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## Substitution of Dietary Starch for Dextrose in Hyperlipemic Subjects.* (31611)

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As many patients with lipemia continue to have elevated triglyceride levels on fat free diets(1), attention has been directed to the relation between carbohydrate ingestion and serum lipids. Two recent reviews have suggested that not only are triglyceride levels related to the proportion of total calories derived from fat, protein and carbohydrate, but that the type of carbohydrate itself influences blood lipid levels(2,3). For example, McDonald(4) found in a small group of normal men, that sucrose specifically increased serum triglycerides but maize starch did not. Kuo and Bassett(5) have reported 5 hyperglyceridemic subjects in whom substitution of sucrose for starch also elevated serum triglycerides. Despite these findings, there is still controversy about the precise influence of complex and simple sugars, since Lees(6) found that diets high in either sucrose or starch were associated with equivalent increases in plasma triglycerides in 7 normal subjects. Because caloric intake may be an important variable in the response of plasma triglycerides to dietary manipulation, we have investigated these conflicting results in studies of 2 lipemic subjects on a metabolic ward where precise control of dietary intake was possible.

*Methods.* Two men ages 58 and 47 were found to have lipemic serum after an overnight fast on an *ad lib* diet and were then hospitalized for study. For the first 4 days of study each was given a formula diet (containing corn oil, skim milk and dextrose) with total calories divided as 40% fat, 45% carbohydrate, 15% protein. During this period caloric intake was adjusted to maintain constant body weight. A standard 100 g oral glucose tolerance test and assay for post-heparin lipolytic activity(7) was performed. Both subjects had a normal lipolytic response to intravenous heparin and mild glucose intolerance(8). After weight had stabilized, the patients were then switched to an isocaloric formula diet containing only skim milk and dextrose, with 85% of total calories as carbohydrate (64% dextrose, 21% lactose) and 15% of total calories as protein (skim milk). This diet was maintained for 2 to 3 weeks at which time starch in the form of rice, potatoes, spaghetti, macaroni, oatmeal, matzos and corn starch was substituted for the carbohydrate in the diet. The starch diet was then maintained for another 2 to 3 weeks. The first patient was then discharged, but the second subject remained on the metabolic ward and the original 85% simple sugar and 15% protein formula was reinstituted. After an additional 3 weeks of this diet, total calories were slightly decreased by 5 calories per kilogram for 2 weeks and 10 calories per kilogram for a third week.

Weight was measured daily. Plasma triglycerides were determined by methods previously described(9), 3 times weekly.

*Results and discussion.* In both subjects, after one week of the high carbohydrate diet, plasma triglyceride levels reached stable values

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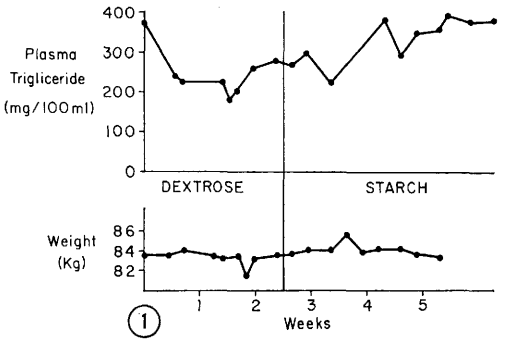


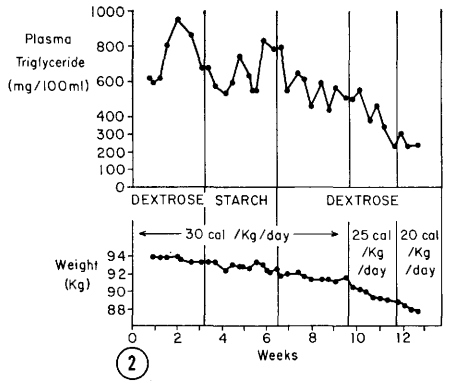


FIG. 1. Effect of starch substitution for simple sugars upon plasma triglyceride in a 58-year-old male. Ht = 191 cm. Wt = 84 kg. The "dextrose" formula contained 64% dextrose, 21% lactose and 15% protein as percent of total calories (2520 cal).

FIG. 2. Effect of starch substitution and caloric restriction on plasma triglyceride in a 47-year-old male. Ht = 168 cm. Wt = 94 kg. The "dextrose" formula contained 64% dextrose, 21% lactose and 15% protein as percent of total calories (2835 cal while ingesting 30 cal/kg).

and were elevated. When starch was substituted for simple sugars, there was no change in plasma triglycerides (Fig. 1, 2). When the second patient was returned to the high dextrose formula, there was a modest decrease in plasma triglyceride. This was associated with a very slight weight loss apparent only retrospectively after the evaluation of the total 9-week hospitalization. When calories were slightly restricted from 30 calories per kilogram, to 25 calories per kilogram (412 g total CHO), there was a definite drop in plasma triglyceride within one week. When calories were further restricted by another 5 calories per kilogram for a week, plasma triglyceride dropped to almost 1/3 of their original values. These changes were accompanied by a modest 2 kg weight loss. Both patients had some difficulty in finishing the required daily calories while ingesting starch diets. This was particularly noticeable during the initial period shortly after the change from the high dextrose formula to starch. This difficulty was almost entirely related to the bulk of the starch diet which caused both patients to feel "full" most of the day. Aside from this feeling of fullness, both formula and starch diets were tolerated well.

Thus, results in this study show no fall of plasma triglyceride during a high starch diet, and contrast with the decrease described by others(4,5,10). In some of these studies sucrose has been used as the simple sugar rather than glucose and lactose. Since sucrose contains equal portions of fructose and glucose it is possible that it is the fructose in sucrose which specifically raises triglyceride levels and could account for part of the difference in findings. However, we have recently tested a third patient (not reported) with sucrose and starch and again find comparable triglyceride levels while eating either diet. Furthermore, Lees(6) has compared sucrose and starch in normal subjects and reports no difference in their effects on triglyceride concentration. Since some of the studies which show lower triglyceride levels on starch diets were performed on outpatients, perhaps voluntary caloric restriction related to the feeling of fullness on high starch diets may have been responsible for part of the drop in serum triglycerides. In our second patient, modest caloric restriction, even on a high carbohydrate diet, lowered plasma triglyceride strikingly from 500 to 200 mg per cent within 2 weeks. Although both of these subjects appeared to have lipemia of the "carbohydrate induced" type(1) it is also possible that the type of patient selected for study may be another important variable and that these discrepant findings show "carbohydrate induced" lipemia to be more than one disease. Obviously, more studies on the effects of specific carbohydrates on serum lipids in these patients are needed fully to evaluate the problem. However, it would appear that future studies must be performed on hospitalized

patients so that minor differences in caloric balance will be recognized. Cohen *et al*(10) reported that a patient with carbohydrate induced lipemia sustained a reduction in plasma triglycerides on a starch diet. However, review of these data shows that the patient lost approximately 2 kg during each dietary period in which starch was given, with no weight loss in 2 similar periods of unsaturated fat and sucrose diets. Although this weight change appears to be minor, results in the present study indicate that it is of sufficient magnitude to be an important factor in the observed decrease in triglyceride level.

*Summary.* The comparative effects of dietary starch and dextrose on plasma triglyceride levels were studied on a metabolic ward in 2 lipemic patients. Plasma triglycerides were elevated when these subjects ingested a virtually fat free diet. Substitution of starch for the high dextrose formula produced no further change in plasma triglycerides. Caloric restriction in one patient resulted in a marked decrease in triglyceride even though he continued to eat an 85% carbohydrate, 15% protein formula. Both patients complained of a feeling of fullness and had trouble finishing an isocaloric high starch diet. These observations show that isocaloric starch diets did not decrease plasma triglycerides but that caloric restriction while a high carbohydrate diet is fed, will result in lower plasma triglyceride levels. They suggest that, unless careful supervision of dietary intake is maintained, the effects of carbohydrate substitutions in diet may be related to changes in caloric balance rather than to the type of carbohydrate ingested.

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## Correlation of Arachidonic Acid of Sterol Esters with Restrictive and Susceptibility to Naturally-Occurring Atherosclerosis in Pigeons.* (31612)

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The correlation of the arachidonic acid content of serum sterol esters to atherosclerosis has been reported(1,2). Swell and his co-workers(2) have hypothesized, from a study of several species of animals, that the level of arachidonic acid in the serum cholesterol esters may be related to their susceptibility to atherosclerosis. In the present work, the possibility of such a relationship has been studied in 2 breeds of the same animal species (pigeons) which exhibit a marked difference

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