CCLXVI. FURTHER OBSERVATIONS ON THE HEMICELLULOSES OF THE PODS OF RUNNER BEANS

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IN a previous paper [Buston, 1935] some observations were recorded concerning certain of the changes taking place in the cell-wall constituents of the pods of runner beans during their growth and ripening. Evidence was given that during the final stages of ripening there was a loss of "hemicellulose" (i.e. the fraction recoverable from the extract obtained by the action of cold 4% sodium hydroxide), and also that the nature of the hemicellulose itself was modified, there being an increase of pentosan both relatively to hexosan and in terms of weight of pentosan per 100 pods.

This observation led to the question of the origin of the extra pentosan—whether it was additional material entering the pods from the actively synthesizing parts of the plant, or was derived from material such as the hexosan already in the pods. As is well known the suggestion has been made repeatedly that pentosans may arise from hexosans by a process combining mild oxidation (of the primary alcohol groups) and decarboxylation of the urone groups so formed. Much circumstantial evidence has been put forward in support of this theory, but little or no direct experimental work has been done to test its truth.

In an attempt to throw light on this point, experiments were carried out in which the entry of fresh material into the pods during the final stages of ripening was minimized by removing all leaves from the plants at the time when the pods had reached their maximum size but were still green and fleshy. In other experiments fully grown green pods were removed from the plants and allowed to dry slowly in air. Comparative analyses were made of the pods so treated, and of pods from "control" plants allowed to mature in the normal manner.

It was further hoped, in the course of these experiments, to test the suggestion of Schulze & Pfenniger [1910] that a transference of hemicellulose from the pod to the enclosed seeds took place during the final stages of ripening. It was not possible to decide this point, since the increase in hemicellulose in the seeds is some fifty times as great as the simultaneous decrease in the hemicellulose of the pods, any transfer from pod to seed therefore being insignificant in comparison with, and masked by, the amount of newly formed carbohydrate arriving from other parts of the plant. Where the attempt was made to restrict the arrival of fresh carbohydrate (by removal of leaves) there was actually a small loss of hemicellulose from the seeds also.

EXPERIMENTAL

The beans used were the dwarf-growing runner variety "Little Gem" as used in the previous experiments and they were grown under ordinary conditions at the Chelsea Physic Garden. When a crop of beans had reached full

size (late in August) any very old pods showing signs of becoming dry were removed, and also all the small undeveloped pods and flowers, thus leaving as uniform a sample as possible on the plants. Three batches of 50 pods were picked and analysed immediately. On the control plants, the pods were allowed to ripen normally, but any further flowering was prevented; in 3-4 weeks the pods had become quite brown and dry, and were then picked (in batches of 50) and examined. From other plants, all leaves were removed, leaving only the fully grown green pods; again in 3-4 weeks these had become brown and dry, although in this case the seeds had not grown as in the controls. Batches of 50 of these pods were picked on the same day as the controls, and treated similarly. Finally (in the 1935 series only), fully grown pods were picked and allowed to dry in the air for the 3-4-week period.

Treatment of the pods, when dry, followed the lines indicated in the previous paper [1935], extraction of the hemicelluloses and estimations of urone, furfuraldehyde etc. being made in the usual manner. The results are given in Table I.

Attempts were made also to follow carbohydrate changes in the seeds, in view of the suggestion of Schulze & Pfenniger recorded above, but these were not successful. Difficulty was experienced in handling the alkaline extracts, which were of colloidal nature and were contaminated with much protein. The amount of pentosan was much lower than in the pods, as would perhaps be expected in a storage tissue, and a small increase was noted in the fully ripe seeds.

Table I. *Pods of Phaseolus: Hemicellulose, pentosan, urone, hexosan*

		g. per 100 pods			
Year	Batch ...	A	B	C	D
1933 (H. W. B.)	Total hemicellulose	9.17	7.60	—	—
	Pentosan	2.75	3.86	—	—
	Urone	1.03	0.96	—	—
	Hexosan	5.39	2.78	—	—
1935 (A. A. H.)	Total hemicellulose	8.80	8.40	5.60	6.50
	Pentosan	2.45	3.45	3.25	3.62
	Urone	0.95	0.85	0.85	0.95
	Hexosan	5.40	4.10	1.50	1.90
1936 (H. W. B.)	Total hemicellulose	9.22	6.06	5.78	—
	Pentosan	2.19	2.85	3.01	—
	Urone	0.57	0.41	0.38	—
	Hexosan	6.46	2.80	2.39	—

Batch A. Pods fully grown, picked while green.

Batch B. Pods allowed to ripen normally on plants.

Batch C. Pods from "defoliated" plants.

Batch D. Pods detached, allowed to dry in air.

Batches A and D picked, plants for batch C stripped: 1935, 6 Sept.; 1936, 26 Aug.

Batches B and C picked, batch D analysed: 1935, 26 Sept.; 1936, 1 Oct.

(The figures in the above table are based upon the average of at least three determinations.)

DISCUSSION

As was indicated in the previous paper, there is a definite decrease in the total hemicellulose of the bean pod during the final stages of ripening, and this is rather more marked when photosynthesis in the plant is reduced to a minimum by removal of leaves. That the decrease is greater in such defoliated plants suggests that there is, normally, some transfer of carbohydrate from the leaves to the pods even at the end of the period of ripening. In each case also there is an increase of pentosan, both in relation to hexosan and in terms of weight per

100 pods. This increase is of approximately the same order in normal and defoliated plants, but the simultaneous decrease of hexosan is considerably greater in the latter, probably because the supply of hexosan is not being replenished from the leaves. If the pentosan found in the pods enters (as pentose, or water-soluble pentosan) from other parts of the plant it is unlikely that when photosynthesis is severely restricted there will still be as much entering as in the normal plant. The additional pentosan therefore is more likely to have been formed in situ from other constituents of the pods, already present. From the single experiment performed, the greatest increase of pentosan takes place in pods detached from the plant; here there can have been no fresh arrival of either hexose or pentose, and the pentosan must have arisen from material already present. The hexosans, which are evidently of labile nature, would seem to be the most likely precursors.

SUMMARY

The hemicellulose constituents of the pods of runner beans decrease during the final stages of ripening of the seeds, the decrease being most marked in the hexosans. The pentosan content, in terms of weight per 100 pods, increases during this period, both in normal ripening and in plants where photosynthesis is restricted by removal of leaves. There is some evidence of conversion of hexosan into pentosan, especially during the drying of pods detached from the plant.

REFERENCES

- Buston (1935). *Biochem. J.* **29**, 196.
Schulze & Pfenniger (1910). *Hoppe-Seyl. Z.* **68**, 93.