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PHYSICAL AND COMPOSITIONAL CHANGES OF TOMATO FRUITS DURING GROWTH AND DEVELOPMENT

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The tomato fruit, like any other fruit, goes through different stages of development from fruit setting to ripening. The 'Moneymaker' variety has been widely cultivated during the past few years. Examination of physical and compositional changes in the tomato fruits of this variety during growth and development would be of great value in their harvesting, handling and storage.

Materials and Methods

Plants of the 'Moneymaker' variety were grown in the greenhouse of the Institute of Horticultural Engineering (I.T.T.), Wageningen, Netherlands. Fruits were picked from the plants twice, first June 2 and then July 7, 1966. Each picking contained fruits representing six stages of development (Figure 1). Physical and compositional characteristics of fruits in the various developmental stages of the two pickings were determined at the Laboratory of Plant Physiological Research, Agricultural University, Wageningen, The Netherlands. The following characteristics were determined: fruit weight, fruit size, percentage of dry matter, total sugars (9), crude (proteins 6), and carotene and lycopene (10).

Results and Discussion

Fruit weight and size.

Changes in fruit weight and size followed a similar pattern in the two examined pickings (Figure 2). Fruit weight and size increased gradually between the first two stages of development, then showed a marked increase in the third stage. In the fourth stage (mature-green stage) the fruit had almost attained its

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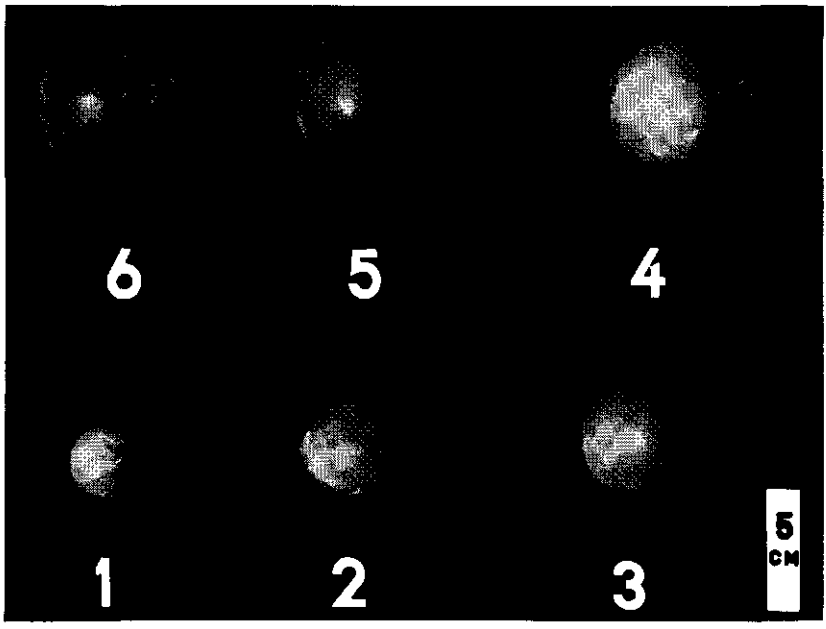

Fig. 1: Development stages of 'Moneymaker' tomato fruits.

Note: This picture was presented in colour by the author, in order to show the various stages of ripening at which the fruits collected were analized, in the order of 1–6 (taken 13.6.1966). Numbers 1–4 included show the increase in size up to full size, all these are still green; number 5 has a pale orange colour, number 6 a deep orange colour. The colour picture was converted into a black and white one, using a specific filter, to retain as much as possible the colour differences, since the costs of colour reproduction unfortunately appeared prohibitive. At the time of the photograph, the fruits came directly from cool storage in the laboratory, and some condensed water vapour appears on their surface.

maximum size and weight. During the fifth and sixth stages, the increase of fruit weight and size was minimal for during this period most changes occurred in the composition of the fruit. MAC DOUGAL (4) attributed this growth pattern to the extraordinarily high imbibition capacity of the tomato fruit due to their content of amino acids, salts and sugars.

Dry matter and moisture percentage.

As the dry matter percentage in tomato fruits decreased, the moisture percentage increased (Figure 3). The percentage of dry matter was highest in stage 1 decreased sharply to stage 2, gradually decreased to stage 4, and changed very little thereafter. These results are in agreement with those of SANDA (8) who found that water content generally increased in tomato fruits between the green-mature and ripe stages. MAC GILLIVARY and CLEMENTE (5) observed that total solids and fruit size were inversely related.

Total sugars and crude proteins content.

Total sugars content increased rapidly between stages 1 and 2, leveled off to stage 3 and sharply increased to the sixth stage (Figure 4). The leveling off between stages 2 and 3 may be due to cell enlargement occurring during this period which results in some dilution of cell compounds. ANDREOTTI and CECI (2) and MABROUK (3) found that ripening of tomato fruits was accompanied by an increase in the sugar content. Their findings are in line with those of the present study.

Crude proteins content of the fruit decreased gradually from stage 1 to stage 6 (Figure 4). This decrease was rather sharp at the begining and then became more gradual. ANDREOTTI (1) noticed that protein nitrogen content decreased during ripening of tomatoes whether calculated on a fresh or dry weight basis.

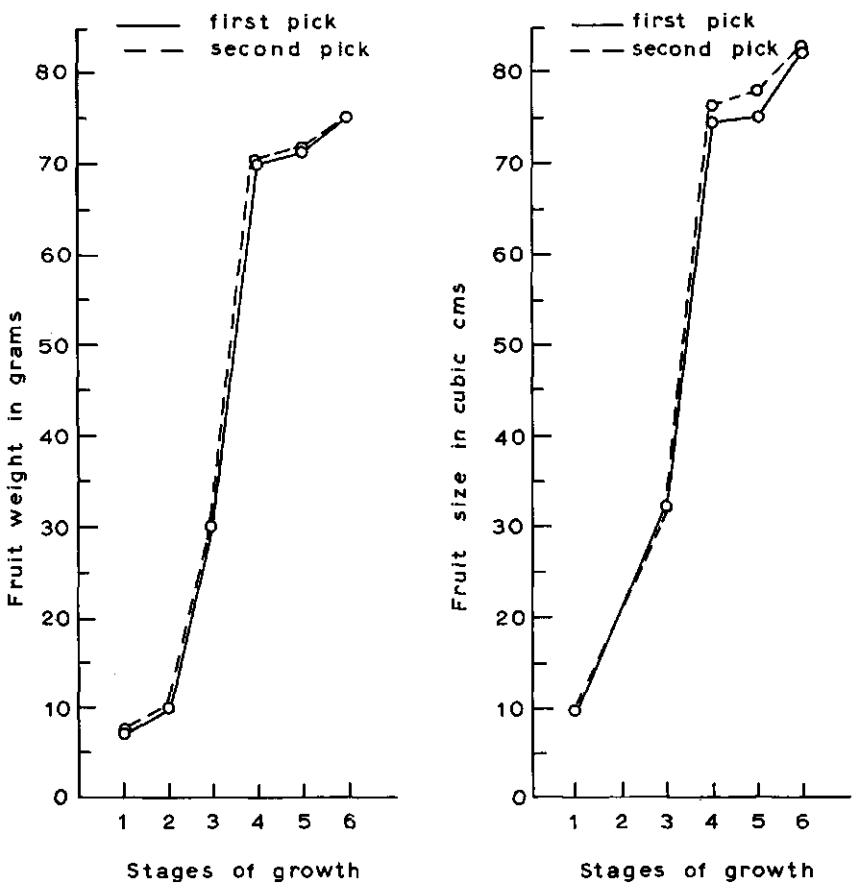

Fig. 2: Weight and size of tomato fruits at various developmental stages.

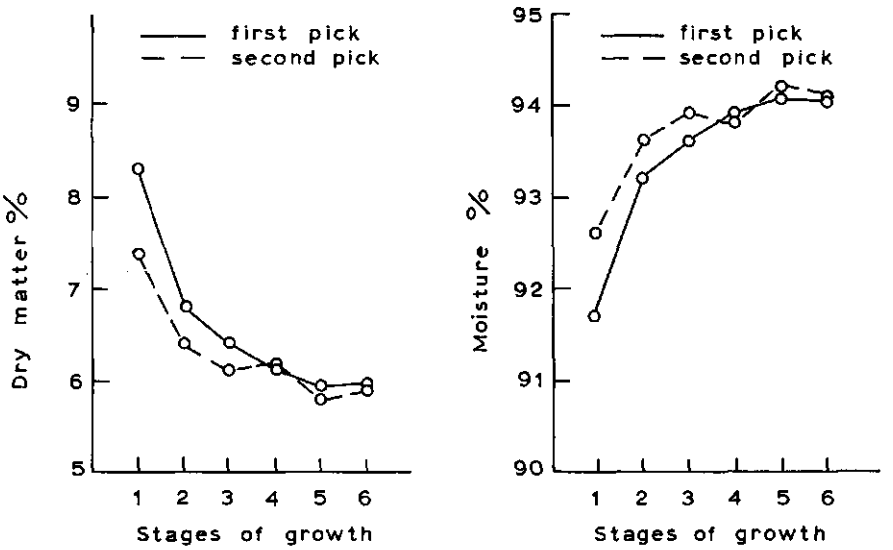

Fig. 3: Dry matter content and moisture percentage of tomato fruits at various developmental stages.

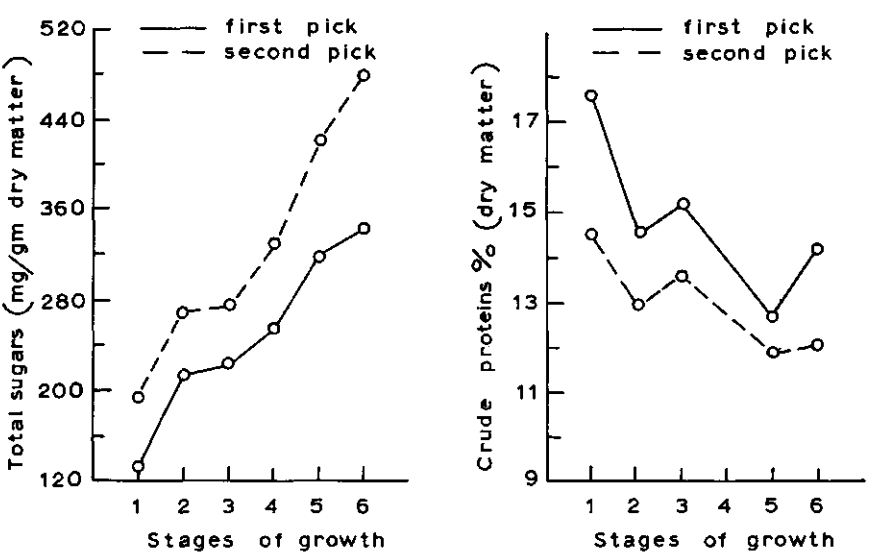

Fig. 4: Total sugars and crude proteins of tomato fruits at various developmental stages.

Carotene and lycopene content.

Changes in carotene and lycopene content of fruits were closely related during the various developmental stages and similar in the two pickings (Figure 5). Carotene was present in very small amounts during the first four stages, while lycopene was negligible. No significant changes in carotene or lycopene content were observed throughout the first four stages. However, there was a rapid increase in both carotene and lycopene in stage 5; between stages 5 and 6 the increase was very sharp. This coincides with ripening as evidenced by visual color changes in the tomato fruits. SADANO and AHMED (7) reported that the carotene content and the concentration of all the individual carotenoids increased during various stages of ripeness on the vine, and vine-ripened fruit contained more carotene than fruit picked green and ripened during storage.

SUMMARY

Determinations of some physical and compositional changes in various stages of development were made on two pickings of 'Moneymaker' tomato fruits. It was observed that tomato fruit growth increased gradually between fruit set and ripeness. The increase was rapid during the third stage and the fruits attained their maximal size at the fourth stage (mature-green stage). The

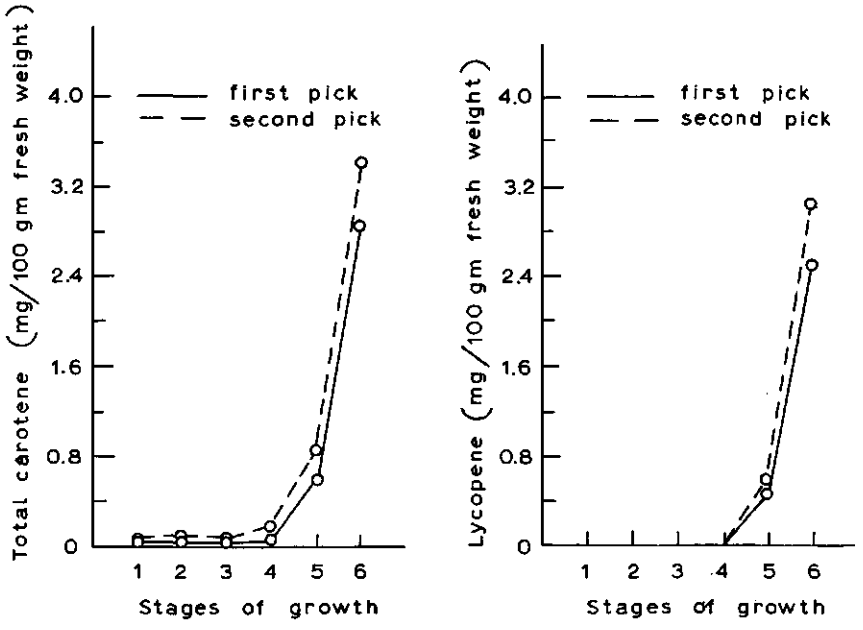

Fig. 5: Total carotene and lycopene content of tomato fruits at various developmental stages.

changes in dry matter percentage were reversible in pattern to changes in growth.

Total sugars increased rapidly during stages 1 and 2 and leveled off in stage 3; thereafter increased appreciably to the sixth stage. Crude proteins decreased gradually between stages 1 and 6. Carotene and lycopene content did not vary much through the fourth stage. Then a rapid increase was observed in the fifth stage, and the increase was more pronounced in stage 6.

Acknowledgement

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POSTSCRIPT

In several studies, e.g. SPOEHR and MILNER, Pl. Physiol. **24**, 102–149 (1949), BONGERS, This Journ, **56** (15), 1–52 (1956), it has been shown that cultures of algae, gradually becoming short of nitrogen, tend to stop multiplication, cells enlarge, and start to accumulate carbohydrates and further on lipids (be it at much lower efficiency of light energy conversion than matter formation during the initial rapid multiplication phase). In the unicellular alga *Haematococcus pluvialis*, this behaviour leads to a conspicious accumulation of red carotenoids, gradually converting e.g. an agar culture from green to dark red. (In some other similar algae a probably analogous shift from green to yellow or orange can be observed).

At seminars in our laboratory, I have sometimes jokingly remarked that a tomato essentially is a macro-*Haematococcus*, and Dr. AZIZ' studies, presented in the present two papers, well substantiate this idea.

Decline of root activity in higher plants often accompagnies (or causes?) maturation, manifest by accumulation in some organs of reserves of carbohydrate or lipid nature. What factor exactly induces a single fruit on a still vigorous plant to mature by its own remains to be seen. It lies at hand to suppose effects induced by or upon the fruit petiole.

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