愛媛大学農学部農場報告
(Bull. Exp. Farm Coll. Agr., Ehime Univ.) 16 : 1 −10 (1995)

Fruit Growth and Development of Chinese Cherry (*Prunus pseudocerasus* Lindl.)

Fusao MIZUTANI, Ryuji HIROTA, Akira HINO*, **, Shoji AMANO*, Kazuomi KADOYA*, Junichiro WATANABE and Hiroaki AKIYOSHI

Summary

We investigated growth and development of Chinese cherry fruit (*Prunus pseudocerasus* Lindl.) in relation to changes in their chemical constituents. They flowered in early March and ripened in middle May. The flowers were self-compatible. Fruit exhibited a double sigmoidal growth curve and matured before the embryos attained their maximal sizes. Fruit were harvested 56 days after full bloom. The mean harvested fruit weight was 2.44 ± 0.40g. Total soluble solids content (SSC) was consistently low during Stage I and Ⅱ and rapidly increased during Stage Ⅲ. However gas chromatographic analysis of sugars in juice revealed their gradual declines during Stage I and Ⅱ although rapid increases were noted during Stage Ⅲ. Major sugars were fructose and glucose whereas sucrose was detected only in a small amount. Malate was a major predominant organic acid, which increased during Stage I and Ⅱ and declined during Stage Ⅲ. Starch content showed a gradual decrease from April 18. Rapid coloration in skin occurred during Stage Ⅲ. The shelf life of harvested fruit was 6 and 21 days when they were stored at 25℃ and 5℃, respectively. The greater enhanced increases in SSC and color development were noted in stored fruit at 25℃ compared with those at 5℃. However, stored fruit showed the greater gradual decline in titratable acid content at 5℃ than at 25℃ but exhibited increases again during the later period of storage.

Introduction

In Japan, speaking of flowers, they are referred to cherry blossoms, which are considered as the national flower. Japanese people appreciate cherry blossoms because they show a noble petal falling after exhibiting all their glory in spring. Such fine sense of beauty is also closely related to excessive evaluation of good appearance of fruit. Therefore, although there are a lot of cherry species and cultivars in Japan, breeders have so far made efforts chiefly for the development of flowering cultivars, not for edible types (Honda and Hayashi, 1974).

*Laboratory of Pomology
**Present : Laboratory of Citriculture

Commercial sweet cherry (*Prunus avium* L.) production of Japan is localized in the northern part such prefectures as Yamanashi, Yamagata, Aomori and Hokkaido, which are generally overlapped with the apple zone (Yoshida, 1994). Recently there has been growing interest in the cherry production in the south-western part of Japan. However, there are little data concerning cultural techniques, cultivars, rootstocks, insects and diseases in such regions.

Chinese cherry (*P. pseudocerasus* Lindl., *P. pauciflora* Bunge) is planted as an ornamental tree in gardens in south western Japan and people enjoy picking edible fruit in early summer. They usually flower in early March and ripen in middle May in the Matsuyama area. The flowering time is approximately one month earlier than most other Japanese cherry trees. Since little information about fruit growth and development of this species is available, we investigated their characteristics by employing a mature tree planted in the campus of the College of Agriculture, Ehime University.

Materials and Methods

Plant - We used a mature Chinese cherry (*P. pseudocerasus* Lindl., *P. pauciflora* Bunge) tree, the age of which is unclear, planted in the campus of the College of Agriculture, Ehime University. Fruit samples were collected at intervals in 1983 for measurement of fruit and seed sizes and analysis of constituents such as sugar and acid content. Shelf life of fruit was investigated after harvesting fruit on May 7, 1982.

Fruit set and self-compatibility - Since cherries often bear self-incompatible traits (Teskey and Shoemaker, 1978; Fogle, 1975), we determined whether this species is self-fertile or not. Before anthesis, some shoots were bagged in order to prevent from cross pollination and other shoots were non-bagged as controls. Fruit set was monitored during the growing season.

Soluble solids and titratable acid content - Soluble solids content of juice was determined by using a refractometer. Titratable acid content was estimated by titrating 0.1ml juice with 0.01N NaOH by using phenolphthalein as an indicator.

Gas chromatographic determination of sugar and organic acid - A 2μl aliquot of juice was taken in a 1ml glass vial, dried and trimethylsilylated with 20μl pyridine + 20μl hexamethyldisilane (HMDS) + 10μl trimethylchlorosilane (TMCS) for 30min at 60℃. Two μl was injected into a gas chromatograph (Hitachi 063) equipped with a 2m length x 3mm i.d. glass column packed with 1.5% SE 30 coated Chromosorb WAW DMCS. The column temperature was programmed from 125℃ to 265℃ at an increment rate of 10℃ and the carrier gas was N_2 at a flow rate of 17ml/min. 1, 3, 5-Triphenylbenzene was used as an internal standard for quantification. Typical chromatograms of trimethylsilylated sample and authentic standard were shown in Fig. 1.

Starch determination - A 200mg sample of flesh was taken and the starch content was determined as described by Carter and Neubert (1954).

Anthocyanin determination - By employing a cork borer, i.d. 0.5cm, two discs of skin were obtained. The discs were immersed in 5ml methanol containing 1% HCl and stood for 2 hours at 5℃. The optical density of the methanolic solution was determined at 530nm.

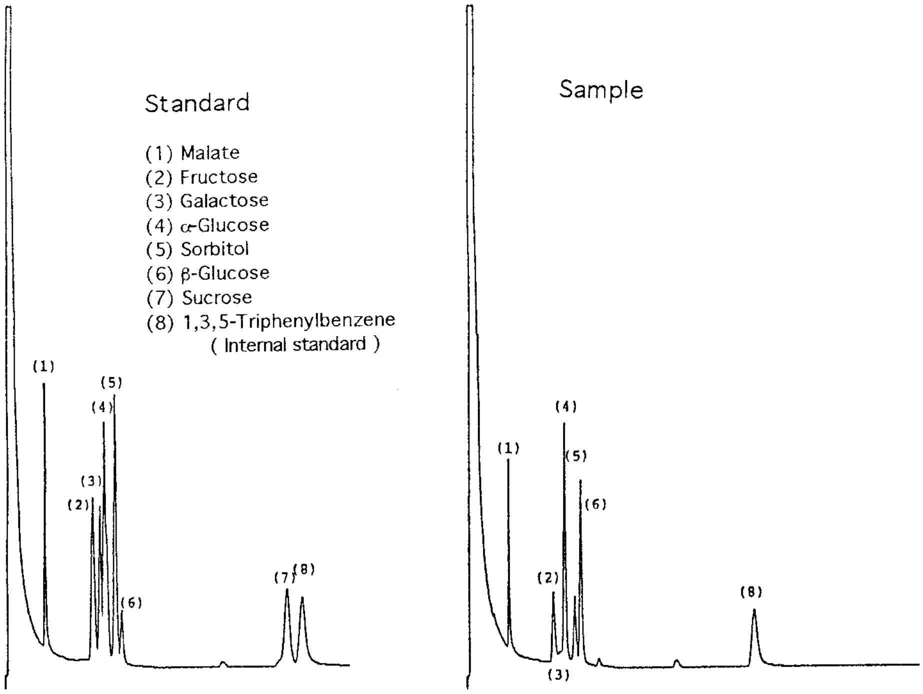

Fig. 1 Gas chromatograms of trimethylsilylated juice samples and authentic standards.

Results and Discussion

Twigs bearing flowers are shown in Fig. 2A. In 1983, flowering started on March 8 and the full bloom was March 18. It seems that flowering time changes with year depending on chilling winter temperatures necessary for bud break and warm spring temperatures for bud swelling. For example, flowering was delayed in 1984 so that it started on March 28. Generally speaking, this species flowers in early March in the Matsuyama area. On the other hand, the flowering time of sweet cherries is in middle April. The percentage of pollen germination was 49.6% when pollen was collected at anthesis and assayed on 1% agar media containing 15% sucrose at 25℃ for 6 hours.

It is well known that many cherry cultivars bear self-incompatible traits (Teskey and Shoemaker, 1978; Fogle, 1975), which means the necessity of cross-compatible pollinizers for fruit set and commercial production. However, Chinese cherry exhibited self-compatibility since bagging flowering shoots had little appreciable reduction in fruit set compared with non-bagged control shoots (Fig. 3).

Fruit at each sampling date are shown in Fig. 2B. Fig. 4A shows the time course of fruit and seed growth. Fruit growth exhibited double sigmoidal curves; Stage I corresponded to the period from March 23 to April 13, Stage II from April 13 to April 28 and Stage III after April 28. Fruit were harvested 56 days after full bloom. On the other hand, seeds started rapid growth from March 29 and attained their full size on April 13.

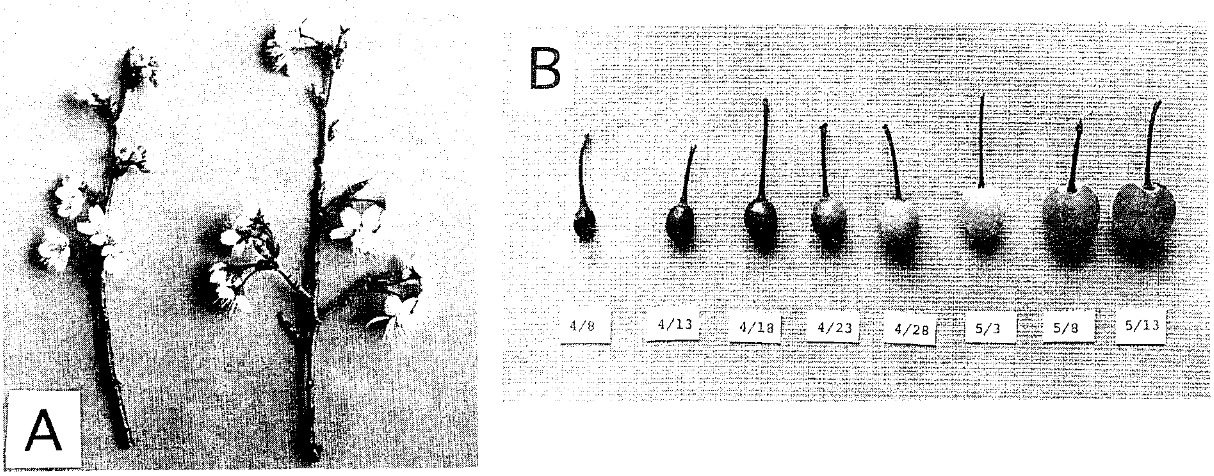

Fig. 2 Twigs bearing flowers (A) and fruit samples at each collecting date (B).

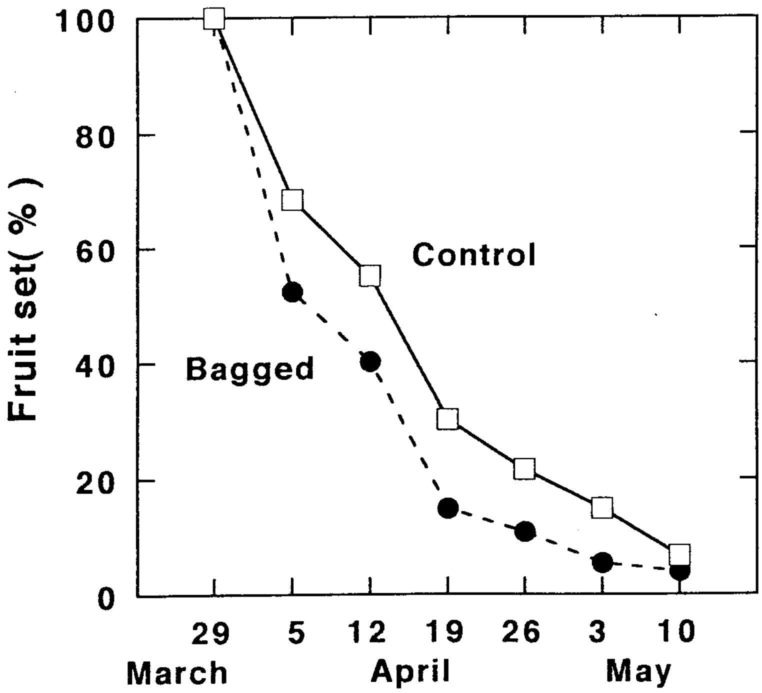

Fig. 3 Time course of fruit set of bagged and non-bagged shoots.

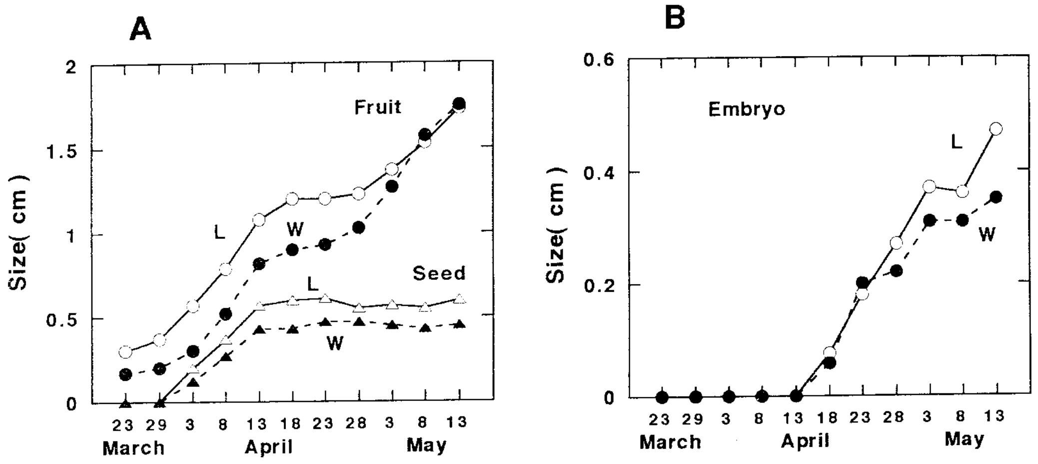

Fig. 4 Growth curves of fruit, seed (A) and embryo (B).
L and W mean length and width, respectively.

There was no visible growth of embryo during Stage I (Fig. 4B). Coincident with the beginning with Stage II, embryos started growth and continued the increase in size. Even at harvest, they seemed to continue the growth. This indicates that fruit mature before the embryos attain their full size as often seen in early maturing cultivars of *Prunus* species.

The changes in the soluble solids and titratable acid content were shown in Fig. 5. The soluble solids content was consistently low from April 8 to April 28, but thereafter increased rapidly to reach about 14%. On the other hand, the titratable acid content increased from April 13 to reach a maximum level on April 28 and declined thereafter to a level of 0.8%.

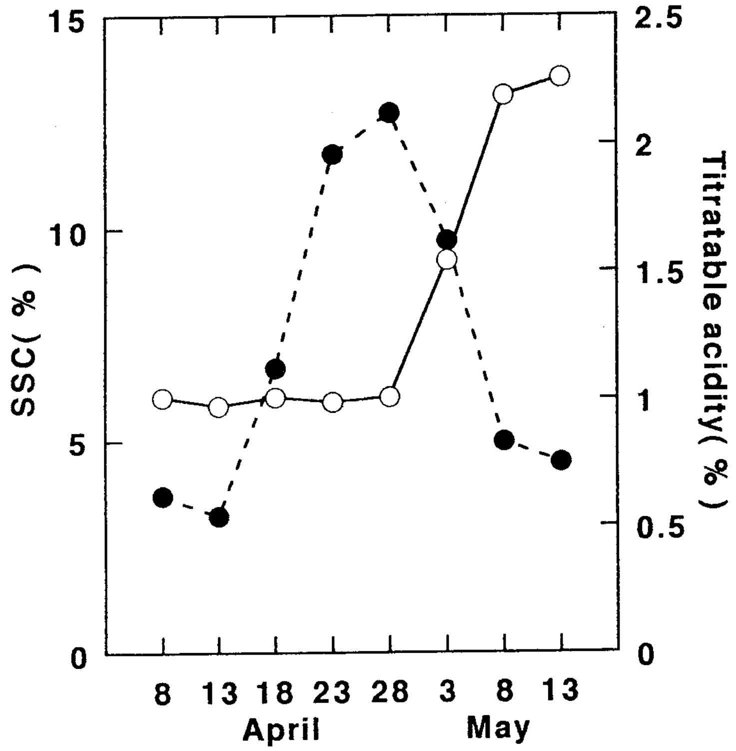

Fig. 5 Seasonal changes in total soluble solids content (○) and titratable acidity (●) in fruit juice.

increased rapidly with maturation. Sorbitol and galactose also exhibited a similar trend but the decline of their content during Stage I and II was not so great as glucose or fructose (Fig. 7). Contrary to the above-mentioned sugars, sucrose showed a gradual decline from April 8 to barely detectable levels on April 28 although a slight temporal increase was noted on May 8 (Fig. 7). Total sugar content, the sum of each sugar level, exhibited a gradual decrease from April 8 to a minimum level on April 28, followed by a rapid increase. The discrepancy between the consistency of soluble solids content and the decline of total sugar content during Stage I and II may be reconciled by fact that in the former case there are other substances than sugars that have refractory traits.

The major organic acid was malate (Fig. 8). This was further confirmed by gas chromatographic analysis of trimethylsilylated sample of organic acid fraction that was obtained by eluting with 1 N ammonium carbonate the anion exchange resin (Amberlite CG-400) through which juice had been passed. The seasonal change was similar to that of titratable acid content (Fig. 5).

Starch content slightly increased from April 8 to April 18, followed by a gradual decline to about 0.2% (Fig. 9).

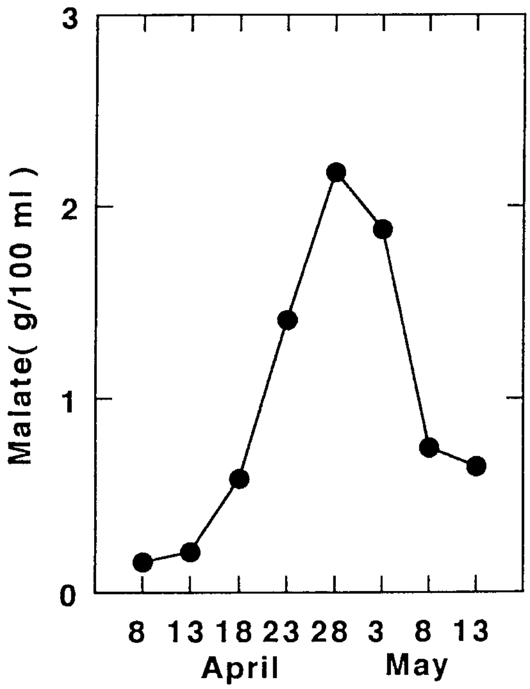

Fig. 8 Seasonal change in malate content of fruit juice.

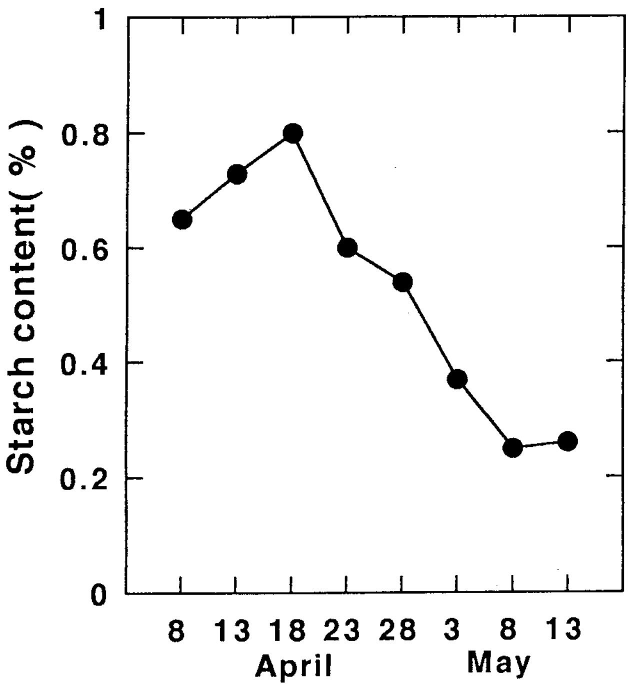

Fig. 9 Seasonal changes in starch content of fruit.

Anthocyanin content in the skin as expressed in optical density at 530nm increased gradually from April 18 to May 8, and then sharply increased with maturation (Fig. 10).

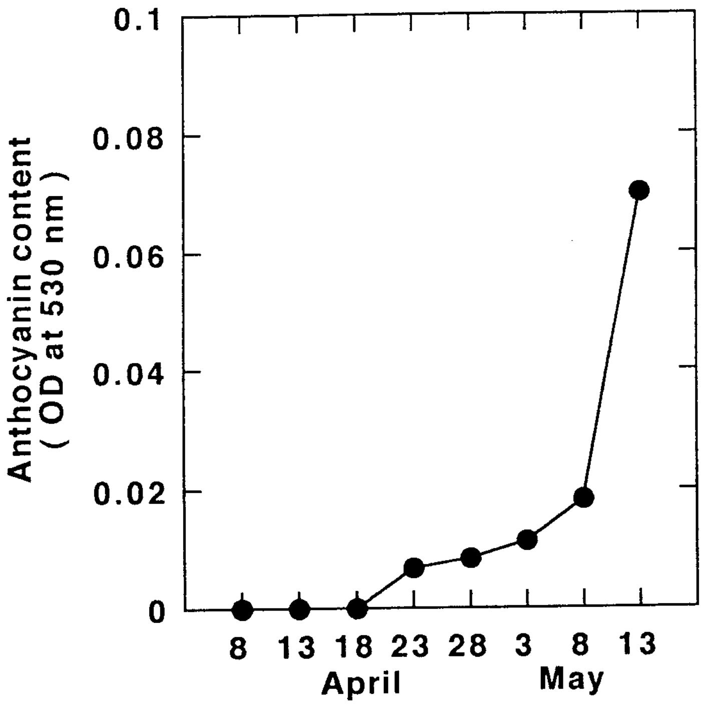

Fig. 10 Seasonal changes in anthocyanin content of fruit skin.

Fruit weight ranged from 1.6g to 3.3g and the mean was 2.44g with a standard deviation of 0.40 (Fig. 11). This value is a third to half the weight of sweet cherry cultivars like 'Napoleon' and 'Satohnishiki' (Taira, 1991) and a fourth that of 'Bing' (Patten and Proebsting, 1986).

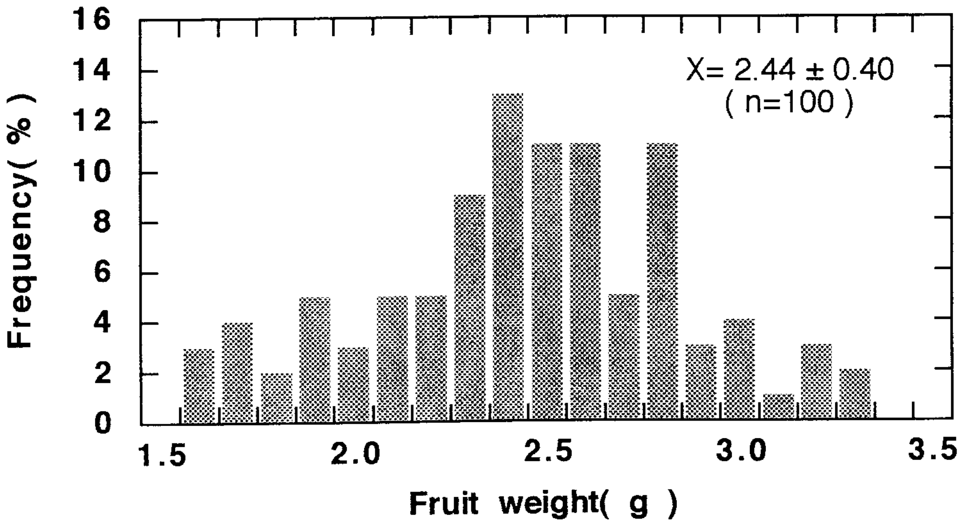

Fig. 11 Variations in harvested fruit weight.

Changes in SSC, titratable acid and anthocyanin content after harvest were investigated. Fruit were picked on May 7, 1982 and stored at 5 and 25℃. Five fruit were employed for each analysis. A shriveled symptom appeared at Day 6 and Day 21 on the skin of those stored 25 and 5℃, respectively (Fig. 12). SSC and anthocyanin content rapidly increased at 25℃ whereas gradual increases were noted at 5℃. On the other hand, titratable acid content showed gradual declines and then increased. The decline was greater at 5℃ than at 25℃.

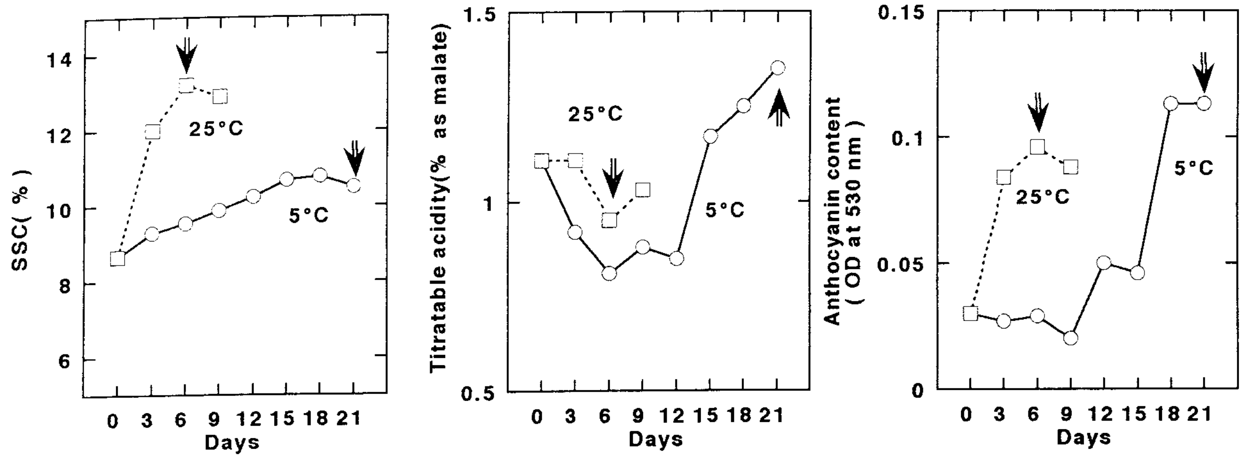

Fig. 12 Changes in total soluble solids content, titratable acidity and anthocyanin content of fruit stored at 5℃ and 25℃ after harvest. Arrows in the figures indicate the appearance of withering symptom on the skin.

In conclusion, there is a rainy season in June and July in Japan that causes the problem of fruit cracking of sweet cherries at harvest time. Thus the growers need the facilities like vinyl houses or large parasols to avoid rain fall. However, in the case of Chinese cherry, fruit can be harvested in early May before the rainy season. Furthermore, contrary to sweet cherries, this species is self-fertile. It is convenient if these properties are incorporated into sweet cherries by cross breeding or recent gene transferring techniques. Since sugar content of fruit is low and fruit size is small compared with those of sweet cherries, further improvement concerning these traits is also needed.

Literature Cited

Carter, G. H. and Neubert, A. M. 1954. Plant starch analysis. Rapid determination of starch in apples. Agri. Food Chem. 2 : 1070−1072.

Fogle, H. W. 1975. Cherries. In: J. Janick and J. N. Moore (Editors), Advances in Fruit Breeding. Purdue University Press, West Lafayette, Indiana. pp. 348−366.

Honda, M. and Hayashi, Y. 1974. "*Nihon No Sakura*" (Cherries in Japan). Seibundo Shinkosha Publishing Co. Tokyo. pp. 306. (In Japanese).

Patten, K. D. and Proebsting, E. L. 1986. Effect of different artificial shading times and natural light intensities on the fruit quality of 'Bing' sweet cherry. J. Amer. Soc. Hort. Sci. 111 : 360−363.

Taira, S. 1991. Sweet cherries. In: Sugiura, A. (Editor), Handbook for Tree Fruit Production. Yokendo Publishing Co. Tokyo. pp. 515−529. (In Japanese)

Teskey, B. J. E. and Shoemaker, J. S. 1978. Cherries. In: Tree Fruit Production. Third Edition, Avi Publishing Company, INC., Westport, Connecticut. pp. 292−357.

Yoshida, M., 1994. Cherry. In: Konishi, K., Iwahori, S., Kitagawa, H. and Yakuwa, T. (Editors), Horticulture in Japan. Asakura Publishing Co., Ltd., Tokyo, pp. 39−40.

Westwood, M. N. 1978. Fruit growth and thinning. In: Temperate Zone Pomology. W. H.

Freeman and Company, San Francisco, pp. 199－219.

摘　　要

シナミザクラ（*Prunus pseudocerasus* Lindl., *P. pauciflora* Bunge）の果実の生長と発達について果実内の成分の変化とともに調査をした。開花は３月の初旬、果実の成熟は５月中旬であった。花は自家結実性を示した。果実の生長は２重Ｓ字曲線を示し、胚が完全に成長する前に果実は成熟するようであった。収穫果の平均重は2.44±0.40ｇであった。可溶性固形物含量は生長のⅠ、Ⅱ期には低く一定の値を示したが、生長のⅢ期には急激に増加した。しかしながら、ガスクロマトクラフで糖含量を分析したところ、生長のⅢ期には同様な含量の増大が見られたが、生長のⅠ、Ⅱ期には含量の減少が見られた。果汁中の主な糖は果糖とブドウ糖で、しょ糖は極めて含量が少なかった。また、果汁中の有機酸はもっぱらリンゴ酸であり、生長のⅠ、Ⅱ期に含量が増加し、Ⅲ期には減少した。デンプン含量は４月18日から減少を示した。果皮の着色は生長のⅢ期に急激に進んだ。収穫果実を25℃と５℃で貯蔵したところ、25℃では６日目に、５℃では21日目に萎びが表れた。25℃では貯蔵後、急激に可溶性固形物含量と着色が増大した。滴定酸含量は５℃のほうが減少が大きかったが、貯蔵後半に再び含量が増大した。