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Relationship between Volatiles and Other Factors Indicating Quality of Melon (*Cucumis Melo* L. cv. Prince Melon) during Fruit Development and Storage

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Abstract

'Prince Melon' (*Cucumis melo* var. *reticulatus* Naud × *Cucumis melo* var. *makuwa* Mak.) was analyzed to determine the relationship among refractometer index, sugar content and volatile compound evolution during developmental and postharvest stage of the fruit. All the components were increased during development up to 34 days after anthesis. Among sugars, only sucrose increased parallel with total sugar and refractometer index. Refractometer index and total sugar in early picked fruit (20 days after anthesis) and in matured fruit (27 days after anthesis) were almost constant during storage at 20°C, although sucrose concentration of mature fruit increased at the 5 th days from the start of storage and then decreased gradually toward 15 days from the start of storage. Volatiles, mainly esters, emanated very little from early picked fruit at harvested day, but the production increased in significant level during the storage. Volatile production from mature fruit was already high at harvesting time and fluctuated that level depend on individual ester during storage. The correlation between refractometer index and volatiles production was high in developing stages, while the correlation was very poor during storage at 20°C in both early picked and mature fruit. These results revealed that volatile would become good indicator for fruit quality at picking time without any destruction. However, volatile can not be a good indicator for storage period and also on the shelf in retail market.

Key Words: fruit quality, 'Prince Melon', sugars, volatiles.

Introduction

In general, quality of fruit depends largely on the harvested maturity. The quality of melons can be also improved with ripening after harvest if the fruit on vine has attained to the maturity with relatively higher content of soluble solid (Chachin and Iwata, 1988). The most important attribute affecting eating-quality is sweetness. However aroma, flesh color and texture depending upon the fruit are also indispensable factors of fruit quality. Aroma is a complex mixture of a large number of volatile compounds whose composition is specific to species and often to variety of fruit (Sanz et al., 1972) and it is one of

the major determinants of fruit quality as perceived by the consumers and has therefore been investigated in detail (Wyllie and Leach, 1990).

It has been shown that the aroma volatiles of melon consist of a complex mixture of esters, whose sensory properties have been described as 'melon-like' (Buttery et al., 1982; Kemp et al., 1971, 1972a, b, 1974) together with other components including nine carbon unsaturated aldehydes, alcohols. Many cultivars of melons are available in market throughout the year. Some expensive melon fruit like 'Earl's favourite' are carefully cultured under controlled conditions

and checked picking time by the days after anthesis. They are guaranteed their quality. On the other hand, it is very difficult to choose a good quality of normal melon fruit as expected. Ripening after harvest in most fruit can be beneficial for shipment and marketing, but sometimes it provides low quality of fruits to consumers (Chachin and Iwata, 1988). Kitamura et al. (1975, 1976) have also reported that significant variation was exhibited in patterns of productions of carbon dioxide, ethylene and low-boiling point volatiles in the course of ripening among melons.

Consumers have checked the quality of melon by sniffing of aroma as well as touching softness and watching surface color. Here we focused on aroma evolution, and wanted to show the relationship between volatiles and sugar content, and also discussed whether volatile became a good indicator for determining quality of melon fruit.

Materials and method

Materials and date of analysis

Melon fruit were obtained from the experimental farm of College of Agriculture, Osaka Prefecture University. Fruits at different growth and maturation stages were picked at 15, 20, 27 and 34 days after anthesis for determination of refractometer index, sugars content and volatile evolution. At 15 days after anthesis, fruit was on the way of enlarging, but surface color turned pail-green; at 20 days, fruit reached full size but still very hard; at 27 days, fruit had good quality for consuming, faint aroma was detected organoleptically, at 34 days after anthesis, fruit had best quality for consuming, fully-developed aroma, while these fruits seem not to be suitable for shipping because of very soft and deep cracking. Fruit picked at 20 and 27 days after anthesis were stored at 20°C and also analyzed.

Determination of refractometer index from pulp of melon fruits

Fresh pulp were pestled in a mortar, and the total soluble solids content was measured by a refractometer (ATAGO).

Alcohol soluble extraction from pulp

Twenty ml of 99% ethanol was boiled in

100ml flask sealed with a rubber cap with a long glass tube for a reflux condenser. Then 5g pulp slices was boiled in the hot ethanol for 15 min. After cooling, they were homogenated in a mortar with a pestle, and the homogenate was filtered with filter paper (Advantec No. 2). The filtrate was filled up to 50ml with 80% ethanol and stored as ethanol extract at 12°C until sugar analysis.

Sugar analysis

Ten ml of ethanol extract was mixed with 1ml of 1% raffinose (an internal standard) and evaporated under vacuum at 35°C until the ethanol was removed. The dried extract was made up to 1ml with water and it was filtered through a 0.45µm Millipore filter unit prior to HPLC analysis. HPLC conditions were as follows, 20 µl of filtrate was injected into an HPLC with Inertsil ODS - 2 column (5µm, 4.6 × 250 mm, GL sciences Inc.) and connected with refraction index detector. Acetonitrile(80%) was used as eluent at a flow rate of 0.8ml/min at 35°C. The peaks were quantified with the peaks of individual sugar standard.

Volatile analysis

The fruit were quartered longitudinally by knife. About 200g of melon pulp with peel and without seeds was placed in a sealed chamber. The volatiles in the headspace were displaced with air at a flow rate of 60 ml/min for 15 min and trapped in a tenax GC (0.5 × 5 cm). The volatiles were separated on a capillary column (J & W column, 0.25 mm × 60 m, film thickness 0.25 µm) in gas chromatography. Chromatographic conditions were as follows, FID temperature 200°C, injector temperature 220°C, carrier gas helium. The oven temperature was held at 40°C for 10 min after injection, programmed to 180°C at 6°C/min and immediately increased to 220°C at 20°C/min and then kept for 1 min for cleaning. The components were identified by comparison of retention times with those of authentic standards.

Results and discussion

Refractometer index and sugar contents during fruit development

Refractometer index of juice increased gradu-

ally up to 27 days after anthesis and then started to decrease a little during ripening stages (Fig. 1A). Refractometer index is a simple optical indicator for measuring concentrations of soluble solid contents in fruit. The meter was also called 'sugar meter' and it is widely used to check harvesting time on growing field of fruits. So, refractometer index may be better one to guarantee the quality than sugar analysis.

Total sugar content increased linearly during developmental and mature stages (Fig. 1B). Fructose and glucose concentration were among 1-2% and almost constant during fruit maturation. Sucrose increased from day 20 and became dominant at day 27 and 34. A accumulation of sucrose during maturation may be related to the intensity of sweetness. These result during fruit maturation is similar with the result of Bianco and Pratt (1977) and Lester and Dunlap (1985). Higher sugar content is an important quality attribute of ripe melons (Seymour and McGlasson, 1993). In melon (cv. Makdimon) fructose, glucose and sucrose are the major component (Wang et al., 1996). Fructose, glucose, sucrose in cv. Makdimon melon during fruit ripening were varied between 1.3-2%, 1.3-1.9%, 4.3-6.9% respectively (Wang et al., 1996).

The relationship between sugar contents and refractometer index during fruit development

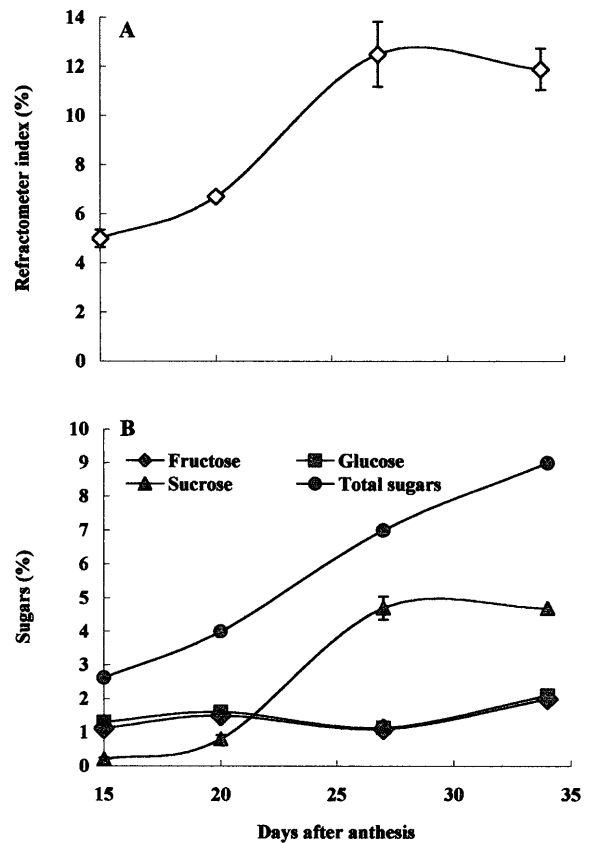


Fig. 1. Changes of refractometer index (A) and sugars content (B) during development and maturation of 'Prince Melon' fruit.

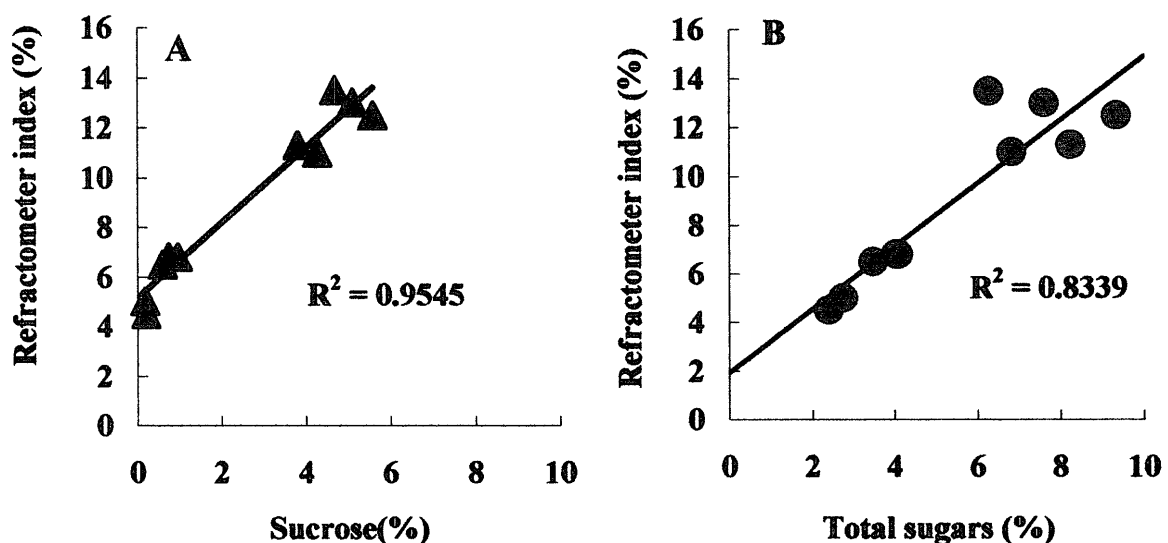


Fig. 2. The relationship between sugars (A, sucrose; B, total sugars) and refractometer index during development and maturation of 'Prince Melon' fruit.

was shown in Fig. 2. Glucose and fructose had no relation, while total sugars and sucrose had high correlation with refractometer index. When these sugar contents are compared with the value of refractometer index, only sucrose increased in similar manner with the index. So, we can use refractometer as sweet index of 'Prince melon' fruit.

Refractometer index and sugar contents during storage

In Fig. 3A, refractometer index from early picked fruit (20 days after anthesis) was almost constant, around 6%, during storage at 20°C, while the index from matured fruit (27 days after anthesis) increased a little at 1st day after storage at 20°C and then gradually decreased up to 15 days. Fructose and glucose concentration remain constant during storage of melon picked at 20 days after anthesis, (Fig. 3B). Sucrose con-

centration increased slightly at 5 day after storage at 20°C, but almost constant during whole storage days. These results indicated that sweetness in early picked melon was not improved after harvest.

When the melon harvested 27 days after anthesis was stored at 20°C (Fig. 3C), fructose and glucose concentration remain constant up to 15 days. Sucrose concentration increased first 5 days and then decreased gradually toward 15 days storage.

Over all observation indicates that sugar content of mature 'Prince Melon' picked at 27 days after anthesis is suitable for consuming at harvest time, and maintain sweetness up to 15 days.

Chachin and Iwata (1988) indicated that sugars accumulated in reducing type (glucose and fructose) and non-reducing type (sucrose) in all parts of pulp during the development of melon while they gradually declined in every fruit harvested at various maturities during storage. On the other hand, our observation showed that sugars content generally kept same levels during storage in any melons.

Volatile emission during maturation and storage

Volatiles produced from matured 'Prince Melon' fruit were as Fig. 4. Main volatiles in the gaschromatogram were chosen and observed during maturation after anthesis and during storage.

Ethanol and ethyl acetate were emanated with large scales and reached peak value at 27 days after anthesis (Fig. 5A), and also other acetate esters emanated moderately with same manner of ethyl acetate, while some of them continuously increased toward the end of storage (Fig. 5B). Aromatic acetate detected at very small level were also increased (Fig. 5B). Presence of aromatic esters in melon was reported by Shalit et al. (2001). Esters with other than acetate moieties also slightly detected with same tendency of production (data not shown).

The volatiles of 'Prince Melon' which was picked at early stage of maturation at 20 days after anthesis and stored at 20°C were analyzed during storage (Fig. 6). At the initial days of storage, volatiles did not detected or detected

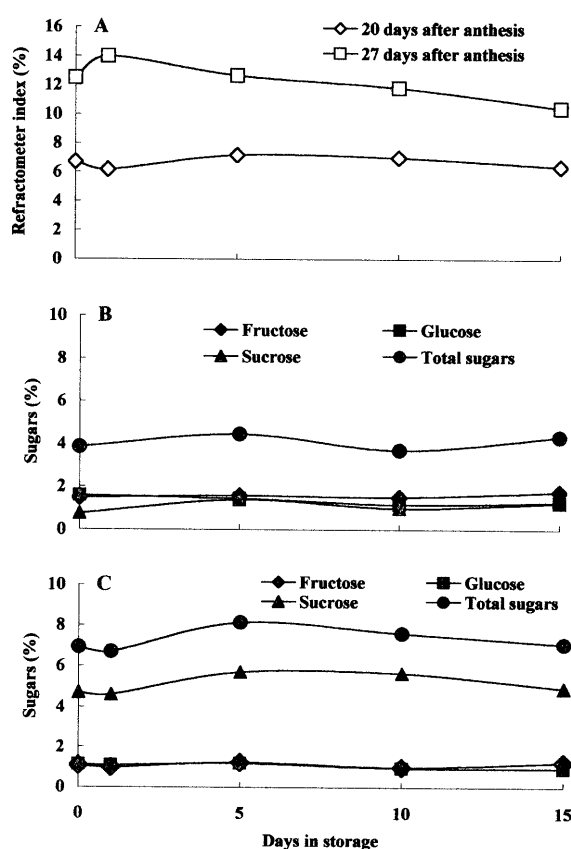


Fig. 3. Changes of refractometer index of early picked fruit (20 days after anthesis) and matured fruit (27 days after anthesis) (A), sugar contents of early picked fruit (B) and matured fruit (C) during storage.

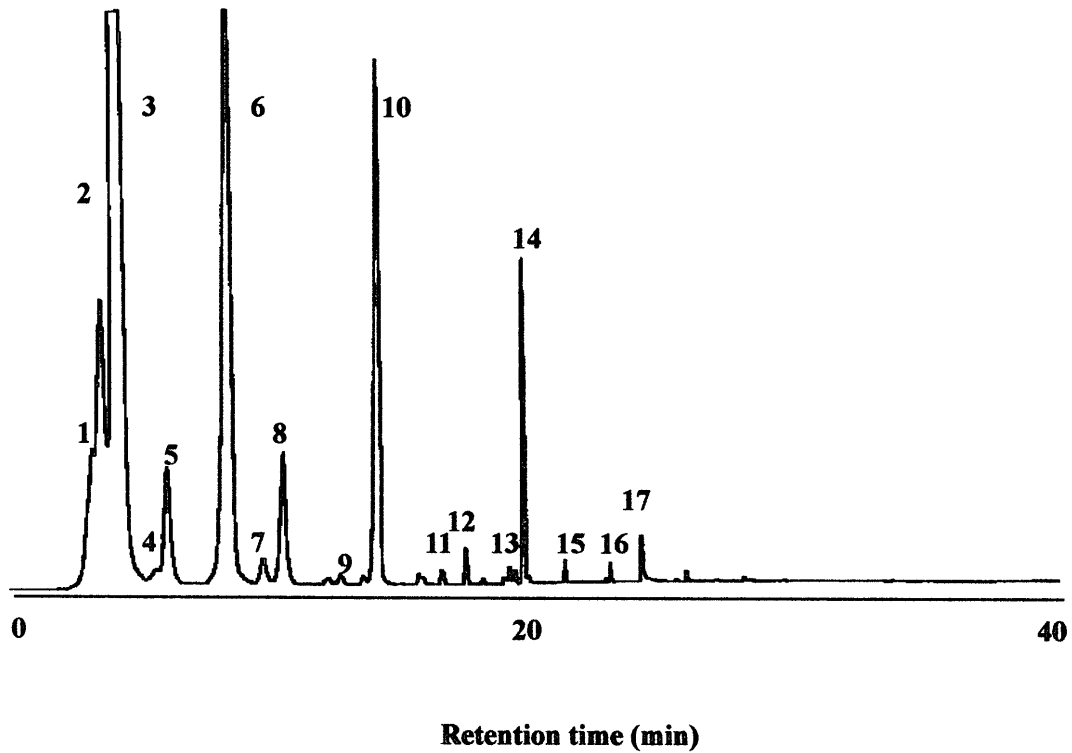


Fig. 4. Gas chromatogram of volatiles from 'Prince Melon' fruit at mature stage.

Peak no.: 1, acetaldehyde; 2, ethanol; 3, ethyl acetate; 4, methyl isobutyrate; 5, ethyl propionate; 6, isobutyl acetate; 7, ethyl butyrate; 8, butyl acetate; 9, ethyl isovalerate; 10, isoamyl acetate; 11, unknown; 12, butyl isobutyrate, 13, ethyl hexanoate; 14, hexyl acetate; 15, isoamyl butyrate; 16, 2-phenyl ethyl alcohol and 17, benzyl acetate.

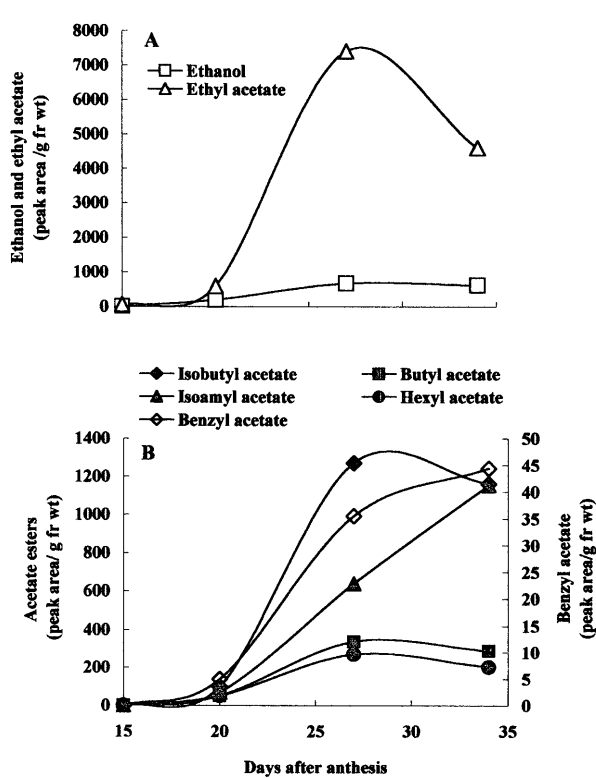


Fig. 5. Changes of ethanol and ethyl acetate (A), other acetate esters (B) evolution from 'Prince Melon' fruit during development and maturation

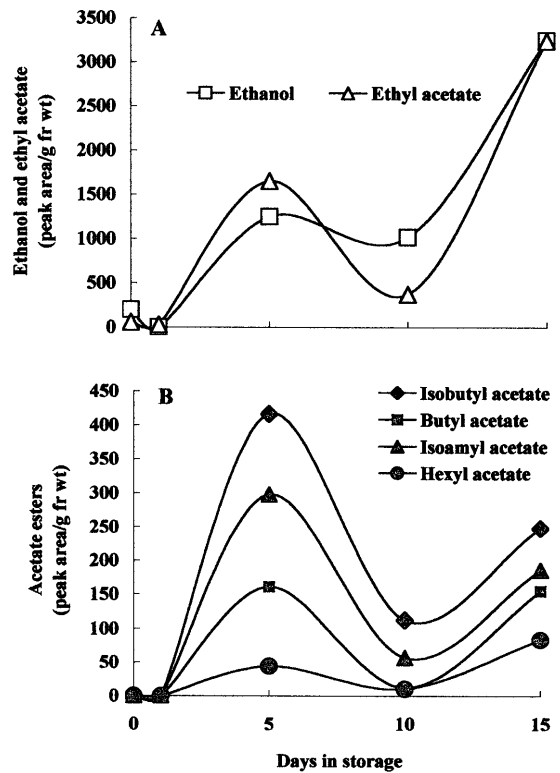


Fig. 6. Changes of ethanol and ethyl acetate (A), other acetate esters (B) evolution from early picked 'Prince Melon' fruit during storage.

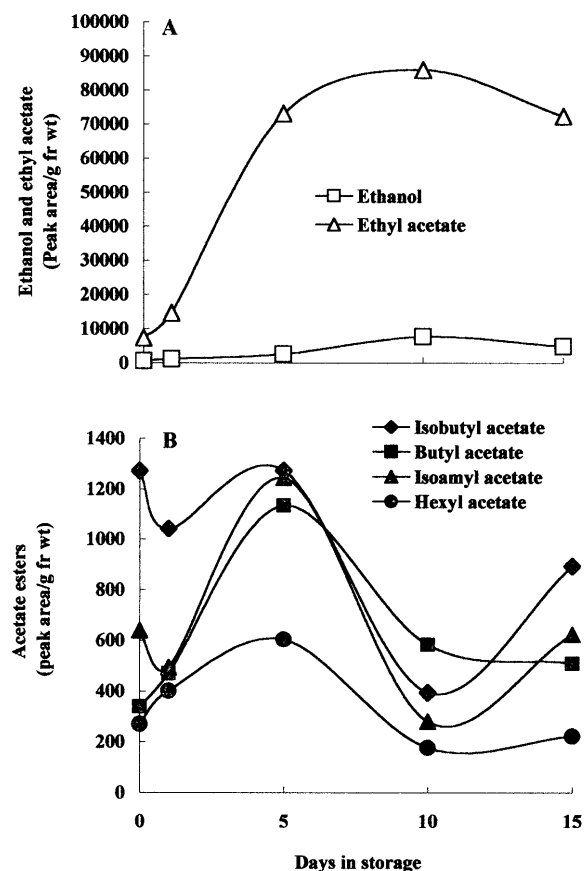


Fig. 7. Changes of ethanol and ethyl acetate (A), other acetate esters (B) evolution from matured 'Prince Melon' fruit during storage.

neglectedly depending upon sample. Then by 5 days storage, many volatiles produced some extent. The aroma was also detectable organoleptically. Production of the volatiles was suppressed at 10 days after the start of storage and then increased toward 15 days of storage.

When Prince melon were picked at matured stage at 27 days after anthesis, volatile production was already high as shown in Fig. 7A and B. During storage (20°C), production of ethyl acetate jumped up during storage. Too much volatiles are not acceptable for some consumers (Macku and Jennings, 1987). Other esters increased not so severely compared with ethyl acetate.

Relationship between refractometer index and volatiles

Refractometer index has good correlation with sucrose content, and therefore with quality

of melon fruit as mentioned earlier. Relationship between refractometer index and esters formation during fruit developing stages, was shown as scatter diagram in Fig. 8A, B and C. Ethyl acetate was detected highly from matured fruit with high quality (over 11 refractometer index). When lots of volatiles were detected during maturation, the fruits have already reached good quality. It means that very sensitive sniffing meter is available in field side, volatile production would be a good indicator for harvesting without destruction. This non-destructive method may be practically important for field-grown, popular melons. The handy sensitive meter for detection of aroma is now developing based on physical weight detection or chemical detection through semi-permeable membrane.

Fig. 8D, E and F shows the relationship between refractometer index and ester formation during storage from early picked melon at 20 days after anthesis. The early picked melons were poor quality with under 8% refractometer index during storage, whereas some of them produced high volatiles. Therefore, as the detection of aroma by nose is fairly sensitive, volatile measurement at consumer side, such as retail market, would not become good way for evaluating quality of melon.

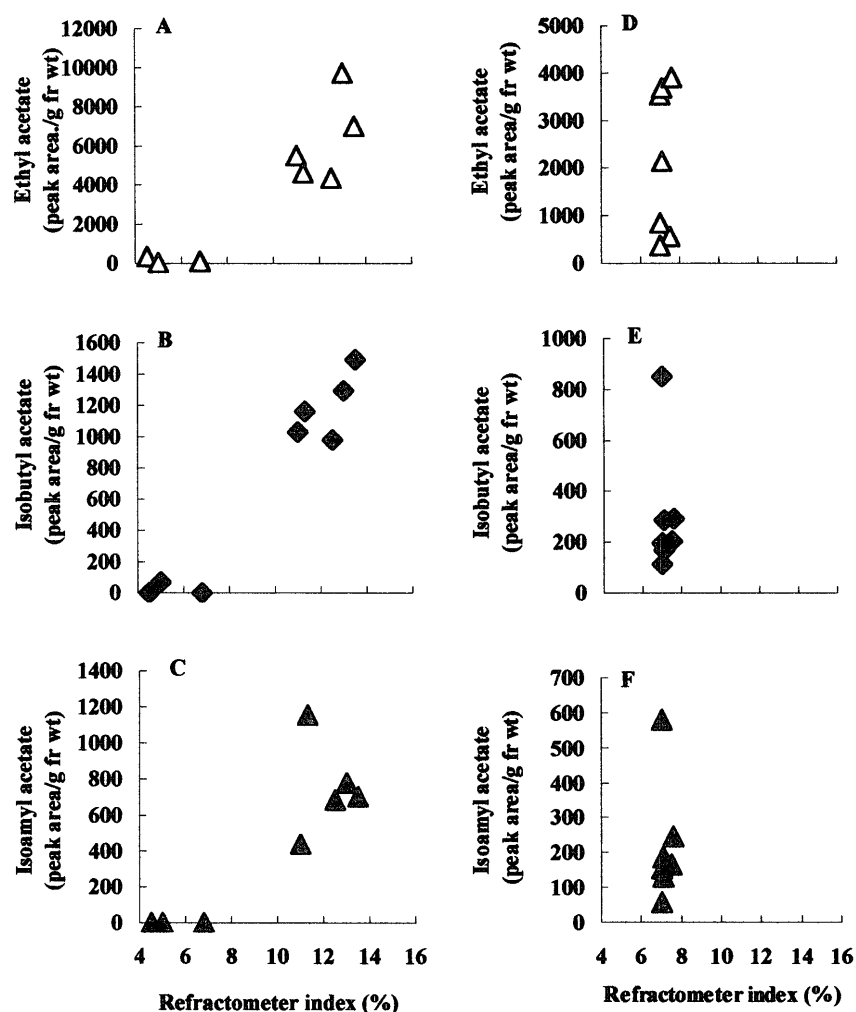


Fig. 8. Scatter diagram between refractometer index and esters evolution from 'Prince Melon' fruit during development and maturation (A, B, C) and storage of early mature stage (D, E, F).

A and D, ethyl acetate; B and E, isobutyl acetate; C and F, isoamyl acetate.

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