THE ENHANCEMENT OF PHYTOCHEMICAL COMPOUNDS IN FRESH PRODUCES
BY ABIOTIC STRESS APPLICATION AT POSTHARVEST HANDLING STAGE
A REVIEW

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ABSTRACT

Fresh produces is one of functional food based on its phytochemical contents. The great amounts of the phytochemical compounds in fresh produces become the main core of quality judgement from fresh produces as a functional food. The use of proper postharvest handling system of fresh produces can be as a tool to protect the loss of the external quality and also can be used to enhance the levels of phytochemical compounds therein at the same time. A good management of plant stresses in respect to key enzymes activation of phytocemicals pathway during postharvest handling treatments of fresh produces can trigger distinct change of contained phytochemicals that can promote their healthy beneficial effect for human life.

Keywords: fresh produces, postharvest handling, enhancement, phytochemical compounds

INTRODUCTION

Many researchers have been informing the potential for exploitation of plant products as a source of beneficial compounds for the production of nutraceuticals, functional foods and food additives (Gil-Chávez et al., 2013). The consumption and acceptance of functional food has been increasing on customers in conjunction with the awareness that by healthy eating is a better way to administer drugs used instead of disease (William, 2006). Due to the increasing of consumers health awareness there is shift on their judgment of food quality form apperance to judging the quality based on nutritional value (Kader, 2003 and Klee, 2010). The consideration to the need of high content of healthy beneficial nutritional compounds has been strengthened by the willingness of a group of consumer to spent more money to obtained these kind of food (Klee, 2010).

One of functional food resources from plants, can be obtained form fresh produces (fresh fruits and vegetables). It is well known that fruit and vegetables are important components of a healthy diet, and their continous consumption may help to prevent major diseases, such as cardiovascular diseases (Pieter van’t Veer, 1999; Wang et al., 2014; Ness et al., 2005), certain cancers (Pieter van’t Veer, 1999; Soerjomataram et al., 2010), and anti obesity (Nuutila et al., 2003; Singh et al., 2007). Epidemiologic studies have also shown many health benefits associated with the consumption of fruit and vegetables (Hung et al., 2004;
McCann et al., 2005). Consumption of fruit and vegetables to help in the deterrence of free-radicals, thereby reducing oxidative damage which can lead to several chronic diseases (Hung et al., 2004; Prior, 2003).

The beneficial effects of fruits and vegetables has been associated with non-essential constituents, known as phytochemicals or bioactive compounds, which have a related bioactivity when they are often consumed as part of a daily diet (Mudgal et al., 2010). The kind of these phytochemical consist of a wide range of objects. The commonly phytochemicals that contained in plants including in fruit and vegetables are phenolic compounds, alkaloids, terpenoids, steroid and glucosinolate. A range of phytochemicals have been reported in fruit and vegetables and are typically grouped based on function, chemical structure and also based on source. A beneficially fresh produces will have high value if the high concentration of their phytochemical compounds can maintained from farmer to consumer, thus, after harvest handling play an important role in this stage. Basically, the produce quality that is imprescriptible, can not be improved significantly after harvest, which is expected to only execute for a window of time (shelf life) typical (Suslaw T, 2000).

Postharvest handlings such as cleaning, sorting, packaging, transportation, storage, postharvest treatments practices including food processing and non toxic substances application involve in level of phytochemical compounds in fresh produces. There are two main factors; storage factors and postharvest treatments practice that have be considered (Tiwari and Cummins, 2013 ; Schreiner and Keil, 2006). The optimization of these factors is an essential step to maintain and/or enhance the level of phytochemicals that affected to their bioactivity.

The consideration of these factors is in association of fresh produces response to the stresses that obtain during this stage. Due to their natural as living organism, fresh produces marketable property can be affected by various condition such as temperature and humidity changed, the composition of the atmosphere, the level of harm microorganism which surrounding them and injury condition. Inappropriate condition will cause the undesirable stress that can produce the loss of fresh produce quality such as appearance, texture, color, flavor and nutritional value including the phytochemical compounds. Therefore, to meet the shift in consumer needs to high level of phytochemical compounds in fresh produces that promote to their healthy life without avoiding the need for external quality attributes of its fresh produces, good knowledge about storage, nontoxic substances additive and food processing need to be a consideration point at postharvest practice stage to meet the consumer satisfaction.

According to Ayala-Zavala et al., 2005, the exposure postharvest treatments such as temperature storage treatments, UV-C irradiation, maturity effectors, atmosphere modification, minimal processing and chemical application to fruits and vegetables affected to their phytochemicals level. Baenas et al (2014) mentioned that the enhancement production of phytochemicals on fresh produces can be applied during postharvest practice by using elicitors treatment.
Postharvest handling management of fruits and vegetables with certain limits can prolong their shelf life. The use of proper postharvest handling system elevate nutritional value such using the low temperature storage, heat treatment, irradiation to increase phytochemicals compounds which become the most desirable phenomenon during distribution of fresh produces. Therefore, the study of postharvest handling in order to maintain/enhance phytochemical compounds in fresh produces must be taken into consideration for developing novel postharvest technology.

Therefore, aims of this brief review are to present an overview of the fresh produces storage and processing treatments as the postharvest handling practice in association with their elicitation affect to enhance the contained beneficial phytochemical compounds and to discussion the implications of this in term of postharvest research development.

THE PROPERTIES OF FRESH PRODUCE PHYTOCHEMICALS

Naturally, fresh produces contain in rich abundance of phytochemicals (Rechkemmer, 2001). As a secondary metabolites in plants including in fresh fruits and vegetables, phytochemicals mostly exert their biological effect on other organisms and environment as defensive substances, antifeedants, attractants and pheromones (Hanson, 2003). Therefore, due to the huge compound of phytochemicals make the classification of them is complicated. Generally, there are four main classes of phytochemicals that widely studied on fresh produces: phenolic compounds, terpenoids, glucosinolates, alkaloids (Crozier et al., 2006). In association of food consumption, phytochemicals perform tremendous in vitro antioxidative ability which hypothesized has close relationship with human healthiness (Duthie et al., 2000). Due to the antioxidant activity of phytochemicals that contained in fresh produces make some people classify fruits and vegetables as functional foods (Laura A. de la Rosa et al., 2010).

The fact that most of phytochemicals act as antioxidant attribute fruit and vegetables becomes important components of a healthy diet, and their continuous consumption may help to prevent many major diseases. Consumption of fruit and vegetables to help in the deterrence of free-radicals, thereby reducing oxidative damage which can lead to several chronic diseases (Hung et al., 2004; Prior, 2003). Need to confirm that consume of phytochemicals in fresh produces may help to prevent from major deseases but may not to cure. Therefore, people need to realized that sustainable eating a healthy diet such as fruits and vegetables that containing high level of phytochemical compounds is an inherent need to preserve their healthiness. The epidemiological study informs that well consumption of high content phytochemicals fruits and vegetables with no smoking habits and contonously infection control combination can reduce the emergence of several chronic deseases including cardiovascular disease and different type of cancer (Ames et al., 1995; Graham and Mettlin, 1981; Giovannucci, 1999; Liu, 2004; Syngletary et al., 2005; Percival et al., 2006). Consequently, the World Health Organization (WHO) recommends a high consumption of fruits and vegetables in a daily with minimum intake as 400 g per person . Increasing and maintaining
phytochemicals level in the fresh produces is one concerted effort to raise public interest about the advantage of consuming health-promoting phytochemicals in fresh produces themself.

The level of a particular phytochemicals in different fruits and vegetables varies depending on cultivar (Nuutila, et al., 2003; Singh, et al., 2007), cultivar variation, climatic conditions, growing locations, agronomic factors, harvest factors (including maturity stage) (Naczk & Shahidi., 2006; Padilla et al., 2007; Vallejo et al., 2003). Apart from these pre-harvest factors, various postharvest handling factors also have a major influence on the existence of phytochemicals in fruits and vegetables and their products. In distribution chain of fresh produces from farmer to consumers, postharvest handling factors play an important role in correlation with quality maintanance of fresh produces product including their contained phytochemicals level.

According to Rajashekar et al (2009), as the antioxidants, the phytochemicals as the product of plant secondary metabolism appear to have similiar protective fuction in plants against oxidative damage caused by various stresses. To cope with the stresses, basically plants have two kind of strategy that they can tolerate it or can either avoid it (Hodges et al., 2004). However, to tolerate oxidative stress with an adaptive mechanism, plants tend to shift toward secondary metabolism in accumulating the production of phytochemicals protective antioxidants. Therefore, with a proper enviromental controlled stress application on fresh produces may organize a facility to improve their containied beneficial health-promote phytochemicals (Rajashekar et al., 2009). For example, among many kinds of flavonoid in plants, flavonols are the most abundant flavonoids in plants and probably the most important flavonoids participating in stress responses that having a wide range of potent physiological activities (Stafford, 1991; Pollastri and Tattini, 2011).

However, enviromental controlled stress application (abiotic stress) as an external stressfull signal, is not directly involved in the phytochemicals metabolism of plants, instead of activating its coresponding efectors such as nitric oxide (NO), this data has been discused by jiao et al.,2016 on their experiment that succesfull to generate of NO that induced isoflavones by UV-B treatment. Their results showed that UV-B-triggered NO generation induced isoflavone accumulation by up-regulating the activity and gene expression of key enzymes (phenylalanine ammonia lyase, PAL; chalcone isomerase, CHI; chalcone synthase, CHS; isoflavone synthase, IFS) that participate in isoflavone biosynthesis.

**POSTHARVEST HANDLING PRACTICE IN ASSOCIATION WITH PHYTOCHEMICALS IN FRESH PRODUCES**

As been known that biological effect of fruits and vegetables is came form the the amounts and types of phytochemicals that are present in the fresh tissues. As mentioned previously, to enhancing the synthesis of phytochemicals in postharvest handling stage of fresh produces, applied the controled abiotic stresses as an elicitor can activating an array of mechanisms, similar to the defense responses to pathogen infections or environmental stimulating and triggering the plant metabolism activity (Baenas et al., 2014). Typical
abiotic elicitor treatments has been used in postharvest handling practices to enhance the phytochemical content and quality composition in many fruits and vegetables, such as the application of low or high temperature treatments, atmosphere controled/modified, wave irradiation, surface coating application, minimal process operation and chemical elicitors application. As mentioned previously, that storage factors and food processing operation are the main concern of pyhtochemical stability in fresh produces at postharvest handling stage, the application of elicitor treatments have been done on these factors.

In application of temperature control, the application of temperature stress is often related to enhanced activities of enzymes involved in antioxidant systems of plants. Plants exposed to uncomfortable temperatures will use several non-enzymatic and enzymatic antioxidants to cope with the harmful effects of oxidative stress; higher activities of antioxidant defense enzymes are correlated with higher stress tolerance. Different plant have revealed that enhancing antioxidant defenseconfers stress tolerance to either high temperature or low temperature stress (Hasanuzzaman et al.,2013).

In addition to controled temperature, enviromental modification during fresh produces postharvest handling by increasing oxygen concentration in the internal and external fruits atmosphere can cause the increase in the production of free radicals that could result in oxidative stress in the fresh produces tissue. This condition can triggering responses of the antioxidant system and affected to occurence of phytochemical compounds include their bioactivity (Ayala-Zavala et al.,2007). It can be concluded that strengthening in oxidative stess modification in fresh produces tissue during storage become an intresting subject to be developed that make postharvest treatment not only enhance the fresh produces shelf lafe but may also elevate their healthy benefecial effect.

According to Tiwari and Cummins (2013), food processing operations as a post handling practice are a kind of applied postharvest technology that controllable to optimize in order to reduce of loss phytochemicals in fresh produces them self. Minimal processing operation such as cutting will effect to injuries occured in fresh produces, either naturally or mechanically in cellular disruption and can allow enzymes to come into contact with their substrate, water loss and oxygen entry can trigger stress and defence response including modulation of the metabolic pathway leading to altered expression of phytochemicals such as phenolic compounds. According to Alarcón-Flores et al (2014), among phytochemicals, phenolic compounds are most easily influenced by cutting injuries.

The use of wave irradiation in postharvest handling practice such as gamma, ultraviolet and other specific wavelength irradiation also can promote the production of phytochemicals in fresh produces. Enzym activation such as PAL activation by UV irradiation involved in increasing phenolic compounds that similair to low temperature effect (Rajashekar at al.,2009). Futhermore, improvement of constitutive inhibitor such as antimicrobial compounds and phytoalexins and activation of specific proteins such as chitinase and glucanase also activied by irradiation stress that exposed surround the fresh produces (Forbes and Smith, 1999).
Another kind of postharvest handling treatment such as application surface coating by non toxic additive substances also can stimulate the enhancement of phytochemicals of fresh produces. For example, edible coating application has beneficial effect to increasing phytochemicals in fresh cut produce during postharvest handling practice. Usually, edible coating material can protect the products against oxidative rancidity and discoloration (Baldwin et al., 1995). In the correlation with phytochemicals development, edible coating can inhibit enzyme phenylphenol oxidase activation which can cause degradation phenolic compounds in fresh cut produces (Jiang et al., 2005).

STORAGE PRACTICE AS ELICITORS

Low or high temperature storage

Shelf life of fresh produces under ambient condition is very limited due to the increase in the rate of respiration after harvest that make them are more susceptible to disease organisms. The respiration of fresh fruits and vegetables can be reduced with many techniques such as low-temperature preservation, canning, dehydration, freeze-drying, controlled atmosphere, and hypobaric and modified atmosphere. Dehydration also control the activities of microorganisms by the removal of water under controlled conditions of temperature, pressure and relative humidity.

Metabolic rate of fruits and vegetables are directly associated to a variety of storage enviromental condition such as temperature, light and atmosphere (Hopkin and Huner, 2009). Storage treatments is one effort in postharvest stage with approaches to enhance shelf life of fresh produces with basicly priciple that revolved in trying to maintain respiration rate, desease development and decay formation by various methods such as temperature controlling, humidity controlling, controlling or modified of existence of oxygen. Among these storage methode, the selection of a proper temperature and manipulation the axistence of oxgen were the ways that reported can be as an elicitor to enhance the level of phytochemicals as healty beneficial compounds in fresh produces (schreiner and Keil, 2006). Mainly, temperature control and controled/modified atmosphere methods are critical conditions in maintaining respiration rate of the products during storage in correlation with metabolic activity.

In postharvest handling stage such as storage practice, the phytochemical compounds biosynthesis stimulate consistenly. In case the metabolic activity was due to the applied storage conditions. Therefore, harvesting time affected to the profile of phytochemical compounds in fresh produce. According to schreiner and Keil, 2006, premature and on time mature harvesting time with good maintainance of respiration rate in optimal storage temperature will increasing the phytochemicals when products were still in the ripening process. This phenomenen are more pronounce at higher temperature of up to 25°C. In the consideration of proper storage temperature selection, product’s physiology need to be adjusted. In consequence product’s genotype, chiling injury sensitivity will have a close relationship with the elicitation activity during optimal storage treatment of fresch produces.
For instance, the evolution of the content of some major flavonols was measured in red and white onion bulbs during 7 months of storage, under refrigerated and under traditional bulk storage in the field has reported by Rodrigues et al (2010). The report informed that total flavonols increased up to 64% after 6 or 7 months of storage. In the red onions, the increase after 6 months storage usually has place when the flavonol post-harvest levels are low (40–64% increase), whereas for white onions the increase after 6-months storage is important for onions with higher levels after harvest (44–60% increase). These results suggest that storage at fluctuating ambient temperatures can positively affect flavonol metabolism, while keeping the flavonols profile.

Comparison of the effect of two different storage temperatures on the quantity of flavonoids in the persimmon fruit reported by Tulin OZ and Kefalas (2010), the profile of persimmon fruit flavonoids at three different maturation stages at 20°C and 0°C was studied. The highest level is found at 20°C. The fluctuation of the flavonoid profile was more extended at 20°C than at 0°C, where the levels between the first and the second development stages were practically the same. At 20°C the levels of flavonoids increased significantly with the developing stage. It may be concluded that flavonoids increased with ripening at both storage temperatures. The storage conditions are very important for the quantity of flavonoids in persimmon fruit. High temperatures treatment seem to induce flavonoid accumulation. Prono-Widayat et al, 2003 also reported that in pepino fruits showed an increasing of β-carotene in high temperature at 18 °C in both of premature and mature fruits. The use of low temperature at 5 °C has no effect of β-carotene in this study.

Low temperature storage treatments on the phytochemicals profile on the fresh produces also have the obvious effect. Rajashekar et al (2009) informed that the use of low temperatures is the most commonly used storage method. In addition to easy to organize, low temperature storage also can be combined with other various postharvest treatments. However, these methods have good eliciting ability of the phytochemicals level of fresh produces especially on the effect of stimulate the metabolism of phenyl propanoid pathway which is the source the most of the phenolic compounds.

Low temperature stress comprises of chilling (20°C) and freezing temperatures (<0°C) also effected to the cellular change of the fresh produces. This response will lead to the excess accumulation of toxic compounds which may cause occurrence of reactive oxygen species (ROS). The end result of ROS accumulation is oxidative stress (Mitler, 2002; Yin and Yi, 2008; Suzuki and Mitler,2006). Therefore, under low temperature stresses, plants have various enzymatic and non-enzymatic defense systems to minimize the deleterious effects of ROS which include the enzymes (Hasanuzzaman et al.,2013).

As reported by Kjeldsen et al.,2003, during 4 months of refrigerated storage, the concentration of total volatiles phytochemicals (terpenoids groups) increased significantly on intact first-class winter carrots cv. Bolero and in cv.Carlo. During this period the concentration of monoterpenes doubled in cv. Bolero and increased 3-fold in cv. Carlo, while that of sesquiterpenes increased almost 5-fold in cv. Bolero and 6-fold in cv. Carlo. After 4 months of refrigerated storage, the mono- and sesquiterpenes in cv. Bolero
accounted for around 25 and 75% of the total volatile mass, respectively, as compared to 41 and 58% at the beginning of the period indicating that secondary plant metabolism was very active during postharvest storage of carrots. In contrast, the concentrations of mono- and sesquiterpenes and total volatiles as well as the relative concentrations fluctuated around the same level during frozen storage of cv. Bolero and cv. Carlo. For phenylpropanoids, which constituted 0.3% of the total volatile mass, the levels were almost the same during the 4 months of frozen storage, whereas there was a minor increase in the concentration during refrigerated storage. The significant increase in the concentration of terpenoids during refrigerated storage from 1 to 4 months showed that terpene biosynthesis has stimulated during storage. Whether this metabolic activity was due to the applied storage conditions or other factors is not known; however, the present results indicate that mono and sesquiterpenes play a central role in relation to changes in the sensory quality of refrigerated carrots in line with sugars and other nonvolatile compounds (Seljasen et al., 2001; Simon P., 1985).

The association of maturity and controled temperature treatments also reported by R.B Jones, 2006 that anthocyanins in a number of fruits such as apples and berries tend to increase with ripening process, and this increase can continue after harvest under the right storage conditions. For examples, anthocyanin content increased in blueberries during 3 weeks of storage at 5°C (Connor et al., 2002), or at 1°C or 15°C in cherries, with an up to 5-fold increase at 15°C (Goncalves et al., 2004). Furthermore, The combination of low temperature storage treatments (4 °C) and cutting processed also observed can increase the content of phytochemicals during the storage of eggplants, carrots and grapes regardless of the presence of absence of light (Alarcón-Flores et al, 2014).

**Controled atmosphere (CA) or Modified atmosphere storage (MA)**

Altered gas composition with oxygen concentration reduced and carbon dioxide concentration increased that surrounding the product atmosphere during storage also can cause a kind of postharvest stress and led and escalation of phytochemicals but these method not too very common in correlation of enhancement phytochemicals in fresh produces due to their effectivity. Just a little information available about the achievement of altered gas composition application for elevating the phytochemicals during storage compare than the use of controled temperature such as low temperature treatments. Among others, the anthocyanin enhancement in strawberries stored at 5°C if CO2 atmospheres reached 10 kPa (Holcroft & Kader, 1998), or in high (95%) O2 in purple carrots (Alasalver et al., 2005). Selcuk and Erkan (2015) also reported that during storage on the MAP treatments in 6°C and 90–95% RH 120 days storage of sweet pomegranates cv. Hicrannar give the result that increased of total phenolic compounds but for the sour sweet pomegranateo cv. Hicrannar in 210 days Total phenolic compounds, increased slightly until the first 120 days of storage, and then decreased during the rest of the storage. Moreover in certain postharvest condition such as high oxygen treatment (60-100%) on blueberry fruits may increased the total phenolic compounds (Zheng et al., 2003).
On the MAP treatment on spinach, Gil et al. (1999) reported that the spinach has content ten compounds of flavonoid. The flavonoid content on the spinach after storage remained very stable both in air and MAP and no degradation during the storage period was observed (3 and 7 days of storage at 10°C.).

In contrast to phenolic compounds, glucosinolate showed the convenient adaptation with these storage methods. The effect of CA or MA storage on glucosinolate content in broccoli, 'Marathon' broccoli heads stored for 25 days at 4°C, under a CA atmosphere of 1.5% O2 and 6% CO2 contained significantly higher glucoraphanin levels than heads stored in air at the same temperature (Rangkadiok et al., 2002).

Radishes packed in modified atmosphere (8.3 kPa O2 + 5.4 kPa CO2) showed an accumulation of glucosinolates after 5 days of storage (Schreiner et al., 2003). Also, the glucosinolate content of broccoli stored in a controlled atmosphere (0.5 kPa O2 + 20 kPa CO2) increased continuously during 7 days of storage (Hansen et al., 1995). Hansen et al. (1995) proposed that this increase in glucosinolate content could be associated with a de novo glucosinolate biosynthesis based on metabolites (e.g., amino acids) originating from the decomposition of other compounds. This process also seems to take place in radish packed in a modified atmosphere (Schreiner et al., 2003). Presumably, the glucosinolate increase in controlled and modified atmospheres is a stress response of the product to the increased CO2 and decreased O2 concentrations. The hypothesis of stress-induced accumulation of glucosinolates is supported by Verkerk et al. (2001). They detected increased levels of indole glucosinolates after chopping and storage of cabbage and broccoli under ambient conditions, indicating a stress response on mechanical impact.

**POSTHARVEST TREATMENTS AS ELICITORS**

**Fresh cut produces**

Fresh-cut products are wounded tissues, and consequently they deteriorate more rapidly and their physiology differs from that of intact fruit and vegetables (Lamikanra, 2002). The processes of peeling, coring, chopping, slicing, dicing, or shredding injure cells, releasing their contents at the sites of wounding. Subcellular compartmentalization is disrupted at the cut surfaces, and the mixing of substrates and enzymes that are normally separated can initiate reactions that normally do not occur (González-Aguilar et al., 2005), which could affect the phytochemical content and antioxidant capacity of the produce.

In general, it was observed that the content of phenolic acids increased in fresh-cut products. This fact could be explained considering that when a sharp blade was used for cutting, it produced a lower release of phenolic acids and lowered the polyphenol oxidase (PPO) activity compared to when a knife was used. This cutting process is known to be a key player in the browning process of various raw and cut fruit and vegetables (Mayer, 2006 and Mishra et al., 2012). During the storage time, increasing in phenolic content on the fresh produce in the first time period of storage may be depending on storage temperature, duration for fresh produces and style of cut that caused wound on the fresh cut products (Padda and Picha., 2008).
Ali shiri et al (2011) reported that different methods of cutting for fruit can be affected to the phenolic content. Fresh cut grape quality were evaluated over 14 days storage at 5°C that harvested by two different methods (1-berry and 4-berrys cutting), packaged in polyethylene terephthalate (PET) and polyvinylchloride (PVC) bags. The phenolic content in 1-berry cutting increased over the storage time, but its content declined in 4-berrys cutting. Therefore, increasing in phenolic content at 1-berry cutting may be due to a stress in berries during grape removal from the caps. At 4-berrys cutting phenolic content decreased during storage that can be related to the postharvest fruit metabolic processes, such as respiration, ethylene production and enzyme activity.

Alarcón-Flores et al (2014) reported for phenolic acids in eggplant, which presented higher values in fresh-cut products compare than fresh products, this phenomenon may be due to the influenced of PPO activity. Their concluded, for eggplants, carrots, and grapes will have similar properties with respect to their content in phytochemicals in fresh and fresh-cut products. Except for tomato, that better to be consumed as fresh product due the dereasing of its phytochemicals by cutting processed.

WAVE IRRADIATION

In general, the use of wave irradiation such as gamma or ultraviolet irradiation, typically used as desinfectans to control food borne pathogens, but it can utilized as elicitor to increase various of phytochemicals especially phenolic compounds (Thomas-barberan and Espin, 2001; Schreiner and keil, 2006). The increased of phenolic compounds has a cerelationship with the increased activity of phenylalanine ammonia-lyase due to the irradiation process. Moreover ultraviolet irradiation also increases the activity of other enzyme involved in flavonoid synthesis. Gamma variation has assumed can increase in favorable oxidative stress by dehydration condition due to the ability to change membrane permeability of products such as happened in garlic. Therefor due to the less of water, condition, pH decrease occured that can trigger a synthesis of anthocyanin and lignin decomposition (Schreiner and keil, 2006).

Generally, there are three classes of the type ultraviolet treatments on postharvest application: UV C (200-280 nm),UV-B (280-320 nm) and UV-A (315-400 nm).(Kowalski,.2009). However, in correlation with enhancement of phytochemicals, many reports has been informed about the effect of ultraviolet treatments in type UV-B and UV-C. Falcone Ferreyra et al (2012) has resumed for the flavonoid response againts UV-B radiation by regulating flavonol synthase (FLS) gen. They hypothesized that the high transcript levels of ZmFLS genes may also contribute to the adaptation to this stress condition with higher UV-B fluxes thus can produce more flavonols.

According to Civello (2014), the effect of ultraviolet treatments performance in order to phytochemical elevation can not seperated from the influence of many experimental factors such as time of exposure, dose and intensity (energy), product physiology (ripenig or developmental stage, temperature and treatment uniformity.
UV-B application has been reported to elevate the phenolic compounds, flavonoids and flavonol concentration in the both peel and flesh of two commercial tomato cultivar (Money marker and the mutant genotype high pigment-1) that harvested at mature green (Castagna et al., 2014). In addition to tomato experiment, UV-B application also showed good performance to stimulate the development of phytochemicals in peaches and nectarines. Scatimmo et al (2014) concluded that the use of an appropriate UV-B dose in peaches and nectarines induced positive effects on polyphenol accumulation but it also has to be considered about the choice of the genotype since the metabolic response was different depending on the cultivar considered.

Therefore, Bravo et al (2013) reported that low UV-C dose in ligh red tomato can induced a significant improvement on lycopene and phenolic compounds concentration. How ever, they have also been informed that the beneficial effect is dependent on the treatment condition since the finding of the negative effect of UV-C exposure at 12 h due to the inducement of photooxidation. Moreover, Minhua et al (2015) also reported the effect of postharvest UV-C treatments on peach fruits. They found that peach fruit exposed to 3.0 kJ·m⁻²UV-C light significantly delayed the losses of titratable acidity and vitamin C content, increased fruit red color, and maintained higher sensory quality of peach fruit during storage. The 3.0 kJ·m⁻² UV-C treatment also enhanced the PAL activity, and promoted the accumulation of total phenolics at first 3 days of storage.

Moreover, the application of gamma irradiation in association of phytochemicals induction also depend on the treatment condition. Mami et al (2013) reported on five different doses of gamma irradiation were used for white button mushroom post harvest treatments (0.5, 1, 1.5 and 2 kGy ). There were significant differences between irradiated and nonirradiated mushrooms in evaluated indices. However, the phenolic compounds revealed that mushrooms in doses of 1.5 and 1 kGy contained more phenols than 0, 0.5 and 2 kGy. Similarly, Moosavi et al (2013) found that the phenolic compounds of stroed almonds increased at the dose of 10 kGy gamma irradiation compare to non stored treatment. While the flavonoids and antioxidant values were constant. In addition of 10 kGy dose, 2 kGy dose has give slightly increased the antiradical activity of both stored and non stored almonds while but the other doses (6 and 10 kGy gamma irradiation) significantly reduced antiradical activity that containd in the commodity.

The use of other wavelenght irradiation such as flourescence, blue and red LED light during storage also reported by Eun Young Ko et al.,2014 for onion commodity. Effect of different light wavelengths on onion after harvest and storage, with fluorescent, blue (450 nm), red (660 nm) and uV-A light influenced the quercetin and quercetin glucosides profile. In a peeled onion, all the light treatments elevated quercetin content in bulb.

ADDITIVE SUBSTANCES APPLICATION.

The effect of additive substance applied to harvested fresh produces were investigated mainly in respect to quality property of fresh produces such as nutrititional value. Numerous additive substance
applied such as salicylic acid, methyl jasmonate and ethylene has been done for enhancement phytochemicals during post harvest treatments. (schreiner and Keil, 2006). According to Zhao et al (2005): Bondaryk (1994) and schreiner and Keil (2006) , the main purpose of these additive substances is to induced pathogen infestation and mechanical wounding but they have also been used to trigger signal cassades that stimulate phytochemical sythesis as the impact of defense response activation.

Another option to overcome the application of additive substance as an effort to increase the nutritional content including phytochemicals is edible coating treatment, especially for fresh cut produces (Laura A. de la Rosa et al.,2010). Edible coatings from renewable sources can function as barriers to water vapor, gases, and other solutes and also as carriers of many functional ingredients, such as antimicrobial and antioxidant agents, thus enhancing quality and extending shelf life of fresh and minimally processed fruits and vegetables (Lin and Zhao, 2007).

The enhancement of phenolic compounds on fruits by chitosan edible coating treatments has been reported. Petriccione et al 2015 reported that edible coating treatment with concentration 1 % and 2 % of chitosan solution and stored at 2 °C for nine days increased the level of phenolic compounds flavonoid in the strawberry fruits. Another source of edible coating material also given positive effect on phytochemicals such as 1 % quar gum in persimmon fruits (Saha et al., 2015), 5% and 10 % arabic gums in sweet lemons (Eskandari et al.,2014), cassava starch coatings incorporated with propolis combinations in strawberry fruits (Thomas et al.,2016) and the combination of alginate and antibrowning agent in fresh cut mango (Robles-Sánchez et al.,2013).

CONCLUSION

In correlation of functional food development, to obtained the high quality of healthy beneficial fresh produces, beside good crop practice, the application of post harvest technology also need to be applied. Nowadays, the quality judgement not only determined from the external quality of attributes but also from its nutrient content in particular phytochemical compounds that have the ability to prevent major diseases. Since many factors that have to be influenced the quality after handling treatments, multidiciplinary research must be involved. The affect of the different types of treatments to the physiology of plants is still unclear .More studies need to be doing for a better understanding both key enzymes activation and defence mechanism leading to induced resistance as well as the promotion of phytochemicals biosyntesis. Therefore, the development of post-harvest technology research approaches omics (meta- bolomic, genomic, proteomics and integrative multiomics) techniques need to be integrated in order to synchronizing the achievement of high level of phytochemicals and high external quality attributes fresh attributes. These approaces could lead to identification and associate biochemical pathway of key regulatory factors involved in induction of phytochemicals accumulation and freshness maintanance of fresh produces.

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