MALAYSIAN GREEN CAPSICUM: GAMMA IRRADIATION EFFECTS

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ABSTRACT

Capsicum is an important agricultural crop, not only due to its economic interest, but it is also a rich source of ascorbic acid. As capsicum is susceptible to damage such as wilt, shrunken or crease and water loss that will reduce its' qaauality, thus a thorough post-harvest management are needed. Capsicum have a short life span of 2-3 weeks at a temperature of 7.5 ° C after harvest. Various ways were done to extend capsicum shelf life which is by controlling the temperature during storage and proper handling. However, capsicum storage at temperature below 5°C can causing chilling injury. Therefore, capsicum need a new proper method of handling and technology to reduce post-harvest loss. Among introduced new technology is food irradiation using gamma rays. A harvest capsicum were cleaned and divided into 3 groups and irradiated with different doses of 0.00 kGy (control), 1.50 kGy and 2.25 kGy. Physical parameters (weight, colour, FAMA index, and wrinkle formation) and chemical (level of sugar and ascorbic acid) were analysed on 1st, 5th, 9th, 13th, 17th and 21st day of storage. As a result, the percentage of ascorbic acid and sugar content (Brix %) in capsicum (0.0 kGy) has a higher value than capsicum that have been irradiated. Colour changes of capsicum did not show significant differences in all capsicum. For weight loss, all capsicum decreased with storage time but the capsicum irradiated at 1.50 kGy had the slowest decline than others on 9th day to 21st day of storage. In conclusion, dose of 1.50 kGy is the optimum dose in extending capsicum shelf life for 4 days with small or no significant difference with the control.

ABSTRAK

Capsicum adalah tanaman pertanian yang penting, bukan sahaja kerana kepentingan ekonominya, tetapi ia juga merupakan sumber asid askorbik yang kaya. Oleh kerana capsicum terdedah kepada kerosakan seperti kelonggaran, kekuningan atau lipatan dan kehilangan air yang akan mengurangkan 'qaauality', maka pengurusan pasca panen yang menyeluruh diperlukan. Capsicum mempunyai jangka hayat pendek 2-3 minggu pada suhu 7.5 ° C selepas musim menuai. Pelbagai cara telah dilakukan untuk memanjangkan hayat likat capsicum iaitu dengan mengawal suhu semasa penyimpanan dan *pengendalian yang betul. Walau bagaimanapun, penyimpanan limau pada suhu di bawah 5 ° C boleh menyebabkan kecederaan yang mengerikan. Oleh itu, capsicum memerlukan kaedah pengendalian dan teknologi baru untuk mengurangkan kehilangan pasca panen. Antara teknologi baru yang diperkenalkan ialah penyinaran makanan menggunakan sinar gamma. Capsicum penuaian dibersihkan dan dibahagikan kepada 3 kumpulan dan disiradi dengan dosis yang berbeza 0.00 kGy (kawalan), 1.50 kGy dan 2.25 kGy. Parameter fizikal (berat, warna, indeks FAMA, dan pembentukan kedutan) dan kimia (tahap gula dan asid askorbik) dianalisis pada hari pertama, ke-5, ke-9, ke-13, ke-17 dan penyimpanan. Hasilnya, peratusan asid askorbat dan kandungan gula (Brix%) dalam kapikum (0.0 kGy) mempunyai nilai yang lebih tinggi daripada capsicum yang telah disinari. Perubahan warna kapsul tidak menunjukkan perbezaan ketara dalam semua capsicum. Untuk penurunan berat badan, semua capsicum berkurangan dengan masa penyimpanan tetapi capsicum yang disinari pada 1.50 kGy mempunyai penurunan yang paling perlahan berbanding yang lain pada hari ke-9 hingga penyimpanan 21 hari. Kesimpulannya, dosis 1.50 kGy adalah dos optimum dalam memperluaskan hayat laptikum selama 4 hari dengan perbezaan kecil atau tiada perbezaan ketara dengan kawalan.*

INTRODUCTION

Malaysian capsicum has been widely planted uphill which has cold and tropical climate around 7-29 ° C. Major plantation of capsicum can be found in Cameron Highland, Kundasang and Lojing (FAMA 2012). There are various colours of capsicum in the market such as green, yellow and red consist from varieties of type such as California Wander, King, Green Giant and Winner Alberto F1 (Holland) (FAMA 2012). Nowadays, the demand for this fruit in Malaysia is high due to easy preparation and crunchy to consume with other vegetables. In Malaysia, capsicum is known as sweet chillies or big pepper, while as botanical name known as *Capsicum anuum L.* from Solanaceae family (FAMA 2012). In 2012, Department of Agriculture, Fisheries and Forestry (DAFF), Australia had taken an alternative to irradiate tomato and capsicum as a quarantine measure for their imported foods to treat fruit fly and other pests (FSANZ 2014). Irradiation of food has been a proven technique to decontaminate microorganism which affects the half-life and quality of food products. Gamma irradiation is a common method in producing beneficial induced mutation in crops due to simple application (Omar et al. 2008). This method is widely use especially for dried capsicum and herbs to yield a better product.

Capsicum has several advantages to consume in daily life includes avoiding cardiovascular illness; atherosclerosis; cancers; bleeding; delaying aging process; and improving physical resistance and appetite (Marin et al. 2004). Capsicum has a short half-life around 2-3 weeks in 7 ° C temperature after harvesting, but in room temperature the half-life is less than 2 weeks (Cantwell 2008). Many researches have study irradiated capsicum seeds due to significant benefit to crop and mankind. The study of capsicum plant from irradiated seeds showed that the seeds irradiated at 0.3 and 0.4 kGy do not affect survival of plants while irradiated seeds at 0.5 to 0.8 kGy were severely affected (Omar et al. 2008). Other study in Indonesia has used gamma irradiation to increase capsicum resistance against *Begomovirus* infection which impact capsicum yield (Gaswanto et al. 2016)

Compared to other vegetables, capsicum is categorized in a group of vegetable which have tendency to be damage after harvesting such as mechanical damage and insects' infection. *Begomovirus* infection is an example of the virus transmission by *Bemisia tabaci* insect (Gaswanto et al. 2016). Green capsicum is very susceptible to be dehydrated and heat damage causes rapid wrinkles and changes in color in a few days without cold storage (Gonzalez-Aguilar et al. 1999).

Therefore, capsicum need a new technology to enhance it half-life in cold storage and decrease the damage after harvesting. This will help in import and export application as being done by many countries including Malaysia. Based on Food Irradiation Regulations 2011 in Food Act 1983, fresh fruits and vegetables can be irradiated up to 2.5 kGy for shelf-life extension, and up to 1 kGy for delay ripening and quarantine control (Malaysia 2011). This study will represent the chemical and physical changes of irradiated fresh green capsicum after harvesting by changes of capsicum weight, sugar content, vitamin C content and surface changes such as colour or wrinkles production.

METHODOLOGY

A group of green capsicum of FAMA Index 1 was harvested at Cameron Highland and cleaned with water to remove the impurities. Then, it was divided into 3 groups represents the radiation dose of 0 kGy (control), 1.5 kGy and 2.25 kGy using Gamma cell 220 Excel. Each group was divided into 3 subgroups consist of 3 parameters measured in this study (weight loss, sugar content, and vitamin C content). The samples of each parameter were measured and observed in several storage time intervals: 1 d, 5 d, 9 d, 13 d, 17 d and 21 d. All samples were stored in refrigerator with temperature of 7 ° C during the experiment period.

For measurement of weight loss, the capsicum from each group are weighed using electrical balance. The calculation of percentage weight loss (WL) is calculated based on Eq. (1):

$$WL\ (\%) = \frac{(W_b - W_i)}{W_b} \times 100 \qquad (1)$$

where W_b is the weight of fruit before irradiated, and W_i is the weight of irradiated fruit at i = 1, 5, 9, 13, 17 and 21 day.

As for sugar content measurement, the capsicum is smashed into pulp to make capsicum solution (juice), then the level of sugar content is measured using pocket refractometer (Model PAL-1, Atago) which covers 0 to 53% Brix.

The determination of vitamin C content are based on ascorbic acid content in capsicum. There are two sections for this test which are, i) preparation of solution, and ii) titration. In section one, there are four solution that need to be prepared which is dichlorophenolindophenol (DCPIP), metaphosphoric acid-acetic acid (HPO_3-HAc), standard acid ascorbic solution and capsicum juice. For the second section which is titration, the solution needed are standard ascorbic acid solution and capsicum juice. The titration of standard acid ascorbic solution will be done to get the standard curve. After that, the concentration of capsicum ascorbic acid will be calculated by titration of capsicum juice and using standard curve.

Finally, the surface changes from control and irradiated capsicum are observed for any colour changes determined by FAMA indexes and wrinkles production.

RESULTS AND DISCUSSION

Percentage weight loss

Figure 1 shows the weight loss of all capsicum increases with storage time. The figure also shows that the lowest percentage weight loss of capsicum at 21st day is irradiated capsicum at 1.50 kGy followed by control and 2.25 kGy with percentage of 7.15 %, 9.12 % and 10.43 % respectively. The weight loss for 1.50 kGy irradiated capsicum have a slow and steady rate of weight loss from 1st day until 21st day. This shows an agreement of peach fruit behavior when irradiated at 1.2 kGy to 1.4 kGy, which shows extension of shelf-life from 6 to 20 days at room temperature and cold storage (Wani et al. 2008). Despite the weight loss, all irradiated capsicum shows no significant changes compared to control.

The weight loss is mainly due to water loss during respiration of capsicum. Respiration is a chemical process that decompose sugar and oxygen into carbon dioxide, water and heat (Becker et al. 2016). Respiration affected by a few factors such as light, chemical pressure, temperature, atmospheric composition and physical pressure (Saltveit 2016).

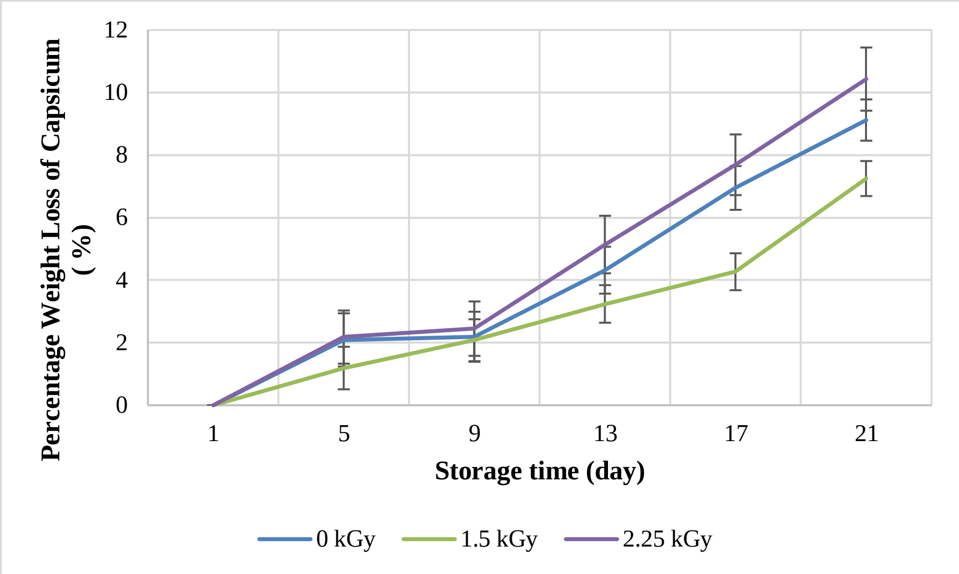

Figure 1. Percentage weight loss (%) of capsicum against storage time (day)

Sugar content (% Brix)

In addition, radiation also affects the level of sugar content in capsicum. Figure 2 shows the amount of granulation in the amount of sugar content in capsicum with increasing storage time. The level of sugar content was found to increase during the initial storage for several days and then decreased again. As stated by Mukherjee and Dutta (1967) the increase in sugar content in initial storage is due to the change of carbohydrates and other polysaccharides into soluble sugar. The decrease of sugar level in the later stage of storage is due to the increase in respiration rate whereby the sugar is used in oxidation process in Kreb's cycle (Singh 1980).

The highest level of sugar content was noted on 21st day by control capsicum followed by irradiated capsicum at 1.5 kGy and 2.25 kGy, which is 5.70 %, 4.93 % and 4.63 %, respectively. Overall, control capsicum shows high sugar content compared to the irradiated capsicum and this result agrees with Reddy (2009) which states the sugar content decreases when the radiation dose is increases. There are very low differences of irradiated capsicum sugar content compared to control.

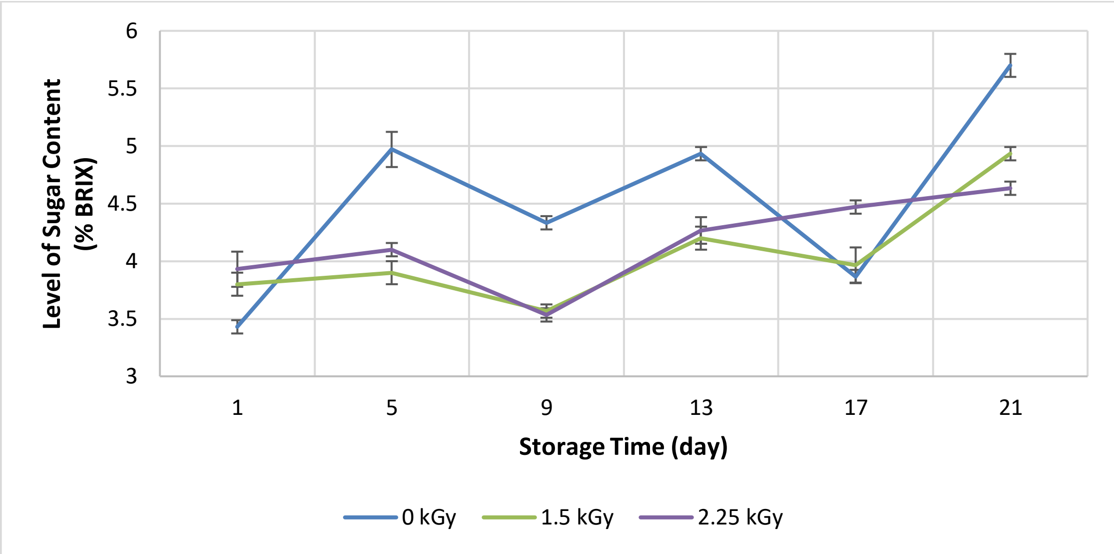

Figure 2. Level of sugar content (Brix %) against storage time (day)

Ascorbic acid content

Based on Figure 3, the percentage of ascorbic acid in capsicum is shown. As the storage time increases, the percentage of ascorbic acid are also increases by assuming the value of ascorbic acid content of all capsicum was 100% at first day of storage. Figure 3 clearly shows that control capsicum has high percentage of ascorbic acid compared to others. The increase in gamma radiation dose reduces the level of ascorbic acid. This is caused by the rapid conversion of ascorbic acid to dehydroascorbic acid with the presence of enzymatic ascorbic acid (Baghel et al. 2005). It is also confirmed by Tobback (1977) that ascorbic acid is highly sensitive to ionizing radiation where the ascorbic acid converts dehydroascorbic acid when irradiated. As a result, radiation causes ascorbic acid in capsicum to decrease when the dose is higher.

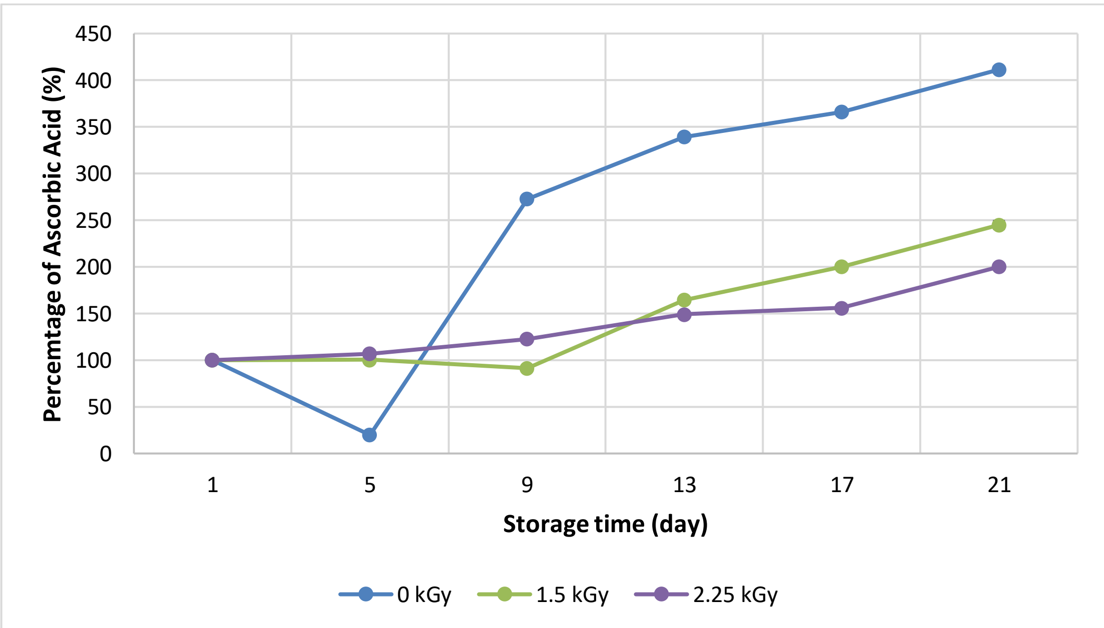

Figure 3. Percentage of ascorbic acid (%) against storage time (day)

Effect of radiation on capsicum surface

Figure 4 shows the effect of radiation on capsicum surface. On the 1st day of storage, results show that capsicum harvested is according to FAMA index 1 which is not fully ripe with young green colour. Around one week to 15th day, the capsicum was observed under FAMA Index 2 for both control and irradiated capsicum. Starting at 17th day of storage, the control capsicum and 2.25 kGy irradiated capsicum starting to degrade and wrinkles are observed formed on the surface while 1.50 kGy irradiated capsicum is still in good condition with FAMA index 3. On 21st day of storage, all observed capsicum is overripe. At this stage, the commercial value of the capsicum is very low or none. Wrinkles formed are related to weight loss and this result supports the data of weight loss of capsicum against storage time.

Storage time (day)	**Dose (kGy)**		
	0.00 (Control)	**1.50**	**2.25**
1			
	Index 1	Index 1	Index 1
5			
	Index 1	Index 1	Index 1
9			
	Index 2	Index 2	Index 2
13			

	Index 2	Index 2	Index 2
17			
	Index 3	Index 3	Index 3
21			
	Overripe	Overripe	Overripe

Figure 4: Effect of radiation on capsicum surface

Overall observation of gamma radiation affecting capsicum can be summarized to be successfully extends its shelf-life around 4 days. This could be seen at 17th day of storage time, the percentage of around 7 % weight loss observed for control capsicum and 2.25 kGy irradiated capsicum, compared to 1.5 kGy irradiated capsicum observed to have similar weight loss at 21st day. The results also supported by physical observation and other measurements.

CONCLUSION

In conclusion, gamma irradiation of 1.5 kGy is the optimum dose which can extend the shelf-life of capsicum form 17th days up to 21st day while having a small significant change to its physical and chemical properties.

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