Glutamine and Glutamic Acid as Sources of Supplemental Nitrogen for Adult Rats (35400)

MADELYN WOMACK

Human Nutrition Research Division, United States Department of Agriculture, Agricultural Research Service, Beltsville, Maryland 20705

Since glutamine and asparagine are present in many proteins, amide nitrogen may constitute as much as 20% of the total nitrogen, as it does in wheat proteins. Nevertheless, little attention has been paid to possible differences in utilization of amide vs α-amino nitrogen.

Earlier studies in this laboratory indicated that young rats fed equal quantities of food, total nitrogen, and essential amino acids had more carcass nitrogen when the supplemental nitrogen was all α-amino nitrogen than when it was part amide nitrogen (1). Preliminary studies with adult rats, using the nitrogen balance technique, suggested that rats of this age group utilized amide nitrogen to reduce nitrogen losses when sufficient calories were supplied to maintain nitrogen equilibrium, but not when nitrogen intake remained the same but calories were restricted to the point that the rats were in negative nitrogen balance. Because of possible practical implications regarding protein–calorie nutrition, the study was therefore repeated with a larger more uniform group of young adult rats.

Experimental Methods. The amounts of essential amino acids given each rat daily were calculated from the data of Smith and Johnson (2) to be sufficient to maintain nitrogen equilibrium when suitably supplemented with additional nitrogen and when sufficient calories were supplied. The diets contained (%): L-cystine, 0.20; L-histidine $HCl{\cdot}H_2O$, 0.15; L-isoleucine, 0.38; L-leucine, 0.16; L-lysine HCl, 0.10; L-methionine, 0.26; L-phenylalanine, 0.12; L-threonine, 0.25; L-tryptophan, 0.06; L-tyrosine, 0.10; and L-valine, 0.24. Supplemental nitrogen was supplied by 2.40% glutamic acid or 1.20% glutamine. Other dietary ingredients were as already described (1), with cornstarch added to 100%.

Pathogen-free, Wistar-derived male rats, initial weights 397–466 g, were fasted overnight and then given (each afternoon) 10 g of diet containing either glutamic acid or glutamine. After 1 week of adjustment, half the animals of each group were given extra food. This extra food was given each morning and consisted of 5 g of a mixture of cornstarch, corn oil, and vitamin mixture in the proportions of 84:5:1. Urine and feces were collected daily and stored in the freezer. A small amount of toluene and sulfuric acid were added to the urine. At the end of 5 days, cages were scrubbed with hot water and washings were added to the urine. Nitrogen was determined in diets, urine, and dried, ground feces by the macro-Kjeldahl method.

To restore them to their original well-fed condition, the rats were refed the stock diet[1] for 25 days. They were then fasted overnight, and fed a nitrogen-free diet *ad libitum* for 4 days. The composition of the diet was as already described except additional cornstarch was added to take the place of the amino acids. The nitrogen balance study was repeated as above. All diets (except the nitrogen-free one) were moistened with water (0.5 ml/g) just before they were given to the rats (3).

Results and Discussion. Preliminary studies had established that there were significant differences in nitrogen balances between groups of animals fed two levels of glutamic acid. One group was fed a level furnishing the amount of α-amino acid nitrogen equal to that supplied by glutamine in the present study. The other received the higher amount fed here. For animals with

[1] D and G Research Animal Diet, Price-Wilhoite Company, Frederick, Maryland.

TABLE I. Nitrogen Balance Data for Adult Rats Fed Glutamic Acid (GLU) or Glutamine (GLN) as Source of Supplemental Nitrogen (SN).

SN source and group no.[a]	Condition of animals	Calorie intake[b] (kcal/day/kg$^{3/4}$)	Nitrogen (mg/day)	
			Intake	Balance[c]
1. GLU	Undepleted	125	53.7	—6.1 ± 0.99[d]
2. GLN	Undepleted	126	53.7	—4.7 ± 0.90
3. GLU	Undepleted	80	50.9	—9.1 ± 1.84
4. GLN	Undepleted	81	50.8	—9.5 ± 1.53
5. GLU	Depleted	113	54.7	—1.7 ± 0.74
6. GLN	Depleted	114	54.7	—4.0 ± 1.20
7. GLU	Depleted	73	51.8	—5.0 ± 0.70
8. GLN	Depleted	73	51.9	—6.6 ± 0.95

[a] Number of animals per group: 15–17; average weight during collection period of groups 1–4, 383–391; of groups 5–8, 437–446.

[b] The factors 4, 9, 4 for carbohydrate, fat, and protein were used in calculating calorie intake. The use of 4 for amino acids is admittedly not correct but was used for convenience as the amounts in the diets were low enough to make the error negligible.

[c] Urinary nitrogen varied from a low of 38.7 mg/day for group 5 to a high of 45.0 for group 4.

[d] Mean and standard error.

calorie intakes of 83–91 (av, 88) kcal/day/kg$^{3/4}$, nitrogen balances were —11.2 ± 1.19 vs —7.7 ± 0.90 mg/day ($p<0.05$); for those with calorie intakes of 107–134 (av, 122), balances were —5.5 ± 1.34 vs —0.3 ± 0.81 mg/day ($p<0.01$).

In the present study, regardless of whether the animals were depleted or not, or fed extra calories or not, there were no significant differences in nitrogen balances between the groups fed glutamic acid or glutamine under the same conditions (Table I). Thus it appears that the adult rat is fully capable of utilizing both amide and α-amino nitrogen as a source of supplemental nitrogen under the experimental conditions described.

Calorie intakes of groups 1, 2, 5, and 6 were sufficiently high (Table I) for the animals to maintain weight during the collection periods. Average weight losses of groups 3, 4, 7, and 8 were about 2 g/day. Nitrogen balances showed no direct relationship with calorie intakes; variations were probably related to interactions among nitrogen stores, nitrogen supply, and calorie intake.

It is not surprising to find a difference in utilization of nitrogen compounds by growing and adult rats. Protein needs are more acute in the young rat. Moreover, amounts of protein are larger in the adult and the supply of nitrogen from protein turnover would be greater. Thus, adult rats might be expected to use supplemental dietary nitrogen differently from young growing animals.

Summary. The utilization of α- and amide nitrogen as sources of supplemental nitrogen to reduce nitrogen losses in the adult rat was studied using the nitrogen balance technique. Although young rats have been shown to utilize amide less efficiently than α-amino nitrogen as a source of supplemental nitrogen for carcass nitrogen gains, adult rats utilized the two equally well. Level of calorie intake or nutritional state of the adult animals did not influence the results.

1. Womack, M., J. Food Sci. 34, 430 (1969).

2. Smith, E. B., and Johnson, B. C., Brit. J. Nutr. 21, 17 (1967).

3. Womack, M., Proc. Soc. Exp. Biol. Med. 131, 977 (1969).

Received Sept. 8, 1970. P.S.E.B.M., 1971, Vol. 136.