

Influence of Various Carbohydrates on the Utilization of Low Protein Diet by the Adult Rat

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Abstract : The effect of different dietary carbohydrates on food intake, body weight and nitrogen balance of adult rats fed 5 per cent protein diet ad-libitum for 14, 24 and 45 days or restricted to 70 per cent of their normal food intake for 10 and 31 days was studied. No significant difference in food intake and body weight on either of treatments was observed. Nitrogen balance studies indicated that rats fed ad-libitum or restricted diet having starch as a source of dietary carbohydrate utilized nitrogen more efficiently than sucrose fed animals. Possible explanations have been discussed. Regression equations were calculated and it was found from the regression lines that minimum calories and nitrogen intake to maintain nitrogen equilibrium under experimental conditions were 123 Kcal and 270 mg N per kg $3/4$ /day on starch based diet compared with 136 Kcal and 295 mg N per kg $3/4$ /day on sucrose diet respectively.

1. INTRODUCTION

The effect of type of dietary carbohydrate have been extensively reviewed by Harper and Elvehjem³ and it is generally accepted that most of the more complex carbohydrates give better growth at low protein levels than simple sugars. When sucrose was used as the dietary carbohydrate in the low protein diets, from 2 to 3 per cent more protein was required to support growth equivalent to that obtained with similar diet to which the carbohydrate was corn starch (Harper and Katayama⁴; Monson *et al.*¹¹, Khan and Bender⁶).

Adult rats when fed corn dextrin as the carbohydrate source achieved nitrogen balance at levels of essential aminoacid intake, which led to negative nitrogen balance if sucrose was substituted for the corn dextrin (Womack *et al.*¹⁴).

Nitrogen balance studies on growing rats indicated that the type of dietary carbohydrate affected neither protein digestibility nor nitrogen retention, however, metabolic faecal nitrogen increased and endogenous urinary nitrogen decreased when dextrin was substituted for sucrose in a low protein diet (Wiener *et al.*¹³). The rate of nitrogen retention was

influenced by the level of protein but not that of carbohydrate (Desai¹).

The present experiment was conducted on adult mature rats fed ad-libitum or restricted diets, to study the effect of starch or sucrose as a source of carbohydrates on the utilization of low protein diet.

2. MATERIAL AND METHODS

The experimental diets contained corn oil 5 per cent, vitamin mixture 2 per cent, mineral mixture 4 per cent, casein to provide 5 per cent protein, starch or sucrose to 100 per cent.

Fifty adult male rats, 6—7 months old of sprague-Dawley strain were divided randomly into 10 groups of 5 rats each. The experimental diets randomly assigned to these groups in such a way that 5 groups received diet (ad-libitum) containing starch as a source of carbohydrate and the other 5 groups were fed diet (ad-libitum) with sucrose as a source of carbohydrate. After 14 days feeding, one group from each treatment was killed for carcass analysis. From the remaining 4 groups on starch diet, 2 groups were continued on ad-libitum feeding, while the other 2 groups of rats were restricted to 70 per cent of their

normal food intake. One group from each treatment was killed after 10 days. The remaining groups were continued on the same diets for another 21 days. Similarly other 4 groups on sucrose diet were divided and fed in the same way, so that the rats received the experimental diets ad-libitum for 14, 24 and 45 days, or restricted diets for 10 and 31 days with either starch or sucrose as a source of carbohydrate.

The animals were housed in individual metabolic cages and urine, faeces and shed hair were collected in 1N H₂SO₄. Three or four days pooled collection from each rat was homogenized for 2—3 minutes in a large blender and diluted to volume with distilled water. A 5 ml homogenized sample in duplicate was used to estimate nitrogen by Kjeldahl method.

The caloric value of the diets was determined

in the ballistic bomb calorimeter (Miller and Payne⁹) and the calories consumed were calculated from the food intake data. The nitrogen content of the diets was estimated in duplicate samples of the diets by Kjeldahl method and crude protein was calculated as N x 6.25. The data were subjected to statistical analysis by using Mann Whitney U test (Mann and Whitney⁷).

3. RESULT AND DISCUSSION

The average values for body weights, food intake and nitrogen balance of adult rats fed 5 per cent protein diet ad-libitum for 14, 24 and 45 days, or restricted to 70 per cent of their normal food intake for 10 and 31 days with either starch or sucrose as a source of carbohydrates are presented in Tables 1 and 2, respectively.

Table 1

Average food intake, nitrogen balance and body weight change of adult rats fed ad-libitum diet containing 5 per cent protein, with either starch or sucrose as a source of carbohydrate

Carbohydrate of diet	No. of rats	Days on diet	Body Wt. changes (gm)	Intake		Nitrogen Balance	
				Kcal/kg ^{3/4} day	mg N/kg ^{3/4} day	mg N/kg ^{3/4} day	As per cent of N-intake
Starch	25	14	+12	146	312	+17	+5.0
Sucrose	25	14	+ 7	145	309	- 2	-0.7
Starch	10	24	+27	150	321	+17	+5.0
Sucrose	10	24	+22	144	308	+ 2	+0.7
Starch	5	45	+28	148	317	+ 6	+2.0
Sucrose	5	45	+19	141	302	- 6	-1.7

Table 2

Average food intake, nitrogen balance and body weight losses of adult rats fed 5 per cent protein diet restricted to 70 per cent of the normal food intake

Carbohydrate of diet	No. of rats	Days on diet	Body Wt. Loss (gm)	Intake		Nitrogen Balance	
				Kcal/Kg ^{3/4} day	mg N/Kg ^{3/4} day	mg N/Kg ^{3/4} day	As per cent of N-intake
Starch	10	10	28	102	217	-69	-32
Sucrose	10	10	28	103	220	-94	-43
Starch	5	31	45	105	225	-52	-23
Sucrose	5	31	38	108	231	-62	-27

3.1 Food Intake and Body Weight :

Animals fed on starch diet (ad-libitum) had slightly higher food intakes and weight gains than the sucrose fed rats.

There was no difference in the body weight losses of animals fed either of the restricted diets for 10 days. When restriction was prolonged to 31 days, the average losses of body weights of rats fed starch were slightly greater (45 gm) than those receiving sucrose diet (38 gm). This could be due to slightly higher food intakes of rats on sucrose restricted diet.

3.2 Nitrogen Balance :

In order to compare the effects of starch and sucrose on the utilization of protein, nitrogen balance studies were conducted on rats fed ad-libitum or restricted diets for various lengths of time. A general trend of greater nitrogen retention was observed in all starch fed rats as compared to animals on sucrose diets fed ad-libitum.

3.3 Ad-libitum Feeding :

14 Days Period :—Significantly more nitrogen ($P < 0.02$) was excreted in urine and faeces by rats receiving sucrose than those receiving starch. The average values for nitrogen balance of starch versus sucrose fed rats were +17 versus -2 mg N/kg 3/4/day.

24 Days Period :—The average nitrogen balances of animals on starch and sucrose were +17 and +2 respectively but the difference was not significant.

45 Days Period :—In long term trials of feeding starch or sucrose for 45 days there was no significant difference in nitrogen balance values. However, the average values of starch and sucrose fed rats were +6 and -6 mg N/kg-3/4/day respectively.

Dietary Restriction :

Nitrogen excretion of rats on restricted sucrose diet was greater than those on starch diets throughout the period of food restriction.

10 Days Restriction :

The average values of nitrogen balance on sucrose and starch fed rats restricted for 10 days were -94 and -69 mg N/kg-3/4/day respectively.

Dietary Carbohydrate and Protein Utilization

The values were found to be significantly different ($P < 0.05$). Comparison of the average values of nitrogen balance of animals receiving restricted diets revealed that there were greater negative nitrogen balance (-97, -96 and -87 mg N/kg-3/4/day) in sucrose group than the starch fed group (-77, -71 and -60 mg N/kg-3/4/day) on the 3rd, 7th and 10th days of restriction respectively.

31 Days Restriction :

Long period of food restriction showed low negative nitrogen balance values as compared to the animals restricted for 10 days. This seems to have been a gradual adaptation to both types of carbohydrates in the restricted diets. The average nitrogen balance values of rats fed starch were lower (-52 mg N/kg-3/4/day) than those of sucrose (-62 mg N/kg-3/4/day) but the difference was not significant.

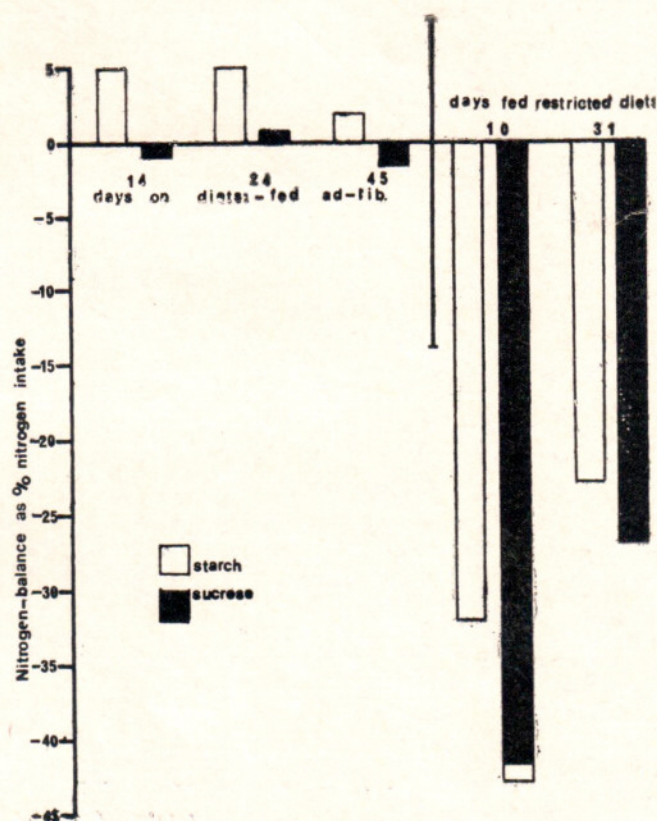


Fig. 1. Nitrogen balance of rats fed ad-libitum or restricted diets with either starch or sucrose as a source of carbohydrate.

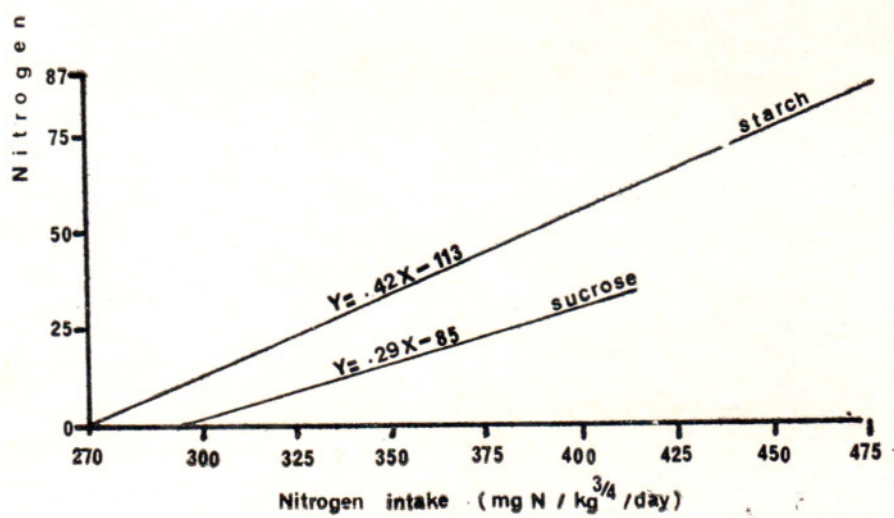
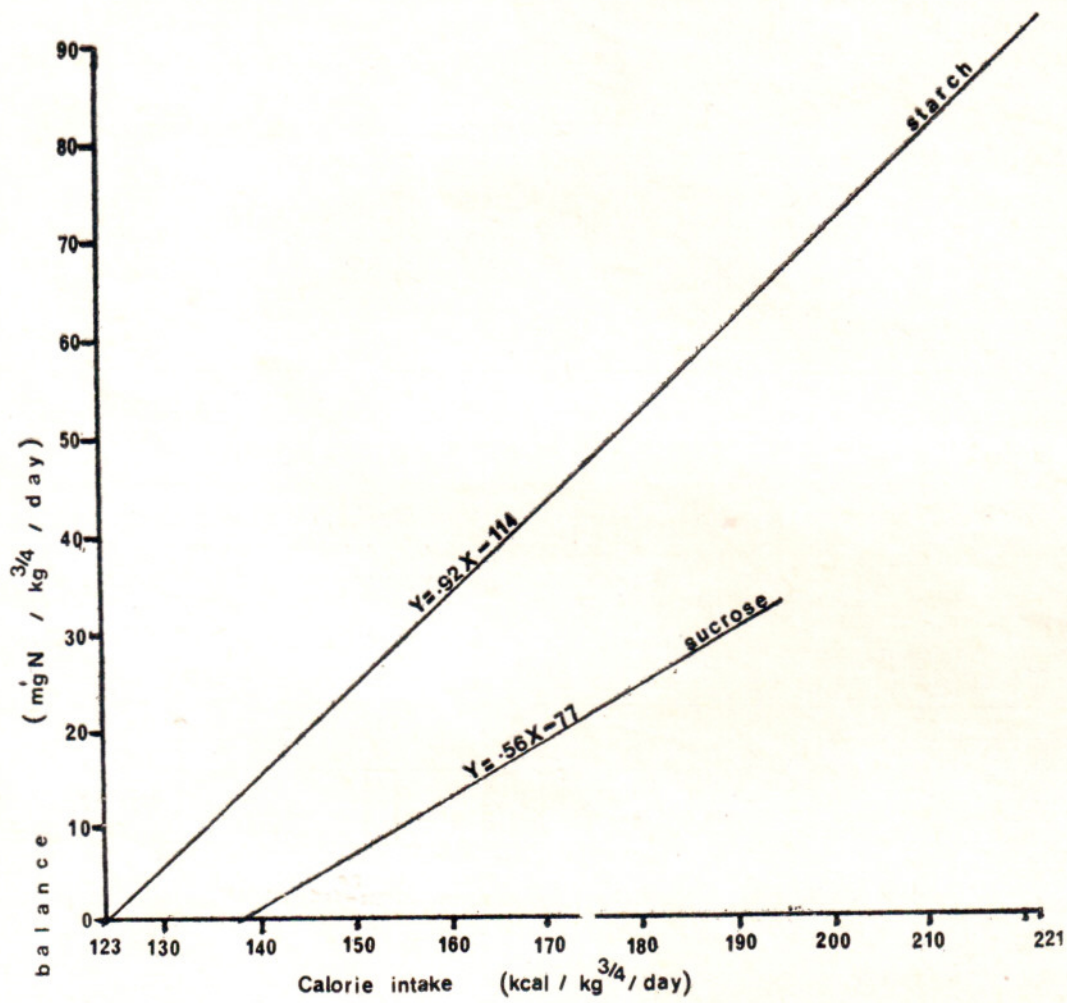


FIG. 2 Relationship between food intake and nitrogen balance of rats fed 5% Protein diet (ad-lib)

Nitrogen Balance as the per cent of Nitrogen Intake:

The efficiency of nitrogen utilizations was determined both on starch and sucrose diets by calculating nitrogen balance values per 100 mg nitrogen intake/kg-3/4/day. The average values of rats fed ad-libitum and restricted diets are given in Table 1 and 2 respectively.

It is evident (Fig. 1) that adult rats when fed 5 per cent protein diet ad-libitum or restricted to 70 per cent of their normal food intake having starch as a source of dietary carbohydrate, utilized nitrogen more efficiently than when fed sucrose. Womack *et al.*¹⁴ and Marshall and Womack⁸, found similar results in adult rats fed low protein diets.

Regression equations were calculated by using the results of calories and nitrogen intakes of rats fed either starch or sucrose against the nitrogen balance (Fig. 2).

The minimum calorie intakes to maintain nitrogen balance under the experimental conditions were 123 kcal/kg-3/4/day on starch based diet compared with 136 kcal/kg-3/4/day on sucrose diet. Similarly, nitrogen equilibrium was maintained with a nitrogen intake of 270 mg N/kg-3/4/day on starch diet compared with 295 mg N/kg-3/4/day on the sucrose diet.

There are several possible explanations for the effect of starch in the diet on the utilization by the rats of the low levels of proteins.

It is well known that most starches contain small amounts of protein and it might be suggested that the low casein ration is supplemented by the amino acids from the starch protein.

The possibility of existence of a different type of bacterial flora when starch is present could conceivably affect the availability of dietary amino acids to the host organism. Johnson *et al.*⁵ found that the intestinal flora of hens fed dextrin had ten times as many coliform organisms as had animals fed sucrose. Monson *et al.*¹⁰ have suggested that an unknown growth factor may be required by chicks fed sucrose rations and have suggested that this may be syn-

thesized by the intestinal micro-organisms when dextrin is fed.

Hall and Sydenstricker² suggested that essential amino acids may be synthesized by the intestinal micro-organisms of rats fed corn starch. It is possible that microflora in the intestinal tract of the rat, like those in the rumen of ruminants, synthesize amino acids essential for mammals and that small amounts of these amino acids may be made available through the hydrolysis of dead bacterial cells.

Some of the differences between sucrose and starch have been attributed to their different rates of passage and absorption along the intestine. Monson *et al.*¹⁰ have shown that dextrin rations pass through the gastro-intestinal tract of the chicks more slowly than do sucrose rations. It is thus possible that the rate of digestion may be slower when rations containing corn starch or dextrin in place of sucrose are fed and that this may permit more efficient utilization of proteins. Munro¹² has cited several studies in which the growth of rats was reduced when protein and carbohydrate were fed separately. It may be that sucrose is removed more rapidly from the digestive tract than is corn starch, and that glucose and amino acids are absorbed together for a longer period of time, when corn starch is fed and that this permits better utilization of proteins.

4. REFERENCES

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