean packed in PP was slightly lower (5.17) as compared to nPVC (5.19) and aPVC (5.27).

Ascorbic acid (AA) content of the MP long bean was not affected by packaging materials during storage at 2 °C *(Table 1)* as no significant differences (p >0.05) were observed. The AA content was slightly higher (3.37 mg/100 g) for MP long bean packed with PP container as compared to nPVC (3.48 mg/100 g) and aPVC (3.17 mg/100 g). However, the AA content of all samples was reduced throughout the storage period *(Figure 4)*. Adisa (1986) reported that the loss of ascorbic acid depends on storage temperature rather than on the length of storage period. Microbial growth can also cause a decrease in ascorbic acid content.

Commodities stored in controlled atmosphere (CA) and modified atmosphere packaging (MAP) had better retention of ascorbic acid as compared to storage in the open air (Eris and Turk 1996). The limited air in the package was expected to restrict the oxidation of ascorbic acid by the oxidase enzyme or by other degenerating oxidases produced during pathogenesis (Adisa 1986).

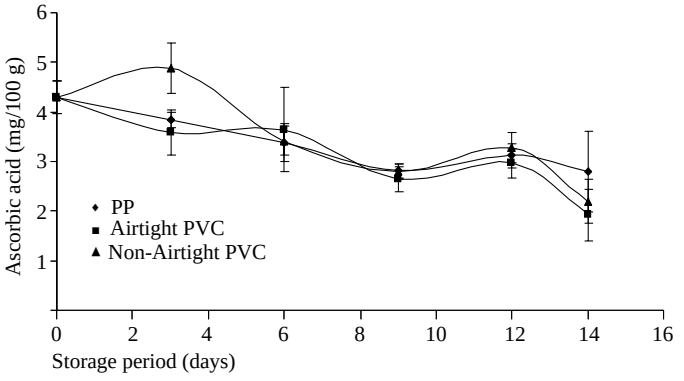

Figure 4. Effects of different types of packaging on ascorbic acid of minimally processed long bean stored at 2 °C for 14 days

The role of ascorbic acid as an antioxidant in many fruits is well documented. Ascorbic acid is known to be an enzymatic browning inhibitor caused by polyphenol oxidase and has the ability to convert quinones back to phenols (Miller and Heilman 1952; Lambrecht 1995). Reduction in ascorbic acid content was always associated with the increase of surface browning (Wong et al. 1994).

Significant difference (p <0.05) was observed between PP and aPVC packages but not with nPVC package in CO_2 concentration of minimally processed long bean during storage at 2 °C *(Table 1)*. More CO_2 accumulated in aPVC (4.15%) and PP (1.90%) containers compared to the nPVC container (0.69%), which is probably related to the C_2H_4 stimulated respiration of the MP long bean *(Table 1)*. However, the CO_2 concentration of samples packed in aPVC and nPVC was decreased but the PP packing increased throughout the storage period *(Figure 5)*. The activity of several decay organisms can be reduced by high concentration of CO_2 (>10%) (Wills et al. 1981).

The respiration rate in all containers was not affected by storage duration. Kader (1986) reported that injury could occur if the commodities cannot tolerate high CO_2. Carbon dioxide has an inhibitory effect on ethylene-induced softening (Rosen and Kader 1989), and anaerobic conditions may create off-flavour of the product. Increased respiration rate results in internal browning and spoilage of bell pepper (Bussel and Kenigsberger 1975; Kays 1991). If a produce can tolerate a high CO_2 atmosphere, the breakdown of pectic substance can be inhibited, hence, firmness can be retained for a longer period. Furthermore, flavour retention may also be improved (Salunkhe and Desai 1984) and chilling injury can be reduced (Weichmann 1987). Non-airtight PVC (nPVC) package allowed the release of CO_2 to outside atmosphere and this result was supported by Zaulia et al. (2001) on red chilli.

The production rate of ethylene (C_2H_4) in all MP long bean packed in different types of packaging were significantly different (p <0.05) during storage at 2 °C *(Figure 6)*. However, there was no significant difference (p >0.05) in ethylene production rate *(Table 1)*. The ethylene production rate of MP long bean packed with PP was slightly lower (0.436 µl/kg/h) compared to aPVC (0.434 µl/kg/h) and nPVC (0.516 µl/kg/h) *(Table 1)*. Ethylene production rate of PP packed samples was significantly reduced when storage was prolonged. The increased rate of ethylene production in long bean as a response to mechanical damage has been reported on other produce, which also has an effect on their physiology and quality (Baldwin 1994).

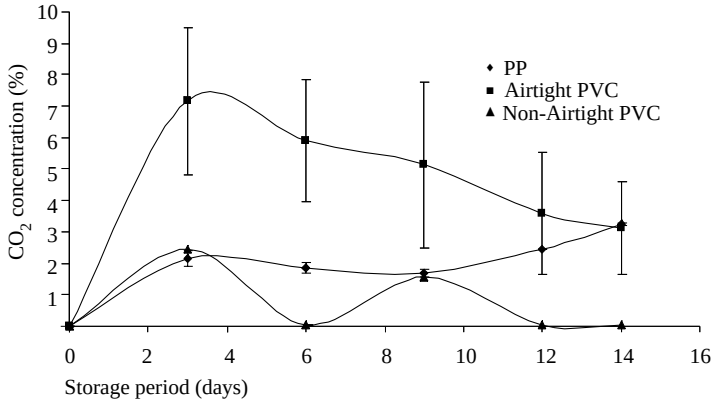

Figure 5. Effects of different types of packaging on CO_2 concentration of minimally processed long bean stored at 2 ℃ for 14 days

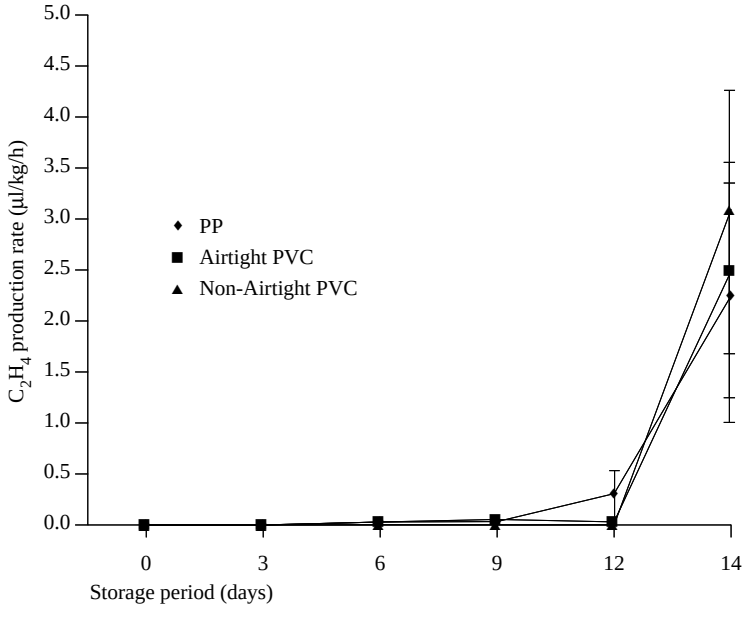

Figure 6. Effects of different types of packaging on ethylene production rate of minimally processed long bean stored at 2 ℃ for 14 days

Ethylene is always associated with senescence tissue (Wills et al. 1981). Ethylene can accumulate in sealed packaging and causes undesirable changes to the quality of the products (Abe and Watada 1991).

The O_2 concentration differred significantly (p <0.05) with different types of packaging stored at 2 °C *(Table 1* and *Figure 7)*. The highest concentration (12.38%) was observed in PP packing followed by nPVC (10.69%) and aPVC (8.40%).

The total yeast and mould count (TYMC), observed in the PP packing, decreased at early storage at 2 °C on day 0 (2.12×10^6) until the end of storage period at day 14 (6.80×10^5) (cfu/g). Similar trend was also detected in total viable count (TVC) where it decreased to 3.10×10^3 until after 14 days of storage *(Table 2)*.

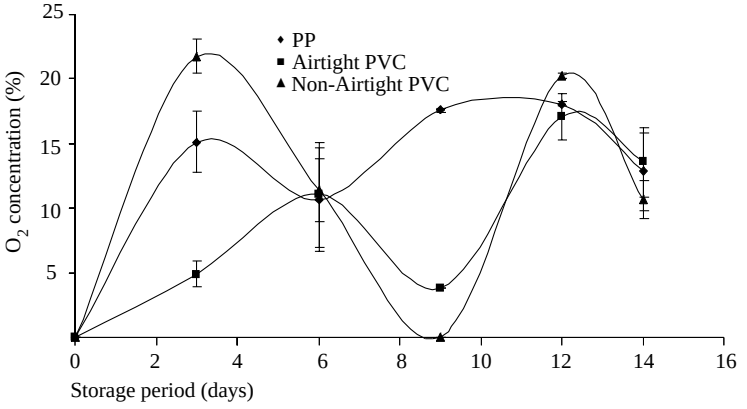

Figure 7. Effects of different types of packaging on oxygen consumption of minimally processed long bean stored at 2 °C for 14 days

Table 2. Microbiological changes of minimally processed long bean packed in different types of packaging and stored at 2 °C for 14 days

Storage period (day)	Types of packaging	Yeast and mould (cfu/g)	Total viable count (cfu/g)	Coliform (MPN/g)
0	PP	2.12 x 10^6	1.19 x 10^4	>240
	aPVC	2.12 x 10^6	1.19 x 10^4	>240
	nPVC	2.12 x 10^6	1.19 x 10^4	>240
3	PP	7.90 x 10^5	1.11 x 10^4	>240
	aPVC	7.20 x 10^5	2.07 x 10^4	>240
	nPVC	1.11 x 10^6	1.48 x 10^4	>240
6	PP	7.74 x 10^6	1.64 x 10^4	>240
	aPVC	8.00 x 10^5	1.01 x 10^4	160
	nPVC	1.42 x 10^6	1.07 x 10^4	>240
9	PP	7.60 x 10^5	7.70 x 10^3	>240
	aPVC	9.80 x 10^5	4.70 x 10^3	160
	nPVC	1.60 x 10^6	7.51 x 10^3	92
12	PP	7.10 x 10^5	3.60 x 10^3	4.9
	aPVC	1.68 x 10^6	3.60 x 10^3	22
	nPVC	1.42 x 10^6	1.07 x 10^4	35
14	PP	6.80 x 10^5	3.10 x 10^3	2.3
	aPVC	1.72 x 10^6	3.20 x 10^3	13
	nPVC	2.02 x 10^6	4.0 x 10^3	22

PP = Polypropylene
aPVC = Airtight polyvinly chloride
nPVC = Non-airtight Polyvinyl chloride

There was a slight significant difference (p <0.05) in the TYMC count for the MP long bean packed in aPVC (1.72 x 10^6) and nPVC (2.02 x 10^6) cfu/g after 14 days of storage at 2 °C. Counts for TVC of product in aPVC and nPVC packs on the 14 days of storage were 3.2 x 10^3 and 4.0 x 10^3 cfu/g, respectively *(Table 2)*. Minimally processed long bean packed with PP can be stored more than 14 days without obvious microbiological quality changes. However, samples packed with aPVC and nPVC can be stored less than 14 days. Coliform was detected in all samples packed

in all packing materials throughout the storage period but *E. coli* was not detected *(Table 2)*.

The nature of the product, atmospheric conditions during storage and overall resistance of the package to the passage of moisture, atmospheric gases and odours, size of the package in relation to its cubic capacity generally are influencing the shelf life of the packaged products (Paine 1969). The PP packing material was found to be better than aPVC and nPVC for storing MP long bean for at least 14 days at 2 °C.

Contamination may occur upon opening the samples packed in aPVC and nPVC. Once the package is opened, the remaining pieces need to be stored in other container for further storage consumption. The use of PP container was more suitable for packing MP long bean either for small size samples or for commercial purposes. The quality of the products was maintained when packed in PP container, but not in aPVC or nPVC container.

Conclusion

Polypropylene (PP) container provided the best condition and is the most suitable type of packaging for minimally processed (MP) long bean with the storage life can be extended up to 14 days at 2 °C. Minimally processed (MP) long bean packed using nPVC suffered rapid dessication, whereas aPVC caused condensation within the package which favoured the microbial growth. Significant differences (p <0.05) in the percentage of weight loss, pH, and concentrations of O_2 and CO_2 between the PP packaging and other packaging (aPVC, nPVC) of MP long bean stored at 2 °C indicated the advantage of using PP packaging either for small scale or commercial production.

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Abstrak

Kacang panjang (*Vigna sesquipedalis* L.) yang telah dipotong kepada saiz 3–4 cm dan dibungkus menggunakan tiga jenis pembungkus yang berbeza iaitu bekas polipropilena (PP) bulat, polivinil klorida kedap udara (aPVC) dan polivinil klorida 500 ml tidak kedap udara (nPVC). Semua sampel disimpan pada suhu 2 °C dan kualiti produk dinilai setiap 3 hari penyimpanan selama 14 hari. Penilaian kualiti merangkumi perubahan fizikal dan kimia, kepekatan CO_2, kadar penggunaan O_2 dan pengeluaran etilena. Hayat simpanan kacang panjang yang diproses secara minimum (MP) ialah 14 hari pada suhu 2 °C. Perubahan kandungan jumlah asid tertitrat (TTA) dan asid askorbik (AA), penggunaan O_2 dan kepekatan CO_2, dan kadar pengeluaran etilena bagi kacang panjang yang diproses secara minimum adalah berkurangan secara bererti (p <0.05) apabila disimpan pada 2 °C semasa tempoh penyimpanan. Juga terdapat perbezaan (p <0.05) bererti antara jenis-jenis pembungkusan terhadap peratus kehilangan berat, pH, penggunaan O_2 dan kepekatan CO_2, tetapi tiada perbezaan (p >0.05) bererti terhadap kandungan TTA, AA dan kadar pengeluaran etilena.

Peratus kehilangan berat bagi MP kacang panjang menunjukkan peningkatan (p <0.05) yang bererti (1.34%) apabila menggunakan bekas nPVC yang menyebabkan sampel mengalami pendehidratan. Simptom ini tidak dapat dilihat pada sampel di dalam bekas PP dan aPVC. Kacang panjang yang diproses secara minimum menjadi lembik dan kembang dengan cepatnya. Ini kemungkinan disebabkan kondensasi wap air pernafasan dan pengurangan kandungan O_2 di dalam pembungkus yang seterusnya menyebabkan berlakunya fermentasi alkohol. Analisis mikrobiologi bagi kacang panjang yang diproses secara minimum menunjukkan pengurangan kontaminasi koliform dan peningkatan bilangan yis dan kulapuk semasa tempoh penyimpanan. Oleh itu, untuk pembungkusan MP kacang panjang bagi kegunaan komersial, bekas PP ialah pilihan yang baik dan lebih sesuai berbanding dengan aPVC dan nPVC memandangkan kesegaran produk boleh bertahan lama.

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