Seasonal changes in the concentration of sugars and organic acids in peach fruits.

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Summary The present investigation was undertaken to determine quantitatively changes in the concentration of sugars and organic acids during fruits growth.

During development fruits showed characteristic fluctuations in acid content-usually the initial level was low, it increased steadily with growth reaching a maximum in mid-season and then steadily declined as the fruits matures. Malic acid was the most prominent acid during fruit growth in the three varieties. The difference in organic acids between early and late maturing varieties appeared to be depend upon the relative lengths of growth period.

Starch content in the three varieties increased rapidly in the first few weeks of growth and reached a maximum about May 6 to 13. Although starch content disappeared fell to a zero value later in the season.

Seasonal changes in sugars of three varieties generally were showed about the same pattern. The content of glucose and fructose in the three varieties continued to increase slowly until mid-season and reached a maximum at beginning pit-harding. Subsequently, both contents continued to decrease rapidly until ripening.

Sucrose concentration in the three varieties remained at low level until pit-harding period, although increased rapidly during the last two weeks of maturation.

Sugar-alcohol content remained approximately constant or increased slightly during growing season.

Changes in sugars and organic acids associated with the fruit development have been reported by a number of workers (4, 5, 6, 7, 9, 10, 11). But little information is available for the peach fruits. The relationship between sugars and organic acids in fruit is very important factor to decide the quality of peach fruits.

The present paper was made to determine quantitative changes in the concentration of sugars and organic acids throughout the growing season.

Materials and Methods

Used for the experiment in 1969 were the three varieties of peach "Sunakowase" (early maturing variety), "Ōkubo" (middle maturing one) and "Hakutō" (late maturing one) growing in the experimental orchard at Kyoto Prefectural University.

The fruits were normally picked at weekly intervals from full bloom until maturity. The samples were placed in polyethylene bags, sealed and stored at −20°C until analyzed. Ten grams of frozen fruits (fresh weight from each) were extracted with 80% ethanol and homogenized in a stainless steel waring blender. The ethanol extract

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was then evaporated until the alcohol was gone and poured onto a 2×20 cm cation exchange resin column (H^+ form) containing Amberlite IR 120, 200-mesh. The effluent from IR 120 column was passed through a 2×20 cm anion exchange column containing Amberlite IRA 400, 200-mesh in the carbonate form. The effluent from the anion exchange resin contained the sugar fraction which was evaporated to dryness using a water bath and samples were stored in the refrigerator until analysis were made.

The organic acids retained by IRA 400 anion exchange column were eluted by passing 500 ml of 1 N ammonium carbonate. The eluate was evaporated to dryness in a manner similar to that used for sugars.

The residue was used for quantitative determination of starch. The procedure was used in studies of rapid determination of starch in apples by Carter (1954) (1).

Determination of sugars. - The sugars were separated by ascending one dimensional chromatography on Toyo No. 51 paper. The solvent systems were used to check the indentity of the sugars: n-butanol-acetic acid-water (4 : 1 : 1 v/v). The sugars present on the developed chromatograms were indentified by comparison with Rf values of known sugars in this solvent system. Individual sugar fractions were obtained by eluting the spots cut from paper strips with 10 ml of distilled water for over night.

Glucose, fructose and sucrose were determined quantitatively by colorimetric method of anthrone. Sugar-alcohol was used chromotropic acid method as described by West et al. (1949) (18).

The determination of organic acids. - Malic acid estimations were carried out using the method of Goodban. (1957) (2).

Citric acid estimations were carried out using the method of Pucher. (1941) (14).

Results

The changes in concentration of malic and citric acids throughout the growing season were given in Fig. 1, 2.

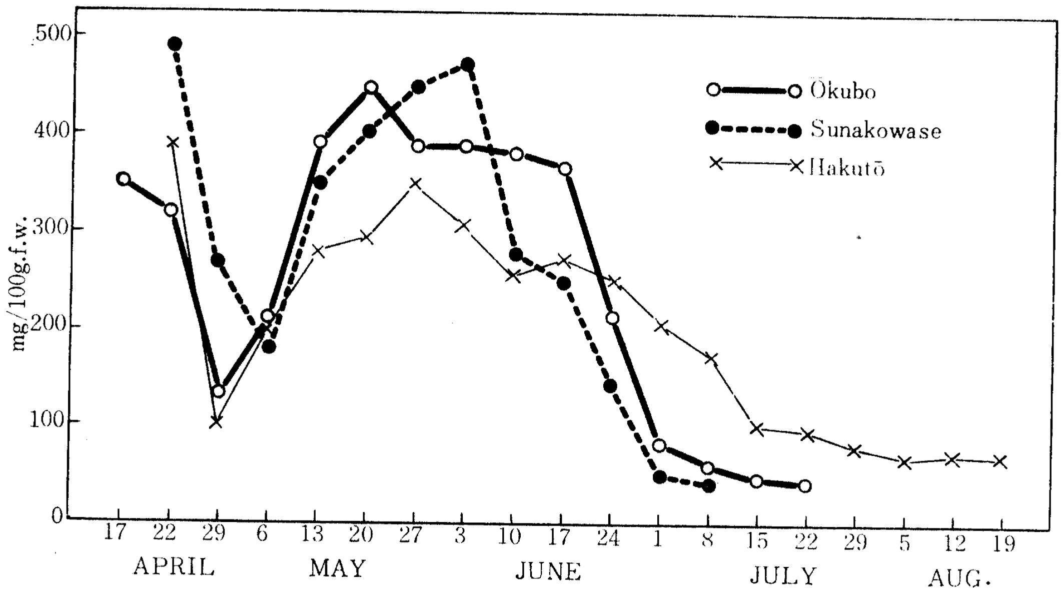

Fig. 1. Seasonal changes in the content of malic acids in the three varieties. (1969)

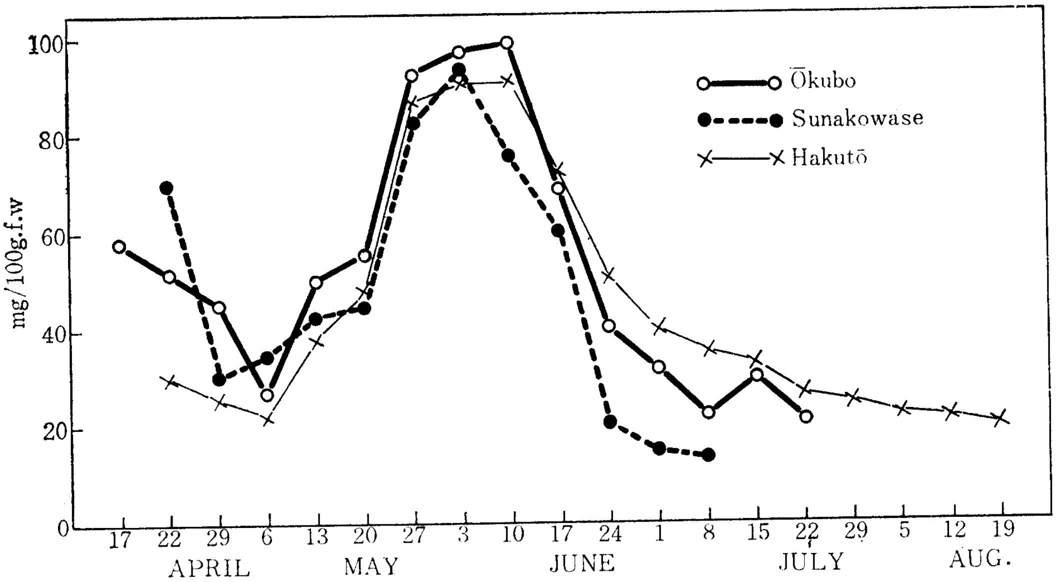

Fig. 2. - Seasonal changes in the content of citric acids in the three varieties. (1969)

Concentration of malic and citric acids among the three varieties continued to decrease for 2 to 3 weeks after full bloom, and increase remarkably until the end of May. In both, there was a maximum in malic acid concentration toward the end of May followed by a peak in citric acid concentration two or three weeks later. From near the beginning of June, content of organic acids continued to decrease slowly until the ripening. The difference in

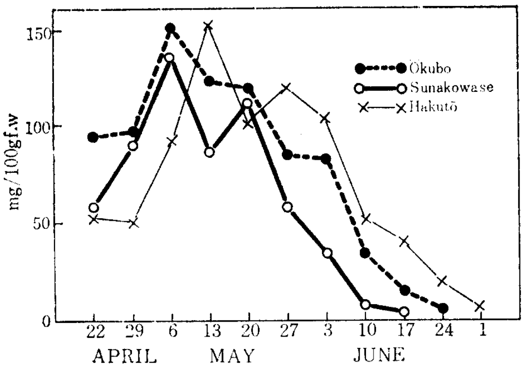

Fig. 3. - Seasonal changes in the content of starch in the three varieties. (1969)

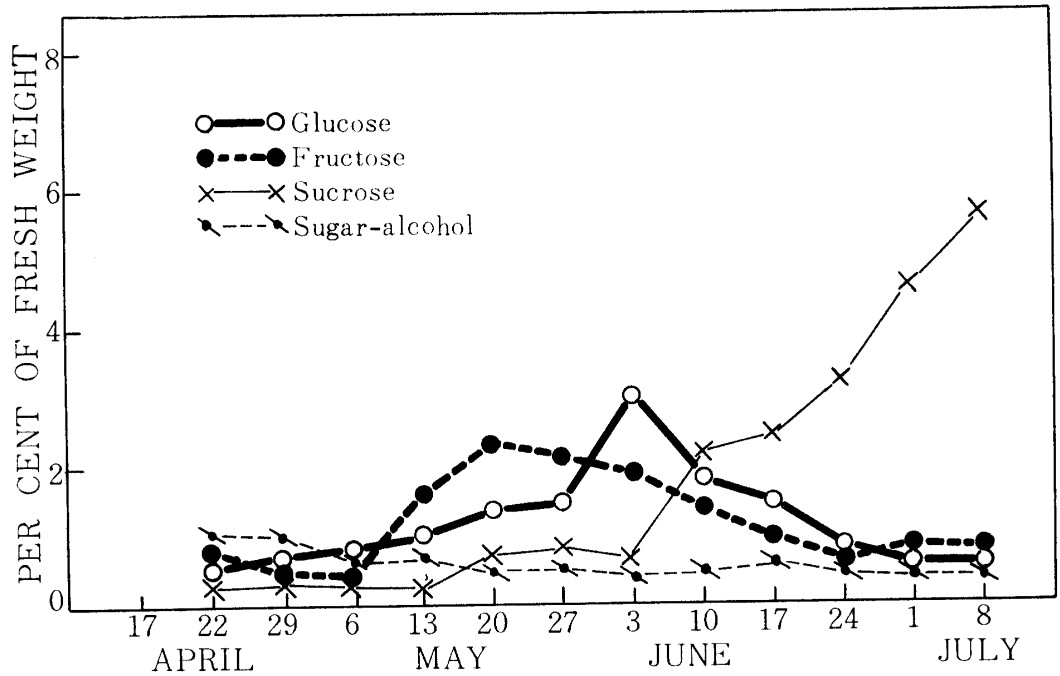

Fig. 4. - Seasonal changes in the content of sugars in peach fruits Sunakowase. (1969)

organic acids between early and late maturing varieties appeared to be depend upon the relative lengths of growth period of fruits. Malic acid was the most prominent acid during fruit growth in the three varieties.

Changes in the starch content among the varieties were given in Fig. 3. Starch content in the three varieties increased rapidly in the first few weeks of growth and reached a maximum about May 6 to 13. However, starch content disappeared fell to a zero value later in the season. There was relatively small scatter in the maximum values of starch concentration among the varieties of peach investigated - 0.13% in

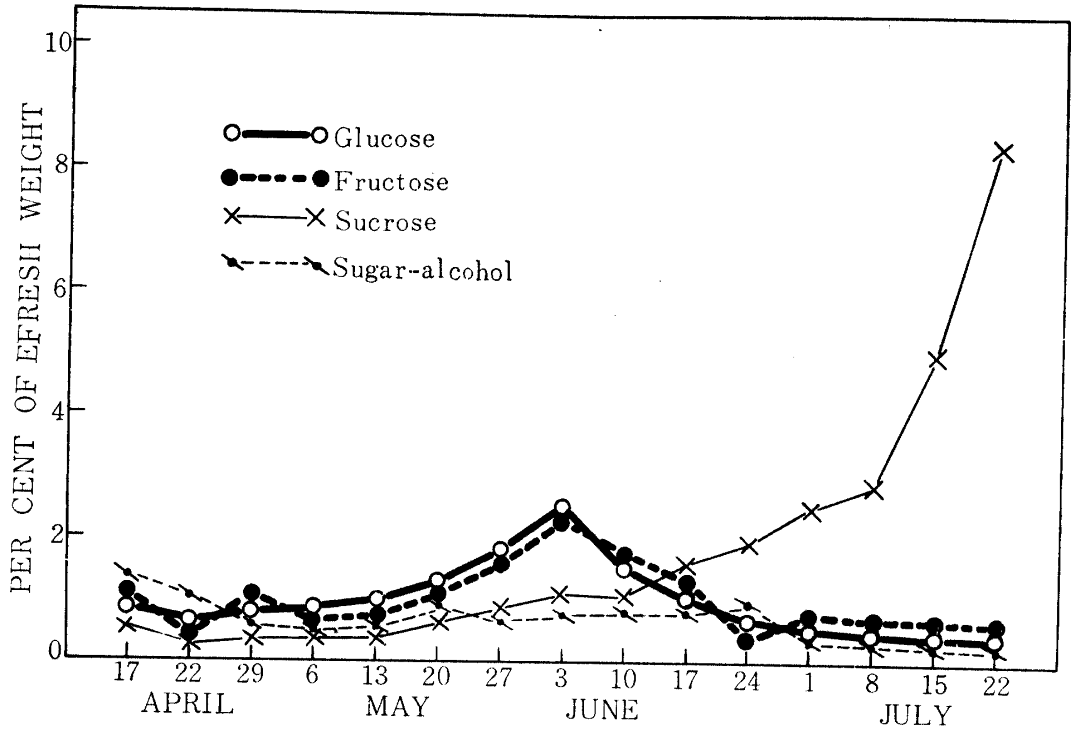

Fig. 5. - Seasonal changes in the content of sugars in peach fruits Ōkubo. (1969)

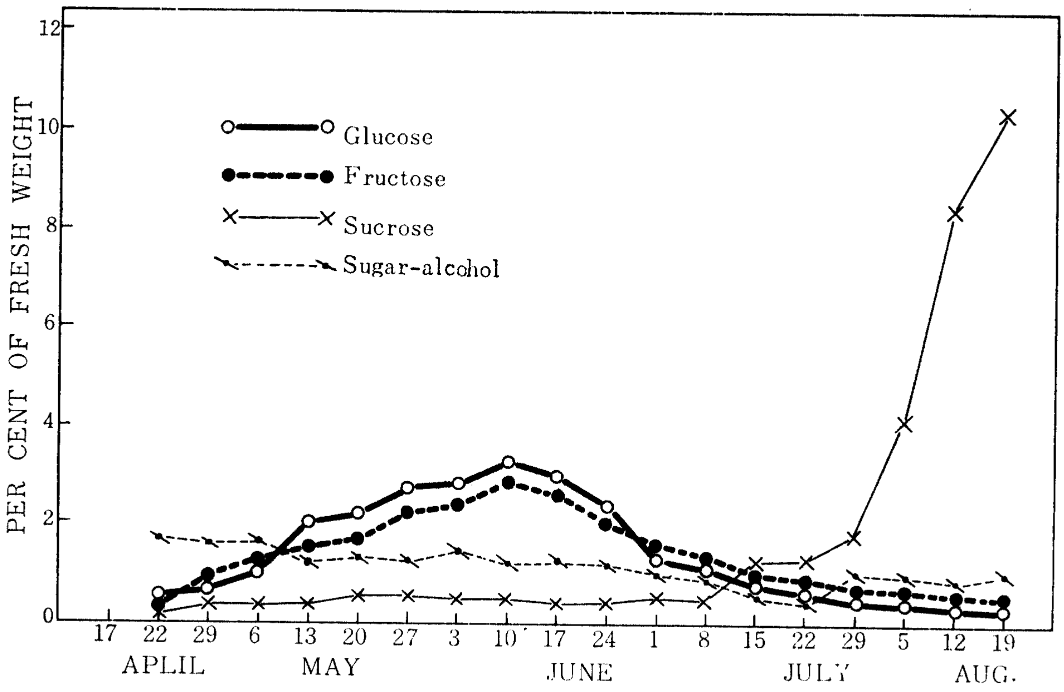

Fig. 6. - Seasonal changes in the content of sugars in peach fruits Hakutō. (1969)

early maturing "Sunakowase" to 0.15% in late maturing "Hakutō".

The changes in concentration of sugars throughout the growing season were given in Fig. 4, 5, 6. Seasonal changes in sugar of three varieties generally were showed relatively the same pattern. The content of glucose and fructose among the varieties continued to increase slowly until the mid-season and reached a maximum at the biginning of pit harding. Subsequently, it continued to decline steadily until the ripening. Glucose ahd fructose were contained approximately equal amounts during fruit development. Sucrose content among the varieties remained at low level until the pit-harding period, although it increased rapidly during the last two weeks of maturation to a high values.

Sugar-alcohol content among the varieties remained approximately constant or increased slightly during the growing season.

Discussion

During development peach fruit showed characteristic fluctuations in acid content-usually the initial level was low, it increased steadily with growth reaching a maximum in mid-season and then steadily declined as the fruits mature. Similar results are well known in the other fruits (4, 10, 12, 15). It is believed that a large part of organic acid may be synthesized in the leaves and translocated to the fruits. Experiments with isotopically labelled material support this argument (13). However, Tomkins (16) suggests that a part of the acids are formed in apple fruits from carbohydrates. It is very interesting that organic acid could come not only from leaves, but formed within the fruits themselves.

It is evident from Fig. 3, changes in starch content of peaches during development in the varieties is similar to that reported by Kidd et al. (8) in the apple.

The main sugar transported from the leaves to fruit is sucrose. However the sugar or their derivatives are important for translocation in some plants. In apple, it has been shown that C-labelled D-glucitol is translocated from leaves at a greater rate than sucrose. (17, 19). Thus, it can be considered that sugar-alcohol is also an important translocating compound in *Rosaceous* species such as apples and peaches.

At maturity in peach fruits, sucrose content accumulated very much in the fruits. The mechanism for this sudden change in the metabolism of peach fruits is not known. Initial hydrolysis of starch with the concomitance of sucrose is seen in apple and pear, however the increase in sucrose content is much greater than could be a accounted for by hydrosis of starch. The question arises as to which of the sucrose is synthesized in the leaves or other organs and then translocated to the fruits and which are synthesized in fruit tissues.

It is interesting that in grapes, where there is good evidence that sucrose is the sugar which is transported, it is reducing sugars which accumulate in the fruits (3). Krotkov et al. (7) came to the conclusion that the carbohydrate and acid metabolisms of the apple are closely connected, but that relation is not a simple one. Further more, it will be necessary for this kind of study.

要旨：モモ果実の品質の良否を決定する主なる要因は糖および有機酸であるといわれている。そこでこれらの基礎的な資料を得る目的で，砂子早生，大久保および白桃の3品種を供試して，糖および有機酸の季節的な消長を調べた。その結果有機酸は開花後一度減少し，以後生育中期まで増加し，それ以降漸次減少して成熟期にいたった。またモモ果実ではリンゴ酸が最も多く含まれており，有機酸の品種差異は果実成育期間の長さに帰因するものと考えられた。

糖の消長に関しては，デンプンは開花後2～3週間までは増加したが，果実生育中に漸次消失した。果実の生育にともなってグルコースとフラクトース含量は生育中期まで増加したが，シュークローズ含量はこの期間低くあまり変化せず，成熟2週間前ごろから急増した。糖アルコールは果実生育期間中あまり変化せずほぼ一定であった。

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