Pakistan J. Bot. 2 (2) : 25—30

BIOCHEMICAL STUDIES IN THE DEVELOPING AND RIPENING BANANA

II. Changes in the contents of total carbon, starch, sucrose, glucose and fructose

M.A.A. KHAN and M.M.A. FOIZUL JALAL

Department of Botany, University of Dacca, East Pakistan.

Abstract

In developing and ripening banana fruits the dry matter was found to increase gradually with age followed by a small decrease at the ripening stage. The total carbon content of banana followed a similar curve. The starch content increased gradually from early stage to full maturity, while there was hardly any change in sugar contents during this period. During ripening starch content decreased with a concomitant rise in the sugar content. Glucose and sucrose were found to be the major sugars in young and ripe bananas respectively.

Introduction

The banana fruit is rich in carbohydrates. Starch is the major carbohydrate component in the green banana from early stage till the beginning of the ripening process, but sugars constitute chief carbohydrates in the ripening banana (Biale 1960, Biale and Young 1962).

The present biochemical study on the estimation of the contents of starch, glucose, fructose and sucrose in a local commercial variety of banana is aimed at determining the changes in their amounts at the growing and ripening stages and correlating them with the ripening process.

Material

The fruits of the most important local commercial variety "Sagar" of parthenocarpic banana *Musa sapientum* L. grown in the Botanical Garden of Dacca University were used. The age of the banana was counted from the day when the bract opened. First and fourth bunches from the base of the inflorescence were selected for the experiment. Two to three fingers of the banana were collected each time from the plant when they were of 10, 20, 30, 40, 60, 80, 100, 110, 118 and 121 days old. The yellowing of the fruits started after 110 days and was completed before 121 days.

Methods

The production and purification of carbon dioxide from the carbon contents in the banana were done according to the wet combustion method of Furman (1963). Alternate transverse slices of the fruits were dried in an oven at 70 C. The carbon dioxide evolved from the powdered samples during wet combustion was purified and finally collected in sodium hydroxide solution. The amount of carbon was estimated in this solution by the titrimetric method described by Vogel (1961).

The killing of tissues, extraction, and estimation of starch were done following the technique of McCready *et al.* (1950).

Alternate slices of banana were taken and sugars were extracted with 80% hot ethanol by Waring Blendor. The extract was evaporated to dryness and the residue was dissolved in water. Sugars were estimated from the aqueous solution. The hexose was determined before hydrolysis of the extract by titration method with Fehling's solution described by Clarke (1949). Total hexose and total fructose were separately determined spectrophotometrically after hydrolysis of the extract according to the method described by Scott and Melvin (1953), and Ashwell (1957, indole reaction method) respectively. The values of sucrose, glucose and fructose contents in banana fruit were calculated from these determinations.

Experimental Results

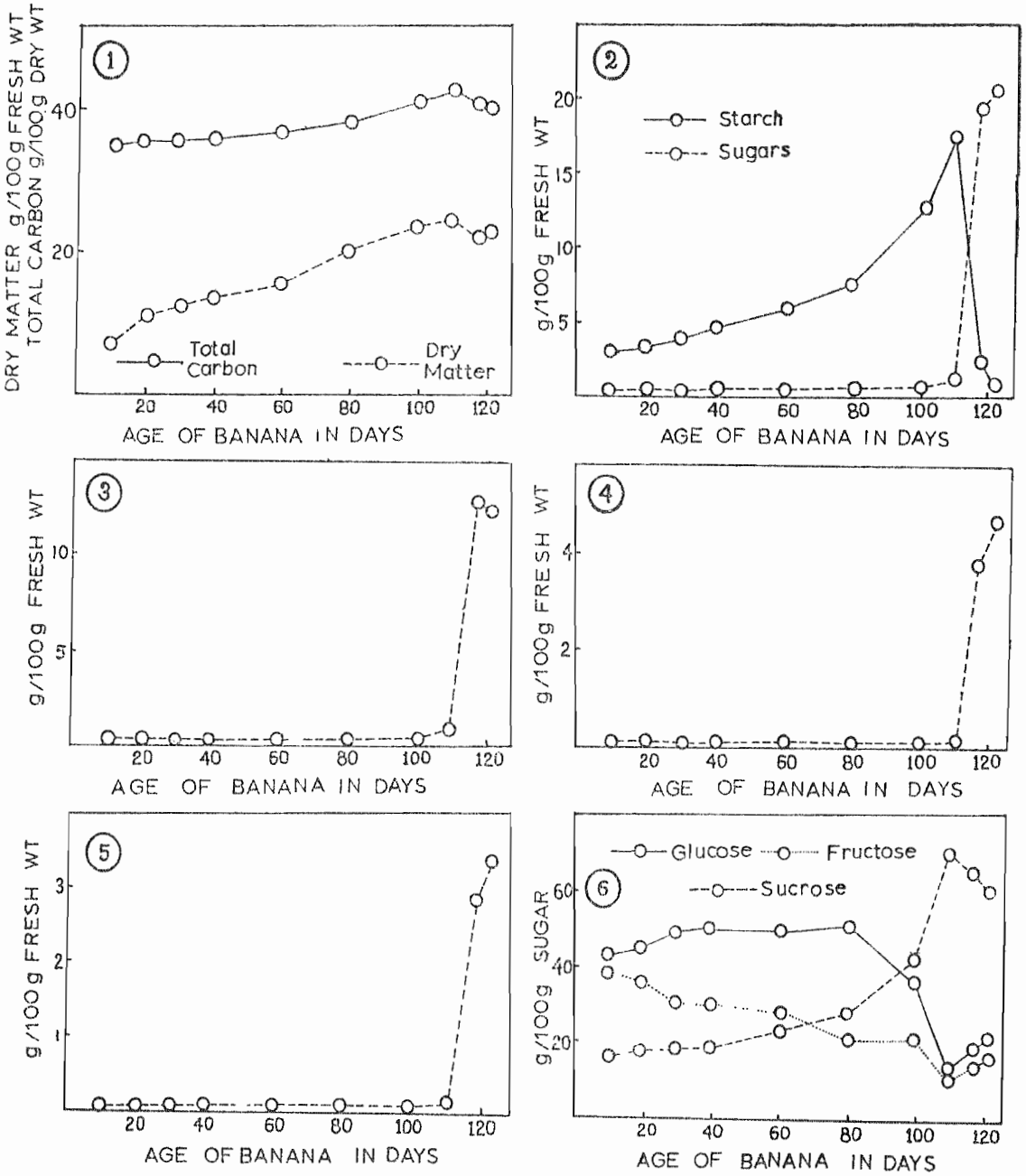
Change in dry material : Ten-day old banana contained 7.13 g of dry material per 100 g fresh weight and this gradually increased to 24.31 g in 110-day old fully developed green banana. It slightly decreased in the yellowing banana of 118 days and then again increased slightly in 121-day old fully yellow banana (Fig. 1).

Change in total carbon : The amount of the total carbon was 35.41g per 100g dry material in 10-day old banana. This gradually increased to 42.35g in 110-day old banana. During ripening the carbon content slightly decreased (Fig. 1).

Change in starch content : Ten-day old banana contained 2.69 g of starch per 100 g fresh tissue and it gradually increased to 17.53 g in 110-day old fully grown green banana. Its rate of increase was greater between 80 and 110 days. The starch content sharply decreased to 1.08 g per 100 g fresh tissue in fully ripe banana of 121 days (Fig.2).

Change in sugar content : Sucrose content was 0.029 g per 100 g fresh weight in 10-day old banana. It hardly increased during the next 100 days but sharply increased to about 12 g in 118 and 121 days (Fig. 3). Similar changes were observed in case of glucose (Fig. 4) and fructose (Fig. 5).

Sucrose was the minor sugar at the young stage of banana and it gradually increased to 73.1% of total sugar in 110-day old banana. But it gradually decreased to 60.8% in 121-day ripe fruit. Glucose and fructose content in 10-day old banana were 43.3% and 39.8% of total sugar respectively. During the development these decreased, but after 110 days in the ripening period, percentage of both the sugars increased slightly (Fig. 6).



Changes in banana at different ages, Fig. 1. the contents of total carbon and dry material, Fig. 2. starch and total sugar contents, Fig. 3. sucrose content, Fig. 4. glucose content, Fig. 5. fructose content and Fig. 6. changes in quantities of glucose, fructose and sucrose per 100 g total sugar in banana at different ages.

Discussion

Dry material and the total carbon content in the banana fruit : The dry material as well as the total carbon in the banana fruit gradually increased from 10 to 110 days. This observation reveals that the water content is more in the younger banana. Similar change of an increase of dry matter content during the growth of banana was observed by Barnell (1940).

In the ripening stage between 110 and 121 days both the carbon content and the dry matter decreased slightly. The decrease of carbon might be due to its use in the climacteric rise of respiration. Barnell (1941) also observed similar decrease in dry matter content in banana during ripening.

Starch content in the banana fruit : The content of starch gradually increased in banana from 10 to 110 days. The increase of starch was rapid between 80 and 110 days. Barnell (1940) observed that the starch percentage in developing banana of Gros Michel variety increased in two stages—"The first stage of rapid consistent increase being from 0 to 60 days approximately and the second stage, of less rapid increase than the first from 60 to 100 days." The reverse result was found in the present case. The difference might be due to the difference in the varieties of the banana used. Besides, Barnell's records fall into two series : (a) those based on bunches of known age ranging from 0 to 79 days and (b) those based on bunches of arbitrary age from 80 days onward. The use of two sets of banana from different plants might have an influence on the nature of the curve of the starch component shown by Barnell (l.c.). The difference of the results, on the other hand, might depend purely on environmental conditions.

In the ripening stage from 110 to 121 days, the starch contents decreased accompanied by the corresponding increase in sugars. Similar changes of starch and sugar were observed in Gros Michel banana by Poland *et al.* (1938), Barnell (1941), Biale (1960) and Biale and Young (1962).

Sugar content in the banana fruit : Although the contents of glucose, fructose and sucrose were very small in the young and full grown banana, they increased during ripening when the starch content decreased. The excess sugar produced during ripening which was not accounted for by the loss of starch might have come by conversion from the other carbohydrates already present in the banana. Spencer (1965) suggested that extra sugar during ripening might come from hemicellulose of banana.

In 110-day old banana sucrose which was major sugar, slightly decreased during ripening period while glucose and fructose gradually increased. Similar results were reported by Poland *et al.* (1938). 'The changes in the levels of starch and sugars observed in the ripening banana, appear to be the result of the ripening process.' It suggests that the hydrolytic enzymes are activated during ripening. Sugars may be related in two ways to the ripening process ; these may be involved firstly in the production of ethylene and secondly in the climacteric rise of respiration. Burg and Burg (1962,1965) suggested a pathway for the production of ethylene from glucose precursor. But according to Mapson (1970) β-D glucose is oxidised by glucose oxidase to produce hydrogen peroxide which is an essential catalyst in the production of ethylene from methionine.

Acknowledgement

We thank Dr. S.S.M.A Khurashani of the Department of Chemistry, University of Dacca for his kind help in the determination of total carbon.

References

Ashwell, G. 1957. Colorimetric analysis of sugars. In Methods in Enzymology Eds. S.P. Colwick and N.O. Kaplan. Academic Press. N.Y. **3** : 73.

Barnell, H.R. 1940. Studies in tropical fruits. VIII. Carbohydrate metabolism of the banana fruit during development. Ann. Bot. **4** : 39-71.

———1941. Studies in tropical fruits. XI. Carbohydrate metabolism of the banana fruit during ripening under tropical conditions. Ann. Bot. **5** : 217-247.

Biale, J.B. 1960. The post-harvest biochemistry of tropical and subtropical fruits. Adv. Food Res. **10** : 293-354.

———and R.E. Young. 1962. The biochemistry of fruit maturation. Endeavour **21** : 164-174.

Burg, S.P. and E.A. Burg. 1962. Role of ethylene in fruit ripening. Plant physiol. **37** : 179-189.

———1965. Ethylene action and the ripening of fruits. Science **148** : 1190-1196.

Clarke, H.T. 1949. A handbook of organic analysis. Edward Arnold and Co. London. 4th edition. p. 327

Furman, N.H. 1963. Standard methods of chemical analysis. D. van Nostrand Company. Princeton. 6th edition. **1** : 287

Mapson, L.W. 1970. Biosynthesis of ethylene and the ripening of fruit. Endeavour **29** : 29-33.

McCready, R.M., J. Guggolz, V. Silviera & H.S. Owens. 1950. Determination of starch and amylose in vegetables. Anal Chem. **22** : 1156-1158.

Poland, G.L., J.T. Manion, M.W. Brenner & P.L. Harris. 1938. Sugar changes in the banana during ripening. Ind. Eng. Chem. **30** : 340-342.

Scott, T.A. and E.H. Melvin. 1953. Determination of dextran with anthrone. Anal. Chem. **25** : 1656-1661.

Spencer, M. 1965. Fruit ripening. In Plant Biochemistry. Eds. J. Bonner and J.E. Varner. Academic Press. N.Y., p. 793.

Vogel, A.I. 1961. A text book of quantitative inorganic analysis. Longmans London. 3rd edition, p. 249.