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PHYSICOCHEMICAL AND AROMA CHARACTERISTICS CHANGES IN FRESH CUT MELON FRUIT DURING STORAGE

Abeusseiit Ardager, master degree student,
Nanjing Agriculture University, Nanjing city

Annotation

The purpose of this study was to investigate certain physicochemical changes in fresh-cut melon fruit during storage. Flesh colour, soluble solid content, firmness and cell wall hydrolases, such as pectinesterase, polygalacturonase, b-galactosidase and galactanase activities were determined. Flesh colour and soluble solid content remained constant whilst firmness decreased significantly throughout storage. The loss of firmness was associated with the increases in polygalacturonase and galactanase activities. A high b-galactosidase activity was detected; however, a significant change in the enzyme activity was not found. Pectinesterase activity declined throughout storage. These results indicated that firmness is a key factor affecting quality of minimally processed Hami melon fruit and associates with the increase in polygalacturonase and galactanase activities.

Key words: Minimally processed, melon, physicochemical changes, aroma characteristics, firmness, flesh colour, aroma analysis technique, odor activity value, total soluble solid.

Introduction

Nowadays, consumers have been more concerned about health problems related to food consumption. Consumers demand a convenient and fresh food market. However, minimally processed fresh fruits and vegetables are more perishable than intact fruits. Changes in texture, taste and appearance are limiting factors in the quality of minimally processed foods reported in melon fruit (Portela and Cantwell, 1998; Lamikanra et al., 2003; Ergun et al. 2007,).Melon is the 4th important fruit in the world fresh fruit market (Aguayo et al., 2004). Melon is a kind of fruit having a large market share in minimally processed products.

The quality of minimally processed melon changes rapidly during storage (Lamikanra et al., 2000). Changes in texture and flavour are the main factors limiting the quality of minimally processed cantaloupe melon (Lamikanra et al., 2003; Aguayo et al., 2004). However, Portela and Cantwell (2001) had

reported that there were no changes of aroma, off-odor and total sugar in minimally processed cantaloupe melon but the texture significantly declined during storage. Furthermore, the rapid decrease in texture during storage was also reported in other minimally processed melon fruits such as melon (Portela and Cantwell, 1998), Amarillo (Aguayo et al., 2003) and Galia (Ergun et al., 2007).

Ranwala et al. (1992) suggested that the softening of intact muskmelon fruit during ripening resulted from the degradation of pectin polymers by the action of – galactosidase. Furthermore, the presence of β-galactosidase/galactanase activities have also been reported in intact melon fruits during ripening (Rose et al., 1998). The objective was to examine physicochemical changes and cell wall hydrolases in minimally processed melon fruits during storage at 4±1°C.

The characteristic aroma of fresh-cut melon is a result of the enzyme-catalyzed oxidation of free fatty acids, where enzymes released by tissue disruption (e.g., by cutting), in concert with the oxygen entering the system, react with the available free fatty acids, in particular linoleic and linolenic acids, to produce the aroma-impact aroma compounds (Grosch et al. 1971). Lipoxygenase creates C-9 and C-13 hydroperoxides (Tressl et al. 1981) and these hydroperoxides are subsequently cleaved into C6 and C9 saturated and cis unsaturated aldehydes (Galliard et al. 1976). The C6 and C9 aldehydes are then reduced to C6 and C9 alcohols by alcohol dehydrogenase or the cis unsaturated bonds are isomerized to trans by cis/trans isomerase .

Aroma compounds of melon have been the subject of discussion. Past studies have given credit to cis, cis-3,6-nonadien-1-ol as the most important aroma compound in melon (Yajima et al. 1985; Kemp et al. (1974); Pino et al. 2003; Beaulieu et al. 2006). However, according to the lipoxygenase scheme, cis aldehyde, cis-3,6-nonadienal must be formed prior to the formation of the corresponding alcohol. It is likely that previous researchers who used long periods for volatile isolation were unable to isolate aldehyde because it had already been reduced to a corresponding alcohol by the action of alcoholic dehydrogenase . This, along with the knowledge that, almost always, 25 alcohols have appreciably higher odor detection thresholds than aldehydes (Hatanaka et al. 1992), leads us to the hypothesis that unsaturated aldehydes, and in particular cis, cis-3,6-nonadienal, are the predominant odorants in freshly cut melon.

The technique of static headspace analysis (SHA) is good for taking a chemical ―snapshot‖ of fresh-cut melon aroma. In SHA the odor above a sample is allowed to come into equilibrium and then a portion of it is collected for analysis by gas chromatography (GC). It is fast and easy, reproducible, non-destructive and un-biased in contrast to solvent extraction. SHA also eliminates solvent peaks and non-

volatile contaminants during analysis (Rouseff et al. 2001). The concept of odor activity value (OAV) can be applied through SHA using a technique called gas chromatography-olfactometry of decreasing headspace volumes (GCO-H) (Holsher et al. 1992). OAV is the concentration of an odorant in food divided by its odor detection threshold. This eliminates the idea of ―more is stronger and gives a truer analysis of the most potent odorants. Aroma extract dilution analysis (AEDA) can be used complimentary to GCO-H. AEDA is a quantitative GCO procedure for determining the potency of odorants in food aroma extracts (Grosch 1993). In the case of melon, the aroma extract will be obtained by solvent-assisted flavor evaporation (SAFE). SAFE allows the isolation of volatiles from solvent extracts, aqueous foods, aqueous food suspensions such as fruit pulps, or even matrices with a high oil content (Engel et al. 1999).

MATERIALS AND METHODS

Plant material

Melon fruits were obtained from a local fruit grocery shop. The fruits were screened for uniformity, such as being free from any mechanical damage and diseases and the same stage of maturity, and were washed with tap water containing 200 µll-1 sodium hypochlorite solution, and then air dried.

Sample preparation

All equipments , knife and cutting board were washed with tap water and disinfected using 70% ethanol and then air dried. The fruits were cut into half with a sharp knife and each half was cut at the exposed end into 4 equal pieces. The seeds, cavity tissues and peel were then removed. The fruits were cut into cubes approximately 1.5×1.5×1.5 cm3 size. The cubes were kept in plastic containers wrapped with punctured wrapping film, (10 holes were made using a needle) and then kept at 4±1°C for 5 days.

Physicochemical quality attributes, namely flesh colour, firmness, soluble solid content (SSC) and cell wall hydrolases such as pectinesterase, polygalacturonase, galactosidase and galactanase were determined.

Flesh colour

Colour of melon flesh was measured. The chromo meter was calibrated against a white tile. The melon flesh were measured for L* (lightness), a*[green (-) to red (+)], b* [blue (-) to yellow (+)].

Total soluble solid

Juice extracted from 5 cubes of the minimally processed melon from each experiment was used to assay soluble solid content and was evaluated using a hand refractometer.

Firmness

The firmness of minimally processed melon was determined using a TA-XT II texture analyzer, equipped with P4 probe (2 mm diameter). The probe was driven at a crosshead speed of 5.0 mm s-1 to a depth of 5 mm. The maximum force-exerted (expressed as g-force) was used for firmness data.

Electrolyte leakage

Electrolyte leakage determination was modified from the method described by Ergun et al. (2005). Flesh melon cylinders (9 mm in diameter) were taken from equatorial part of a fruit using a cork borer. The cylinders were cut to produce 5 mm thick discs. Six discs per replication were rinsed with de-ionized water and dried using Whatman filter paper no. 1. The discs were put into 50 ml beaker and then 30 ml of 500 mM mannitol solution was added. The conductivity of the solution was immediately measured using a conductivity meter (EC/TDS waterproof Hanna Instruments). The discs were incubated in the mannitol solution for 5 h and then the conductivity was again measured. The discs and bathing solution were then stored in a freezer (-20°C) for 24 h, thawed, and then boiled for 15 min. After the solution had dropped to room temperature, the total conductivity of the solution was recorded. The result was expressed as a percentage of electrolyte leakage.

Aroma Analysis Techniques

Snow et al. (2002) defines headspace analysis as ―a vapor-phase extraction, involving the partitioning of analyses between a non-volatile liquid or solid phase and the vapor phase above the liquid or solid sample…and that this mixture is transferred to a GC or other instrument for analysis.‖ Static headspace analysis (SHA) involves letting the vapor above the sample come into equilibrium before extracting it for analysis. SHA has been used for decades for flavor and fragrances analysis as well as in the environmental and pharmaceutical 14 sciences. Today SHA remains the most validated among the headspace techniques. There are many advantages of headspace analysis. It is fast and simple. It is reproducible, non-destructive and nearly un-biased in contrast to solvent extraction techniques. It also eliminates solvent peaks and non-volatile contaminants during analysis. In fact, SHA captures the same volatile compounds that a human nose would detect from a sample, which allows for a true chemical image of what humans detect in the case of scent or vapor. The only real drawback is the lack of sensitivity. However, the use of cryogenic capture techniques can help to correct this deficiency. Cryogenic condensing is a method in which volatile compounds are captured by condensation in a trap by using liquid nitrogen to lower the temperature of a gas chromatographic injector. This can be done using a programmable temperature vaporizer (PTV) inlet –

universal injection system with the possibility of handling large sample injections-which is perfect for headspace analysis.

To determine the most important volatiles in a headspace sample the concept of odor activity value (OAV) is used. OAV is the concentration of the odorant in the food as compared to its odor detection threshold, generally expressed as a ratio of concentration of a compound divided by its odor detection threshold. One way to put this concept into practice is by application of gas chromatography-olfactometry of decreasing headspace volumes (GCO-H). This technique was first attempted while investigating the ―freshness aroma of roasted coffee. It was noted, ―Major progress was achieved when GC/sniffing was applied, because ADA allowed differentiation between sensorily important, less or unimportant peaks and enable estimation of the contribution of single volatiles to the overall perceptible aroma freshness. In this study, there were far fewer odorants in the headspace than in the stream distilled extract, facilitating the aroma analysis.

As the headspace volume was reduced, fewer and fewer compounds were detected by GCO until only the most intense/important odorants were left. GCO-H has been applied to many foods for aroma analysis, particularly those foods having dynamic aroma systems (Milo et al. 1997; Triqui et al. 1997; Roberts et al. 1996; Rychlik et al. 2001; Lee et al. 2001; Zhou et al. 2002; Buckling et al. 2002; Cadwallader et al. 1998; etc.).

RESULTS AND DISCUSSION

Flesh colour

During storage for 5 days, no significant differences in L*,a* and b*values fresh-cut melon were not found. L*, a* and b*values during storage were about 73.9, -4.6 and 12.5, consequently (Figure 1). It shows that flesh colour did not the key factor limiting quality of fresh-cut Hami melon fruit during storage. Portela and Cantwell (2001) and Ergun et al. (2007) suggested that a decreases in L* and chroma values of minimally processed muskmelon fruit was related to the development of translucent or water-soaking symptom. However, the result in this study shows no development of translucent and water-soaking symptom on the fresh cut melon fruit over storage.

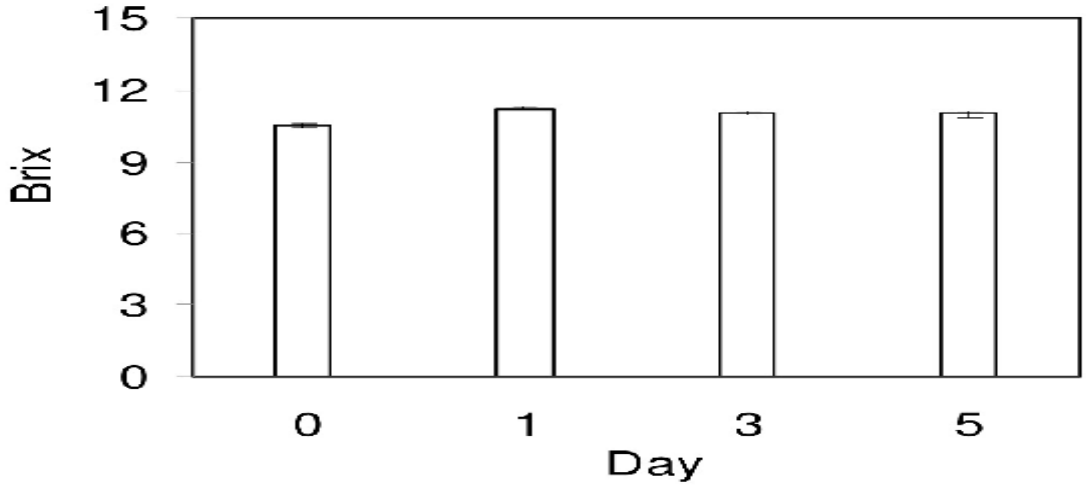

Figure 2. Soluble solid content (°Brix) of fresh-cut melon stored at 4±1°C for 5 days. Vertical bars present the standard error of means (n = 3).

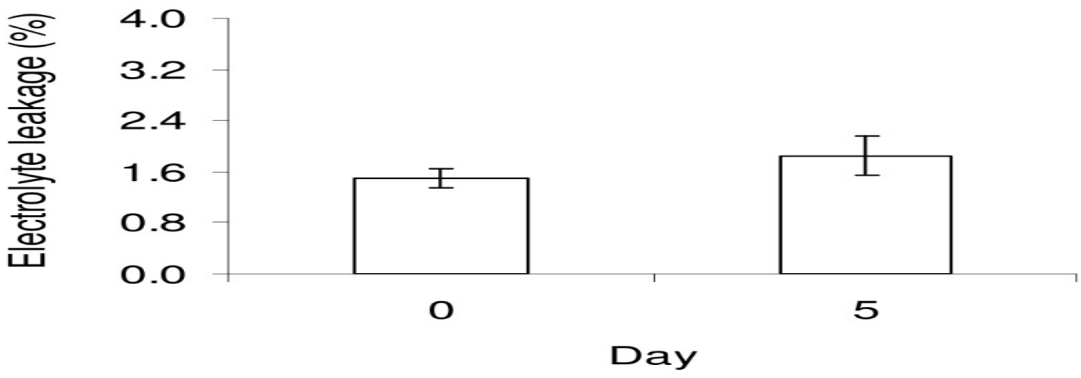

Figure 4. Electrolyte leakage (%) of fresh-cut melon stored at 4±1°C for 5 days. Vertical bars present the standard error of means (n = 3).

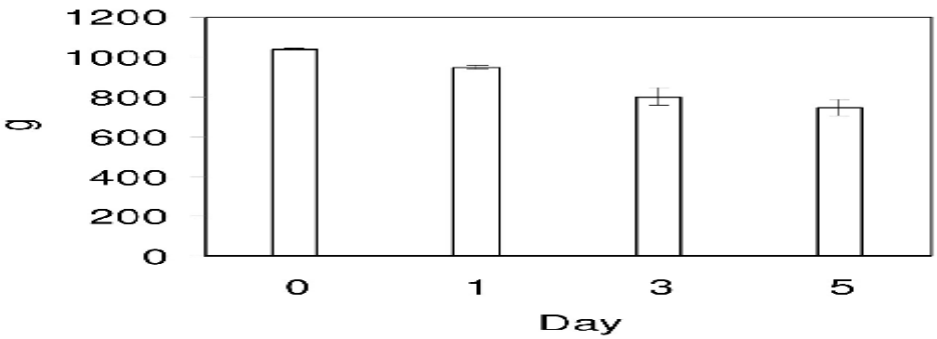

Figure 3. Firmness of fresh-cut melon stored at 4±1°C for 5 days. Vertical bars present the standard error of means (n = 3).

Soluble solid content

Soluble solid content of fresh-cut Honeydew melon fruit remained constant and was about 10.9 °Brix over storage (Figure 2). In melon fruit, soluble solid content is a main factor used to determine the quality in commercial. The minimum requirement in TSS of melon fruit should be higher than or equal 10 °Brix (United Nation Economic Commission for Europe, 2006). The results in this study show that there were no significant changes in soluble solid over storage. Similarly, no changes in soluble solid content have been reported for minimally processed Honeydew melon (Portela and Cantwell, 1998) and Cantaloupe melon (Portela and Cantwell, 2001; Gil et al.,2006).

Firmness and electrolyte leakage

Firmness of fresh-cut melon fruit decreased significantly throughout storage ($p \leq 0.05$). Firmness reduced from 1043 g on day 0 to 747 g on day 5 (Figure3). This shows that the reduction of firmness was an important factor affecting quality of fresh-cut melon fruit during storage. The fresh-cut melon at day 0 and day 5 was selected to measure tissue electrolyte leakage (Figure 4). The electrolyte of the fresh-cut fruit increased slightly from 1.53% at day 0 to 1.82% at day 5 and there was no significant difference.

Softening is universally known as a predominant cause limiting the transportation and shelf-life of fruit. Several previous works of minimally processed melon fruit have reported that the loss of firmness is one of the main factor limiting the quality and shelf-life of cantaloupe melon (Lamikanra et al., 2003; Aguayo et al., 2004), Honeydew melon (Portela and Cantwell, 1998), Amarillo melon (Aguayo et al., 2003) and Galia melon (Ergun et al., 2007). The results in this study show a continuous decrease in firmness of the fresh-cut Honeydew melon which was similar to the previous report. Ergun et al. (2007) reported that the loss of firmness in fresh-cut Galia melon associated with an increase in electrolyte leakage of the tissue. However, a slight increase in electrolyte leakage was shown in this study. This could suggest that the increase in electrolyte leakage might

be associated with the loss of firmness but it is not the key factor affecting the softening of the fresh-cut Honeydew melon fruit.

Cell wall hydrolase activities

It is widely known that softening of fruit is associated with cell wall hydrolase activities. Figure 5 shows cell wall hydrolase activities in fresh-cut Honeydew melon fruit during storage. Pectinesterase activity decreased continuously throughout storage. A small amount of polygalacturonase activity was detected and it increased over storage. A high amount of β-galactosidase activity was found in fresh-cut Honeydew melon fruit; however, it slightly changed during storage. b-galactanase activity increased markedly from days 1 to 3 and 5, respectively. The reduction of fruit firmness is widely recognized that it is accompanied by the action of cell wall hydrolases (Brummell, 2006). During ripening, the extensive depolymerisation of cell wall substances have been attributed to the action of cell wall modifying enzymes, such as polygalacturonase (EC 3.2.1.15), pectinesterase (EC 3.1.1.11), β-galactosidase EC 3.2.1.23) (Lester and Dunlap, 1985; Tucker, 1993) and galactanase (EC 3.2.1.89) (Lazan et al., 2004). The results show that all of those cell wall modifying enzymes were detected in freshcut Honeydew melon fruit during storage. Increase in polygalacturonase and galactanase activities might associate with the reduction of firmness. Lester and Dunlap (1985) reported that polygalacturonase activity was not detected in muskmelon fruit during ripening. In this study, a small amount of polygalacturonase was found and it also increased over storage. Hadfield et al. (1998) suggested that even though PG activity in muskmelon fruit was small it was enough to degrade pectic polymers at the later stage of ripening. The role of pectinesterase activity in melon fruit softening is still unclear because it decreased over storage. Similarly, Supapvanich (2009) reported that pectinesterase activity of intact and fresh-cut Cantaloupe melon fruits decreased during storage. A high level of β-galactosidase activity in minimally processed Honeydew melon fruit during storage was detected in this study. It might have some effect on the fruit softening. In muskmelon fruit, β- galactosidase was reported as an important enzyme regulating the fruit softening (Ranwala et al., 1992). It is generally accepted that β-galactosidase has an ability to catalyse (1→4)-β -D-galactosidic cross-linkage in the side chains of pectic polymers, resulting in breakdown of the large polymers (Ranwala et al., 1992; Ross et al., 1993; Carey et al., 1995). It is accepted that galactanase is an enzyme in galactosidase group having an ability to remove the cell wall galactose during fruit ripening (Carey et al., 1995). The data in this study show a marked increase in galactanase activity of muskmelon fruit during storage. Supapvanich (2009) reported that a high level of galactanase activity was found in β-galactosidase isoform II which related

to the loss of firmness in muskmelon fruit.
Similarly, Ali, et al. (1995) has discovered galactosidase of mango fruit having galactanase activity and the increase in this enzyme was parallel with increase in the fruit softening.

CONCLUSION

Flesh color and soluble solid content were not the main factors limiting the quality of minimally processed melon. The marked reduction of firmness during storage was an important factor on the fruit. An increase in electrolyte leakage might relate to the loss of firmness but it is not the main factor of the fresh-cut fruit softening. The marked increases in polygalaturonase and galactanase activities were parallel with the loss of firmness. A high level of galactosidase was found. These suggest that increase in cell wall hydrolases, especially polygalacturonase, β-galactosidase and galactanase played a key role in the softening of fresh-cut melon fruit during storage.

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ЖАҢА КЕСІЛГЕН ҚАУЫННЫҢ САҚТАУ БАРЫСЫНДАҒЫ ФИЗИКО-ХИМИЯЛЫҚ ЖӘНЕ ИІСІНІҢ СИПАТТАМАЛАРЫНЫҢ ӨЗГЕРУІ

Әбеусейіт Ардагер, магистр студенті
Нанжиң Ауылшаруашылық Университеті, Нанжиң қаласы

Түйін

Бұл зерттеу жұмысының мақсаты жаңа кесілген қауынның сақтау барысындағы физико-химиялық өзгерістерін зерттеу. Қауынның жұмсақ жерінің түсі, еритін қатты бөлшектерінің құрамы, пектинэстреза, полигалактуроназа сияқты жасушалық қабырғасының гидролазы, В-галактозидаза және галактаназаның қызметі анықталған. Сақтау барысында жұмсақ жерінің түсі және еритін қатты бөлшектерінің құрамы өзгеріссіз, ал қаттылығы анағұрлым төмендеді. Қаттылығының төмендеуі полигалактуроназаның көбейуі мен галактаназаның қызмет атқаруына байланысты. В-галактозиданың белсендігінің жоғарлағаны, алайда, ферменттің белсендігіннің айтарлықтай өзгерісі байқалмады. Пектинэстеразының қызметі сақтау барысында төмендеген. Бұл зерттеудің нәтижесі көрсетуі бойынша қауын секілді аз өңделетін жемістердің саасына әсер ететін шешуші фактор төзімділік болып табылды.

Кілттік сөздер: Қауын, аз өндіру, физико-химиялық өзгерістер, иіс сипаттамалар, төзімділік, жұмсақтығының түсі, иіс анализінің методі, еритін қатты бөлшектер, иісінің белсенділігінің мәні.

ИЗМЕНЕНИЯ ФИЗИКО-ХИМИЧЕСКИХ И АРОМАТИЧЕСКИХ ХАРАКТЕРИСТИК СВЕЖИХ ПЛОДОВ ДЫНИ ПРИ ХРАНЕНИИ.

Абеусейт Ардагер, студент-магистрант,
Нанкинский Аграрный Университет, город Нанкин

Резюме

Целью данного исследования было изучение некоторых физико-химических изменений в плодах дыни свежего среза при хранении. Были определены цвета мякоти, содержание растворимых твердых частиц, упругость и клеточной стенки гидролазы, такие как пектинэстераза, полигалактуроназа, В-галактозидазу и деятельности галактаназы. Цвет мякоти и содержание растворимых твердых частиц остается неизменным, а упругость значительно снизилась на протяжении хранения. Потеря упругости было связано с увеличением полигалактуроназы и деятельности галактаназы. Была обнаружена высокая активность В-галактозидазы; однако существенного изменения активности фермента обнаружено не было. Деятельность пектинэстераза снижались на протяжении хранения. Эти результаты показали, что устойчивость является ключевым фактором, влияющим на качество, минимально обработанных плодов дыни и ассоциируется с увеличением полигалактуроназа и деятельности галактаназы.

Ключевые слова: Дыня, минимальная обработка, физико-химические изменения, ароматические характеристики, твердость, цвет мякоти, метод анализа аромата, значение активности запаха, растворимое твердое вещество.