15051

Nutritive Value of Dextri-Maltose Determined by the Single-Food Choice Method.

CURT P. RICHTER.

From the Psychobiological Laboratory, Phipps Psychiatric Clinic, Johns Hopkins Hospital.

The single-food choice method has been used in previous studies[1,2,3] to determine the nutritive values of dextrose, sucrose, casein, and a variety of other substances, together with the effect produced on their utilization by thiamine hydrochloride. Rats of a standard age were kept on a complete stock diet until they had reached a standard weight and then were placed on a diet which consisted of only one food-stuff. The survival times and daily running activity of the rats on the single food were taken as criteria of the nutritive value of each food-stuff. On dextrose alone the rats lived on the average 37 days and with access to 0.02% solution of thiamine hydrochloride 74 days; on sucrose alone they lived on the average 37 days and with access to thiamine solution 56 days; on casein alone they lived on the average 33 days and with access to the thiamine solution 55 days.

This method has now been applied to the study of the nutritive value of dextri-maltose.

Methods. Female rats were kept in individual activity cages which consisted of a revolving drum with a cyclometer and a living compartment with a nonspillable food cup and a graduated inverted water bottle. The rats were placed in the cages at 40 to 50 days of age, weighing at the time 80 to 100 g. They received our stock diet* for a minimum of 15 to 20 days, until they had reached weights between 120 and 159 g. Then the stock diet was replaced in the food cup by dextri-maltose.†

Daily observations were made of running activity, food and water intake, and of the vaginal smears; and body weight was recorded weekly.

Twelve tame domestic female Norway rats were used in these experiments.

Results. Survival Time—Table I shows the individual and average survival times of the rats kept on the single food (A) without access to thiamine hydrochloride and (B) with access to thiamine hydrochloride. For purposes of comparison with dextri-maltose, records (from previous work) have been included for dextrose, maltose, dextrin, corn starch, sucrose, and casein. On the single food without thiamine the survival times for the corn starch and sugars ranged from 31 days for corn starch to 37 days for dextrose. The survival times for casein averaged 33 days and for sucrose 37 days.

In marked contrast the survival times for the rats on dextri-maltose averaged 85 days, over twice as long as for starch or any of the individual sugars.

When given access to thiamine hydrochloride the rats on corn starch survived on the average 86 days, almost exactly as long as the rats on dextri-maltose. The rats on dextrose survived a shorter time, 74 days, and on casein and sucrose a still shorter time, 55 and 56 days respectively.

Food Intake—Since we know most about the effects of a single-food dextrose diet, we have made all of the comparisons of dextri-maltose with this sugar. Fig. 1A shows the average daily food intake for the 12 rats on dextri-maltose compared to values for 21 rats on dextrose, and 12 rats on dextrose with access to the 0.02% solution of thiamine hydrochloride. The intake of dextri-maltose was

* The stock diet used contained graham flour 72.5%, skim milk powder (Breadlac) 10.0%, casein (No. 30, Labco) 10.0%, butter 5.0%, calcium carbonate 1.5%, and sodium chloride 1.0%.

1 Richter, C. P., and Rice, K. K., *Am. J. Physiol.*, 1942, **137**, 573.

2 Richter, C. P., and Rice, K. K., *Am. J. Physiol.*, 1944, **141**, 346.

3 Richter, C. P., and Rice, K. K., *Am. J. Physiol.*, 1945, **143**, 336.

† Dextri-maltose No. 2 furnished by Mead Johnson, Evansville, Indiana.

TABLE I.

Diet	No. of rats	Sex of rats	Avg age at start of single food (days)	Avg wt at start of single food, g	Individual survival times (days)	Avg survival times (days)
A. Single Food Without Access to Thiamine Hydrochloride.						
Control rats (no food)	12	♀	60 (58-68)	133 (119-149)	3,4,4,4,4,4,4,4,4,4,5,5	4
Corn Starch	8	♀	63 (61-70)	134 (126-145)	25,29,29,30,31,34,35,35	31
Casein	16	♀	63 (55-69)	132 (124-145)	26,26,26,27,28,28,32,32, 32,33,33,34,39,45,46	33
Maltose	8	♀	67 (62-71)	142 (137-152)	31,31,32,35,35,36,37,39	34
Dextrin	5	♀	71 (67-73)	140 (129-150)	31,31,37,39,43	36
Dextrose	21	♀	64 (56-71)	137 (120-149)	28,29,32,33,33,34,35,36, 36,36,37,37,38,39,39,40, 40,41,42,42,54	37
Sucrose	11	♀	63 (56-66)	133 (124-145)	29,31,33,34,34,38,39,40, 42,46	37
Dextri-Maltose	12	♀	67 (64-73)	141 (120-159)	57,69,73,81,83,86,90,91, 93,96,98,99	85
B. Single Food with Access to Thiamine Hydrochloride.						
Casein	14	♀	60 (53-63)	137 (119-149)	36,40,41,42,42,52,55,56, 60,64,65,68,70,72	55
Sucrose	13	♀	62 (55-66)	138 (127-148)	35,40,45,47,47,50,55,57, 66,69,70,75,77	56
Dextrose	12	♀	62 (58-66)	139 (130-148)	62,65,67,72,73,74,74,75, 76,76,87,87	74
Corn Starch	5	♀	58 (55-69)	132 (122-141)	81,82,83,92,94	86

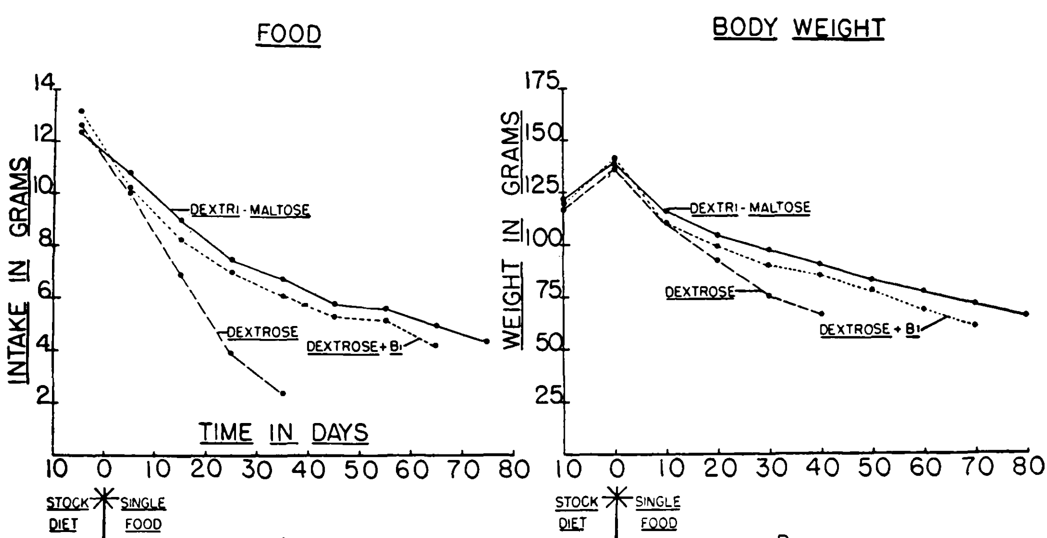

FIG. 1.

definitely higher than the intake of dextrose, either with or without thiamine.

Body Weight—Fig. 1B shows the average body weight of the 3 groups of rats whose respective food intake curves were shown in Fig. 1A. The dextri-maltose rats lost weight at a considerably slower rate than did the rats on dextrose and thiamine.

Activity—The average daily running activity of the rats on dextri-maltose closely approximated that of the rats on dextrose with access to thiamine. The rats remained quite active, running as much as 15 miles per day 60 days after the start of the dextri-maltose diet.

Water Intake—The water intake curves of the dextri-maltose and dextrose plus thiamine groups of rats were essentially the same.

Vaginal Smears—The effects produced on the vaginal smears also were much the same as those found in the dextrose rats which had access to thiamine. The 4-5 day oestrous cycles disappeared after 6 to 8 days leaving only dioestrous smears.

Discussion—The results of these experiments showed that dextri-maltose must contain some substance or substances that are not present either in dextrose or maltose, or even in the unhydrolyzed corn starch. The evidence at hand indicates that thiamine must be one of these substances.‡

In the first place thiamine is the only substance known at the present time which will prolong the survival time of rats kept on a single-food carbohydrate diet. Other members of the vitamin B complex do not have this effect, nor does salt.[4] Further, the average survival time of 85 days of the rats on dextri-maltose without added thiamine closely approximates the survival times of the rats on the other corn sugars and starches when given access to thiamine. In general thiamine slightly more than doubles the survival time of the rats kept on the corn sugars and starches.

From single-food choice experiments we can obtain only an indirect estimate of the amount of thiamine which is probably present in the dextri-maltose. Rats kept on dextrose took approximately 20 γ (allowing 1 cc for evaporation of solution) of thiamine per gram of food. If we assume that approximately the same amount of thiamine is needed for the utilization of dextri-maltose as for dextrose, then each gram of dextri-maltose might contain as much as 20 γ per gram.

With the thiochrome method, Holt[5] and Emerson and Obermeyer[6] found that dextri-maltose contains only 0.7 and 0.9 γ per gram respectively. The values estimated by the single-food choice method undoubtedly are far too high but it is possible also that the values determined by the thiochrome method may be too low.§

It appears likely, however, that dextri-maltose contains at least the minimum amount of thiamine necessary for its full utilization. In other words, more thiamine would not have helped the animal to utilize more dextri-maltose, nor would it have lengthened the survival times. The evidence for this statement is found in the observation that fortification of dextrose with 25 mg of thiamine per 100 g of food, that is, about 380 times as much as the rats on dextrose alone took voluntarily, did not increase the survival time. Six rats which received the thiamine mixed with the dextrose lived on the average 76 days.

The slightly longer average survival times of the rats on dextri-maltose as compared to that of the rats on dextrose with access to thiamine, also their slightly higher food intake and body weight, may indicate that dextri-maltose contains nutritive substances in addition to the thiamine. Emerson and Obermeyer[6] on the basis of results obtained with an entirely different type of experiment also arrived at this conclusion.

Najjar and Holt[7,8] used dextri-maltose as

‡ After the completion of the above experiments 6 rats were kept on a single-food choice diet of dextri-maltose in which all, or nearly all, of the thiamine had been destroyed. These rats survived 31, 35, 35, 35, 52, 54 days respectively, or 40 days on the average. This survival time closely approximates that of the rats kept on dextrose without access to thiamine.

4 Holt, L. E., Jr., and Kajdi, C. N., *Bull. J. H. H.*, 1944, **74**, 142.

5 Holt, L. E., Jr., *Fed. Proc.*, 1944, **3**, 171.

6 Emerson, G. A., and Obermeyer, H. G., PROC. SOC. EXP. BIOL. AND MED., 1944, **57**, 216.

§ According to Dr. Warren M. Cox, Jr., Director of Nutritional Research, Mead Johnson and Company, the thiamine comes largely from the barley malt (sprouted barley) used in the manufacture of dextri-maltose from cereal grains.

7 Najjar, V. A., and Holt, L. E., Jr., *J. A. M. A.*, 1943, **123**, 683.

the source of carbohydrate in a thiamine deficient diet|| which they gave to 9 young adolescent males over an 18-21 month period. The present results may explain in part the long period required to bring out the thiamine deficiency symptoms in most of the subjects, and that one failed even after 20 months to develop deficiency symptoms.

Summary. 1. Twelve female rats kept on a diet in which dextri-maltose constituted the sole source of nourishment survived on the average 85 days. 2. These rats lived 48 days longer than rats of the same weight kept on a single food diet of dextrose or sucrose; and 11 days longer than rats kept on dextrose with access to the 0.02 per cent solution of thiamine hydrochloride. 3. Their food intake was higher and they lost weight at a slower rate than the dextrose and thiamine rats. Their activity, water intake and vaginal smears were essentially the same. 4. It was concluded that the dextri-maltose contains sufficient amounts of thiamine to utilize to its fullest the available carbohydrate.

8 Najjar, V. A., *et al.*, *J. A. M. A.*, 1944, **126**, 357.

|| Vitamin-free casein, Crisco, dextri-maltose, a mineral mixture and a vitamin mixture.

15052

Plasma Chloride and Bicarbonate after Potassium Administration.

WALTER S. WILDE AND FREDERICK P. FERGUSON. (Introduced by A. G. Eaton.)

From the Department of Physiology, School of Medicine, Louisiana State University, New Orleans.

After nephrectomy, the plasma chloride of dogs falls gradually to low levels.[1] The anion is not lost to the exterior and must undergo redistribution. Since, after nephrectomy, potassium accumulates, it may carry chloride and bicarbonate as the potassium salt into tissue cells, such as muscle, according to the Boyle-Conway theory.[2,3] This situation has been mimicked over short periods of time by the injection of potassium nitrate dissolved in a minimum of water to avoid dilution of extracellular chloride and bicarbonate.

Methods. Mongrel male dogs given only water overnight were nephrectomized through the mid-ventral abdominal wall under intraperitoneal sodium amytal (55 mg of the acid per kilo). The potassium nitrate, 2.5 mM per kilo of dog, was injected intraperitoneally as a solution containing 500 mM KNO_3 per liter. Blood was collected from the femoral artery: before, and 2 hours, and 4 hours after the KNO_3 injection. Heparin was mixed into the blood which was collected under oil and covered with a rubber stopper before chilling and centrifugation.

Plasma was analyzed as in previous work[4] for water, dry residue (protein), chloride, and potassium. Sodium was weighed as the triple acetate in the Jena crucible according to Butler and Tuthill.[5] The bicarbonate as carbon dioxide of plasma was determined in duplicate, or in triplicate if checks were unsatisfactory, by the manometric method of van Slyke and Neill,[6] employing the minor modifications of Peters and van Slyke.[7] The pH of plasma was measured from whole

1 Atchley, D. W., and Benedict, E. M., *J. Biol. Chem.*, 1927, **73**, 1.

2 Boyle, P. J., and Conway, E. J., *J. Physiol.*, 1941, **100**, 1.

3 Wilde, W. S., *Bull. Math. Biophysics*, 1944, **6**, 105.

4 Wilde, W. S., *Am. J. Physiol.*, 1945, **143**, 666.

5 Butler, A. M., and Tuthill, E., *J. Biol. Chem.*, 1931, **93**, 171.

6 van Slyke, D. D., and Neill, J. M., *J. Biol. Chem.*, 1924, **61**, 523.

7 Peters, J. P., and van Slyke, D. D., *Quantitative Clinical Chemistry*, Methods, 283 *et seq.*, 292, Baltimore, 1932.