lings and the maternal parents of muscular dystrophy patients.

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Effect of a High Fat Fructose and Casein Diet on Diabetic Cataracts.* (22143)

JOHN W. PATTERSON.

Department of Anatomy, School of Medicine, Western Reserve University, Cleveland, O.

Two or 3 months after the chemical induction of diabetes in rats, the lenses of the animals become opaque(1,2). The rate at which these cataracts develop is directly related to the height of the blood sugar(2). Decreasing the hyperglycemia by partial starvation(3) or the administration of phlorizin(4) delays or prevents cataracts to the extent that the blood sugar is lowered. These results suggest that hyperglycemia may play a direct role in the production of cataracts. If the high blood sugar level acts directly on the lens to produce cataracts, then the amount of sugar reaching the eye by way of the bloodstream should be of importance. Altering the blood supply by unilateral carotid ligation influences the development of galactose cataracts but does not affect the development of diabetic cataracts(5). This finding raises a question regarding the direct role of hyperglycemia and leads to the suggestion that the prevention of cataracts might be due to the provision of an alternate energy supply by the ketosis that accompanies phlorizin administration or starvation. Diets containing large amounts of fat or protein provide non-carbohydrate substrates for energy and delay or prevent cataracts(1,6). However, these diets also lower the blood sugar and an interpretation of the results is difficult. Experiments in this laboratory indicate that a high-fat diet containing fructose rather than glucose, can be fed to diabetic rats without producing a depression in the blood sugar level. The use of this diet makes it possible to determine the effect of the dietary constituents in the prevention of cataracts. This paper reports the results obtained with a diet containing large amounts of fructose, fat and protein.

Methods. Male Sprague-Dawley rats weighing 76-173 g were made diabetic by the intravenous injection of 40 mg per kilo of alloxan monohydrate. The animals were maintained with unlimited amounts of water and ground dog chow. They were weighed and the blood sugars(7) determined once or twice each week. At the end of the first four weeks the blood sugar determinations for each rat were averaged. Those animals with blood sugar levels greater than 350 mg per 100 cc of blood were retained in the experiment and divided into two groups. The control group was maintained on the same diet as had been used in the first 4-week period. The experimental group was placed on an unlimited amount of the special diet. The latter diet consisted of 50% fructose, 25% corn oil and

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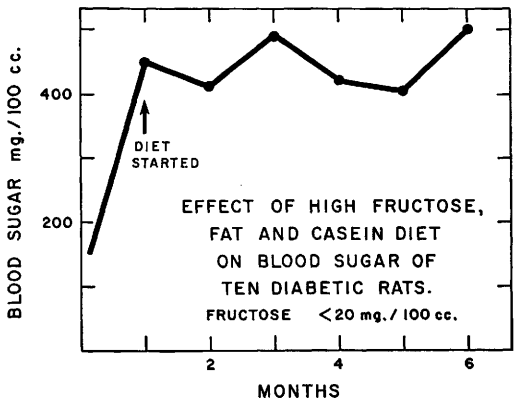

FIG. 1.

25% casein, fortified with an adequate amount of minerals and vitamins. Blood sugars were determined at least once each week and averaged for each 4 week period. During the next 4 months, 4 of the animals on the special diet had average blood sugars which fell below 350 mg per 100 cc of blood on one or more occasions. These animals were dropped from the experiment. Ten animals on the special diet and 10 receiving the chow diet maintained blood sugars consistently above 350 mg per 100 cc.

Results. The effectiveness of fructose in maintaining a high blood sugar level, in spite of a large amount of fat in the diet, is indicated by the blood sugar averages as depicted in Fig. 1. The blood sugar values represent the total amount of glucose and fructose in the blood. Separate determinations for fructose(8) on the same blood samples indicated that the fructose level was 10-20 mg per 100 cc.

The eyes of the rats were examined daily for cataracts as previously described(2). The control group developed cataracts between 59 and 120 days after the induction of diabetes with an average time of 73 days and a standard deviation of 18 days. The rats on the special diet were observed for a period equal to twice this average time or 150 days. During this period 2 of the 10 rats developed cataracts at 86 and 99 days. These cataracts occurred 2 and 3 weeks after a 3-day lapse in the special diet during which time the animals were fed a ground chow diet. The other 8 rats did not have cataracts at 150 days (Fig. 2).

Rats placed on the special diet showed a marked change in their growth rate. Before being placed on the special diet, the animals grew at the expected rate for diabetic rats having a blood sugar of 450-500 mg per 100 cc. After the initiation of the special diet, however, the growth rate was accelerated and comparable to that of diabetic rats with blood sugars between 250-300 mg per 100 cc. This was true in spite of the fact that the blood sugar of these animals was maintained at the higher level (Fig. 3).

Discussion. There are 3 effects of the high fructose, fat and casein diet which are worthy of further comment. First, it maintains a high blood sugar level. Second, it prevents the development of cataracts and third, it accelerates growth.

When a high fat diet containing sucrose is fed to diabetic rats, there is no glycosuria and the growth of the rats is stopped(1). In contrast, a high fat diet containing fructose results in a blood sugar comparable with that of a glucose low fat diet and the animals gain weight. It is possible that a high content of fat in the diet interferes with the intestinal absorption of glucose and not of fructose. Further studies are required to prove this point. The observation that there is very little fructose in the blood of a fructose fed animal is consistent with the fact that fructose is rapidly converted into glucose(9).

The fact that a high fructose, fat and casein diet prevents the development of cataracts definitely rules out hyperglycemia as a direct mediator in the production of cataracts and demonstrates that diabetic cataracts can

EFFECT OF HIGH FRUCTOSE, FAT AND CASEIN DIET ON DEVELOPMENT OF DIABETIC CATARACTS.

DIET	NO. RATS	AVE. WT. gm.	BLOOD SUGAR mg./100 cc.		PER CENT WITH CATARACTS AT 150 DAYS
			CONTROL	ON DIET	50 100
SPECIAL	10	125	450	448	P <0.001
CHOW	10	129	490	475	

FIG. 2.

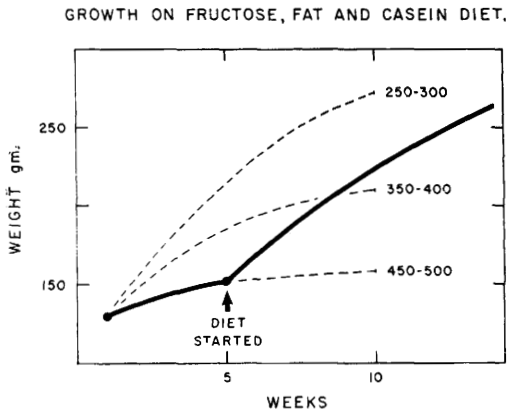

FIG. 3.

be prevented without insulin if energy sources other than glucose are made available. The results are consistent with the suggestion that diabetic cataracts are the result of an inability to obtain adequate energy by the utilization of glucose in the absence of insulin.

The growth rate of rats on a high fructose, fat and casein diet is accelerated. This indicates that tissues, other than lens, are benefited by a diet which provides substrates that do not require insulin for utilization. Rats on a high fat diet containing sucrose show no gain in weight over a period of three months (1). Thus, the presence of fructose provides an advantage. This may be due to the production of a high blood glucose level, and hence, a greater gradient for the penetration of glucose into the cells, or it may be due to the penetration of small amounts of fructose into the cell. It is doubtful whether this improvement in the distribution of carbohydrate is in itself responsible for the improved growth rate. Diets containing fructose without fat(9) and high blood levels of glucose in the absence of fat do not accelerate the growth of diabetic rats. It is more likely that the improved distribution of carbohydrate increases the efficiency with which fat is utilized by the cell. This might be brought about by increasing the availability of oxalacetic acid which is essential for the complete metabolism of fat.

Summary. A diet consisting of 50% fructose, 25% corn oil and 25% casein and fortified with vitamins and minerals was fed to diabetic rats with blood sugar levels over 350 mg per 100 cc of blood. On this diet the blood sugar was maintained at a high level, cataracts were prevented and growth rate accelerated. The beneficial effects of this diet suggest that cataracts and the failure in growth of diabetic rats are the result of a deficit of energy resulting from inadequate glucose utilization in the absence of insulin.

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