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FAILURE OF A DIABETIC TO UTILIZE INULIN.

BY E. C. WISE AND F. W. HEYL.

In a previous paper (1) the failure of a diabetic to utilize the carbohydrate in dried artichoke powder was discussed. The sugar tolerance of the subject was carefully determined on a weighed analyzed diet both before and after supplemental feedings of dried artichoke powder. These data were obtained during an experimental period covering thirty days. While the subject was available and his diet in balance with his apparent sugar tolerance, an additional short experimental period was instituted during which time a supplemental feeding of inulin prepared from artichokes was made. These data were not published at that time but in view of the considerable interest in the results of the feeding of dried artichokes it was thought that the results of the inulin feeding would also prove of interest.

A number of papers have appeared in the literature in the past which indicate that levulose, as well as some of its condensation complexes such as inulin, may serve as a source of a more utilizable carbohydrate in diabetes. A number of references are reviewed by Shohl (2).

Jerusalem artichokes contain approximately 80 per cent moisture and 15 per cent of carbohydrates. The carbohydrates consist largely of inulin and other condensation products of levulose which make up about 85 per cent of the total carbohydrate. The remaining 15 per cent of the carbohydrate consists of sucrose, levulose and dextrose. The quantities of the various sugars vary rather widely with the season of the year. In the preparation of artichokes for food the proportions of the various sugars may also be altered, that is, a portion of the inulin may be hydrolyzed to levulose.

There is evidence to show that inulin is not absorbed. Lewis (3) doubted the value of inulin feeding. Lewis and Frankel (4), working with phlorhizinized dogs, state that there seems to be little probability that an appreciable amount of inulin is converted into any substance that can give rise to glucose in the diabetic. Root and Baker (5) state that inulin produced no significant increase in the blood sugar in either normal or diabetic subjects. It did, however, have a slight effect upon the respiratory quotient of two patients, but the evidence is difficult to consider favorably.

In the case of the diabetic under our observation it is doubtful if any inulin at all was absorbed. The subject was fed on a level very close to his sugar tolerance and in addition to this ate rather large quantites of inulin. Accepting 12 per cent as the amount of inulin in Jerusalem artichokes, the daily ration of inulin, 30 Gm., represents a feeding of about 250 Gm. of whole artichokes. If any appreciable hydrolysis and absorption of the products of hydrolysis had taken place the subject must necessarily have shown some glycosuria. Such, however, was not the case and we feel convinced that inulin is not utilized. However, no inulin was found in the feces so that, with Lewis, we explain the disappearance of the inulin as the result of some type of intestinal fermentation.

If this view of the matter is correct, then the alleged increased tolerance of diabetics to Jerusalem artichokes is readily accounted for. Obviously if the preparation of the artichokes for food leaves an unhydrolyzed portion of inulin the apparent tolerance of the patient to artichoke carbohydrate will be greater than the tolerance to any carbohydrate which is completely utilized. Where the conversion of the inulin is complete, as in the dried artichoke powder which was fed as previously described (1), no advantage of this kind would be noted.

EXPERIMENTAL.

The subject at the beginning of the experiment was receiving a diet yielding 69 Gm. protein, 236 Gm. fat, and 105 Gm. of carbohydrate, the available glucose content of this diet being 169 Gm. Procedure, methods of analysis and other details were carried out as described previously (1). The subject was fed, in addition to the basal diet, 30 Gm. of inulin daily for three days and 22 Gm. on the fourth day, followed by three days on the basal diet only. The inulin used was prepared in the laboratory by precipitating water extracts of fresh artichokes with 95 per cent alcohol and collecting the precipitated inulin. The precipitate was analyzed for inulin by determining its reducing power after hydrolysis. This determination was run in series with C.P. inulin. Our material was approximately 80 per cent inulin and was free from any reducing sugars.

The subject at this time had just concluded a period of supplemental feeding of dried artichoke powder and was now eating the basal diet only. He was still excreting a few grams of glucose daily which was merely a lag from having previously been fed above his tolerance. In spite of the addition of inulin the urinary sugar gradually became negative.

TABLE I.—BASAL FOOD INTAKE.

Day.	Protein, Gm.	Fat, Gm.	Carbohydrate, Gm.	Available glucose, Gm.	Water, cc.	Weight, pounds.	Inulin added in grams of carbohydrate.
31	69.2	236	105	169	950	119	30
32	69.2	236	105	169	1350	119	30
33	69.2	236	105	169	1000	119	30
34	69.2	236	105	169	1000	118	22
35	69.2	236	105	169	1150	118	..
36	69.2	236	105	169	1150	119	..
37	69.2	236	105	169	1200	119	..

TABLE II.—URINE ANALYSES.

Day.	Volume, cc.	Specific gravity.	Acetone.	Nitrogen, Gm.	Sugar, Gm.
31	1370	1.020	None	10.4	4.3
32	1260	1.020	None	10.0	3.8
33	940	1.026	None	10.1	3.1
34	840	1.028	None	10.6	3.5
35	900	1.021	None	9.6	0.0
36	910	1.023	None	10.2	3.6
37	1030	1.020	None	9.6	0.0

From these data it is evident that inulin was not utilized in any appreciable quantity. At the beginning of the inulin feeding the patient was excreting about 4 Gm. of glucose daily and any utilization of inulin would have been reflected in an increased output of urine sugar. Such was not the case and the excretion of glucose became negative on the seventh day in spite of 112 Gm. of inulin fed during the first four days of the period. The basal diet of 169 Gm. of available glucose is so close to the previously determined tolerance of the patient (172 Gm.) that any appreciable absorption of the degradation products of inulin would have been reflected in the urinary sugar.

Additional evidence as to the rôle of inulin is given by the glucose content of the blood. On the morning of the first day during which inulin was fed the fasting blood sugar was 150 mg. per 100 cc., while after feeding inulin for three days the blood sugar was 147 mg. On the last day of the experiment the blood sugar

TABLE III.—FECES AND BLOOD ANALYSES.

	Feces.				Blood.	
Day.	Weight, Gm.	Nitrogen, Gm.	Fat, Gm.	p_H.	Sugar, mg. per 100 cc.	Nonprotein, nitrogen, mg. per 100 cc.
31				7.45	150	32.4
32	74	0.9	4.2			
33	74	0.9	4.2	7.34	147	33.0
34	74	0.9	4.2	7.32		
35	74	0.9	4.2			
36	74	0.9	4.2			
37	74	0.9	4.2	7.44	156	27.3

was 156 mg. During a similar period where the whole dried artichoke powder was fed the blood sugar rose to 190 mg. It is evident from this that inulin did not affect the blood sugar level as would be expected had there been any increased absorption of carbohydrate.

It was thought that since inulin frequently gives rise to intestinal fermentation, some change might be observed in the p_H of the feces. Table III gives these data which remained constant and at the same level as during the basal diet alone.

If we calculate the apparent tolerance of the subject to inulin, we get a daily average of 182 Gm. for the seven-day period. This is 10 Gm. higher than the

TABLE IV.—INULIN PERIOD: CARBOHYDRATE, INTAKE, OUTGO AND TOLERANCE.

Day.	Intake, Gm.	Outgo, Gm.	Tolerance, Gm.
31	199	4.3	195
32	199	3.8	195
33	199	3.1	196
34	191	3.5	188
35	169	0	169
36	169	3.6	165
37	169	0	169
		Apparent tolerance	182

tolerance previously (1) determined for this patient.

That this increase in tolerance is not real but only apparent is evidenced by these data and has been discussed above.

SUMMARY.

A diabetic having a sugar tolerance of 172 Gm. of glucose was fed 112 Gm. of inulin during four days' time in addition to a basal diet yielding 169 Gm. of available glucose. There was no increase in either blood sugar or urine sugar from which we conclude that the inulin was not utilized but was probably destroyed in the intestines. Inulin prepared from artichokes is of no value as a source of carbohydrate to a diabetic.

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THE LEAF OILS OF WASHINGTON CONIFERS: V. PICEA SITCHENSIS.

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Picea sitchensis, or tideland spruce, is the greatest of all spruce trees, being rarely surpassed in massiveness of trunk and height of stem, and there are few more beautiful and impressive sights. Indeed, a view never to be forgotten by those who have visited the forests of Washington is that of a mighty spruce, with its spire-like crown raised high above the broad base of the graceful sweep of its long branches, whose lustrous foliage, now silvery white, now changing to varied shades of green, justifies the title of "the loveliest cone-bearing tree in America."

It is usually about 100 feet high, with a trunk tapering from 3–4 feet at just above its much enlarged base. Occasionally it is found growing 200 feet tall, with a trunk 15–16 feet in diameter but, at the extreme northern limits of its range, it is reduced to a low shrub. The upper branches are short and ascending to form an open, spear-like head, while the lower ones on older trees sweep out in long, graceful curves. The bark is scaly and cinnamon-red to red-brown. The leaves stand out from all sides of the branches, often at right angles, and frequently bring their white upper surfaces to view by a twist at the base. They are 3–12 mm. long and a lustrous green on the lower surface. The cones are 6–10 cm. long and, when full grown, tinged dark red on a yellow-green back-ground. The seeds are full and rounded, pale reddish brown and 8–10 mm. long, usually with four to five cotyledons.

The tideland spruce inhabits moist, sandy soil which is often swampy, or less frequently at the far north wet, rocky slopes. It grows at altitudes along the coast up to 2500 feet, gradually becoming smaller away from the ocean.

The material for the present investigation was obtained from trees growing in a wet, semi-swampy region, possessing a sandy, alluvial soil. The trees were cut down and the leaves and twigs collected. The oil for examination was secured by immediate steam distillation, 170 cc. being produced from 933 pounds. Cohobation of the distillate gave an additional 80 cc., or a total of 250 cc., equivalent to 0.059 per cent.