A NEW FEEDER FOR POWDERED DIETS

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Abstract. A new feeder for powdered diets was developed for use with small rodents. The feeder has unique advantages over commercially available feeders. Wastage is minimal, food intake can be measured, and it is adaptable to various rodent species and different types of powdered diets. This study describes and evaluates the new feeder using three animal groups -- weanling rats, adult rats, and adult hamsters. In the rat studies, the rate of growth of weanling and adult rats fed commercial rat chow in pellet form using conventional feeders was the same as that of rats fed the same chow in meal form using the new feeders. Likewise in the hamster studies, the rate of growth of adult hamsters fed powdered semi-synthetic diet from conventional glass jars was the same as those fed the same diet from the new feeders. The new feeders supplied the animals with a continuous supply of meal free of contamination from feces or urine. Unrecoverable spillage (wastage) was 1-2% of the amount of food given. The new feeders were easy to handle and clean, had ample capacity, and needed little attention.

INTRODUCTION

Rodents are commonly used in nutritional and toxicological studies to examine the effect of various dietary ingredients. These studies often require the use of powdered test diets and accurate measurements of food intake -- a difficult task with pelleted feed because of excessive wastage. Powdered diets tend to be expensive, and excessive wastage not only raises cost, but invalidates food intake measurements. Furthermore, powdered feeds vary in moisture, consistency, oil content, and particle size causing feeding problems in many conventional feeders. Commercially available powder feeders are not adaptable to different animal species or different types of meal, some allow the animal to climb inside the feeding area or food storage area (fecal and urinary contamination), few limit food spillage or allow for its measurement, few prevent the animal from digging in the feeding area, some do not fit commonly used cages, some do not allow multi-animal feeding, and some are difficult to clean. A recent non-commercial rat (1) and mouse (2) feeder eliminates some of the problems associated with conventional feeders. Since it is without an interchangable food hopper, it is not easily modified to accommodate other animal species or powdered diets with differing particle size and flow characteristics. In addition, food is accessible from one side only, the feeder is not self-supporting, and with some diets constant attention may be needed.

For the most part, the above problems were eliminated with the new feeder. This paper describes the feeder in detail, and presents data on body weight gain from several studies in which rats and hamsters were fed from conventional feeders and compared to those fed the same diet using the new feeder.

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MATERIALS and METHODS.

Feeder Description:

The new feeder (Figure 1) is constructed from stainless steel. The feeder is a self-standing rectangular box (shown on the left) with four separate components -- a holding-box, a bottom-screen, a food-hopper, and a lid. The four components (shown on the right) drop in place, and hence, can be assembled or disassembled in seconds for inspection and cleaning. The feeder occupies 13.5 square inches of floor space. A key element of the feeder design is the food-hopper which is freely suspended within the "holding-box" by a transaxle. The transaxle provides a pivot which allows the hopper to "swing" against fixed stops attached to the bottom screen. Food is accessible to the animal by licking through the openings of the screen mesh of the food-hopper. A feeding rodent agitates the hopper causing a "jarring action". This action tends to concentrate the meal towards the bottom and prevent bridging. For "free-flowing" meal, the hopper is held rigid, and for "slow-flowing" meal, it is allowed to swing freely against stops. The food-hopper is easily interchangeable (in a second) which allows use of hoppers with screens of differing mesh sizes, or food hoppers custom-designed for specific food types or animal species. A removable bottom-screen catches most food spillage, and is fitted with "stops" to limit the movement of the food-hopper.

The holding-box (4 1/2 X 5 1/8 X 3 inches, width, height, and depth, respectively) is an open, rectangular frame constructed from 20G sheet metal. Its purpose is to hold the other three components and provide stability to the entire unit. The bottom-screen (5/16 inches high) fits within the bottom flanges of the holding-box, and is easily removed for inspection. The food-hopper is an open screened compartment with tapered sides made from double-crimped wire screen. The screen is 1/16 inch woven wires with 3/16 inch square openings. The end pieces and bottom are 20G non-perforated sheet metal spot-welded to a single piece of folded screen. The end pieces are inverted trapezoids measuring 4 1/8 inches in length, 2 1/2 inches at the top, and 1 inch across the

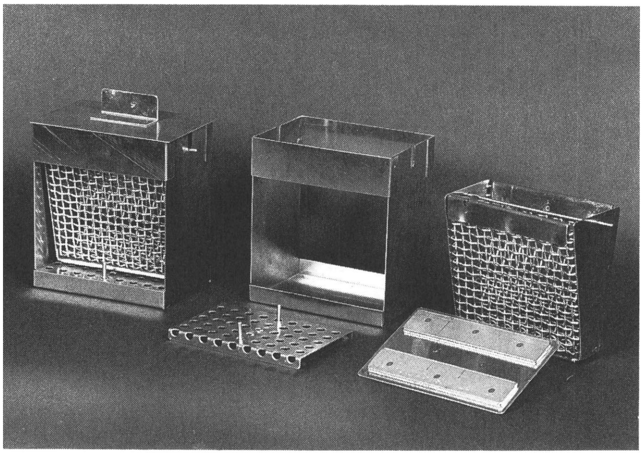

Figure 1. Stainless steel feeders. Left, assembled feeder. Right, disassembled feeder.

bottom. The mesh supports the meal, and its steep slope prevents the meal from falling through the openings.

A rod, or transaxle (3/32 inch diameter, 5 inches long), is fitted through holes in the top of the food-hopper. To hold it in place, the rod was crimped next to the end pieces. The hopper is suspended within the holding-box with the ends of the rod resting within notches (3/16 X 5/8 inches, width and depth, respectively) located on the top rim of the end panels of the holding-box. Thus, the hopper is easily dropped into place, and is free to swing against stops spaced 2 inches apart fastened to the bottom-screen (its movement may be further restricted or stopped by fastening short bolts -- 1/4 X 3/4 inches -- in any of the holes in the bottom-screen). The stops projecting above the screen provide convenient finger-holds to aid in the removal of the bottom screen.

A lid (4 3/4 X 3 3/8 inches, width and depth, respectively) is placed over the box to prevent access to the food by the animals. Two heavy, rectangular plates (1/8 inch stock) are welded to the underside of the lid. They serve to seat the lid on the top of the holding-box and to stabilize the feeder.

Experimental Design:

The new feeders were tested on three rodent groups -- weanling rats, adult rats, and adult hamsters. In the rat study, growth comparisons were made between animals fed a commercial chow in pellet form using conventional bins versus those fed the same chow as a powder using the new feeder. In the hamster study, growth comparisons were made between animals fed a semi-synthetic powdered diet using conventional glass jars versus those fed the same diet using the new feeder. Slopes of the mean body weight (growth curves) were compared using the method of Dixon and Massey (3). All animals were obtained from Harlan-Sprague Dawley, Inc. (Indianapolis, IN), and housed in a federally approved animal care facility. The animal rooms were air-conditioned (66-72 degrees Fahrenheit), humidity controlled (45-55 %) and on a 12 hour light/dark cycle. Feed and water were given ad libitum. Cages and feeders were washed and replaced biweekly. The used feeders were soaked 3 hours or more in disinfectant and then processed through an automatic cage washer for cleaning. After washing, the feeders were inspected for residual matter.

Rats:

Male albino rats (outbred Sprague Dawley strain) were housed in conventional stainless steel rat cages. The floor area was 16 by 23 inches (368 sq.in.) and ceilings were 10 1/2 inches high. The animals were housed six per cage in the weanling rat experiment, and four per cage in the adult rat study. The weanling rats (N = 24) were weighed the day after arrival, and sorted into two weight-matched groups of 12 each. The first group (cages 1 and 2, six each) was fed pellets in a conventional manner, and the second group (cages 3 and 4, six each) was fed the same chow in meal form using the new feeders. The chow was a standard rat/mouse chow (4% Teklad, Teklad Mills, Madison, WI) containing 4% fat, 25% protein, 10% moisture, and essential minerals, vitamins, and amino acids. The meal was milled through a 6 mesh screen (0.1875 inch openings), was free-flowing, and felt dry to the touch. The adult rats (N = 16) were obtained at 48 days of age. At 51 days of age, they were weighed and sorted into two weight-matched groups of 8 each (4 per cage), and fed as above -- one group fed pellets conventionally, and the other group fed meal using the new feeder.

For all rat groups, fresh feed was supplied three times per week. For rats fed pellets, conventional feeding bins attached to the outer side of the cage door were used. For rats fed meal, the new feeders (two per cage) were placed in the middle of the floor area within the cage. The hopper capacity was 305 grams per feeder for the 4% Teklad meal, and the hopper was fixed in place. Cages were observed daily for appearance of animals, food bridging, food spillage, and food availability. Food intake and spillage were monitored during several test periods. To determine net food intake, the hoppers with food-contents were weighed three times each week (Monday, Wednesday, and Friday). Net food intake per day per animal was the difference between the initial and final food-hopper weights corrected for recovered spillage, wastage, number of rats, and interval of days. Food particles that collected under the bottom screen was called "spillage". Spillage not captured by the bottom screen fell through the screened cage floor onto the litter pan. These collections were called "wastage". To measure this wastage, a 9x14 inch paper sheet was placed in the litter pan directly under the feeders. At 24-h intervals, the fecal pellets were removed, the food-wastage weighed, and the paper replaced.

Hamsters:

Adult male hamsters (Golden Syrian) were housed 5-8 per cage in commercial shoe-box style plastic cages with stainless steel wire-frame covers secured 8 inches above the cage floor. Cages were examined daily, and the animals weighed two times per week. During the study, all hamsters were fed either from the new feeder or a glass jar. The jar was a heavy (210 gm), wide-mouth (3 inch diameter opening), low-form (1 3/4 inch high) jar. The feeders (and jars) were placed centrally on the floor of the cage. Food was replaced daily in the jars, and as needed in the new feeders (every 2-4 days). Food intake and spillage were not monitored in the hamster study.

The hamsters (N = 85) were purchased for use in another project to examine the effect of diet on intestinal calcium transport. The hamsters were obtained at 37 days of age, and fed initially a commercial chow (Purina 5012). At 42 days of age, they were separated into two subgroups (weights unmatched) and fed one of two semi-synthetic powdered diets for a 21-day test period. During this test period, the new feeders were evaluated. One group (N = 40) was fed a normal calcium diet (NCD) containing 1.25% calcium (one half fed from glass jars and one half from the new feeders), and the other group (N = 45) were fed a low calcium diet (LCD) containing 0.03% calcium (17 fed from glass jars and 28 from the new feeders). Other than for the differences in calcium, the diets were of similar composition (5% corn oil, 23% protein, 31% corn starch, 22% sucrose, 8% fiber, and the recommended amounts of vitamins and minerals). The diet was milled through an fine 80 mesh screen (0.007 inch openings), and when squeezed by hand, felt slightly "oily" and held its form, but crumbled easily. The hoppers were allowed maximal movement (about 3/4 inches). After this experiment, the animals were used for the calcium uptake study and sacrificed.

RESULTS AND DISCUSSION:

In general, the animals covered a wide range of age and size. For all animal groups, the new feeder provided a continuous supply of food, needed little attention (1-2 man-hours per week for this rat study), and food-intake measurements were easily performed. The feeders were clean and free of residual matter after washing -- a potential problem if hazardous substances are included in the diet. Observation showed feeding animals worked at the mesh with both their tongue and teeth. Although they occasionally grasped the wire mesh with their teeth, the animals obtained food in sufficient quantity by inserting their tongues through the openings of the mesh. Temporary food cavities were formed, but as feeding continued, overlying bridges collapsed and replenished the food supply. Because of the steep slope of the sides of the hopper, food tended to migrate towards the bottom of the hopper. This process was enhanced because of two design features -- animals had access to both sides of the hopper, and the agitation during feeding tended to collapse food bridges. The mesh prevented the animals from digging in the food causing excessive loss or spillage. It was noted that most food particles dropping upon the bottom screen were immediately scavenged by the animals. Those particles not scavenged collected under the screen and a small percentage (wastage) fell into the litter pan. Wastage was 1-2% of the amount of food given.

Table I shows results of food intake and spillage measurements during two consecutive time periods for weanling and adult rats fed meal from the new feeder. The values are mean data from the two cages. Gross intake (amount of food given less the amount left in the food hopper) was corrected for spillage which collected under the bottom screen and for wastage that collected upon the paper sheet placed in the litter pan. During the first test period, spillage was allowed to accumulate under the bottom screen and was measured on the last day. During the second period, the spillage was removed and measured three times -- on the second, fifth, and seventh day. Wastage was greater during the first period (2.4%) as

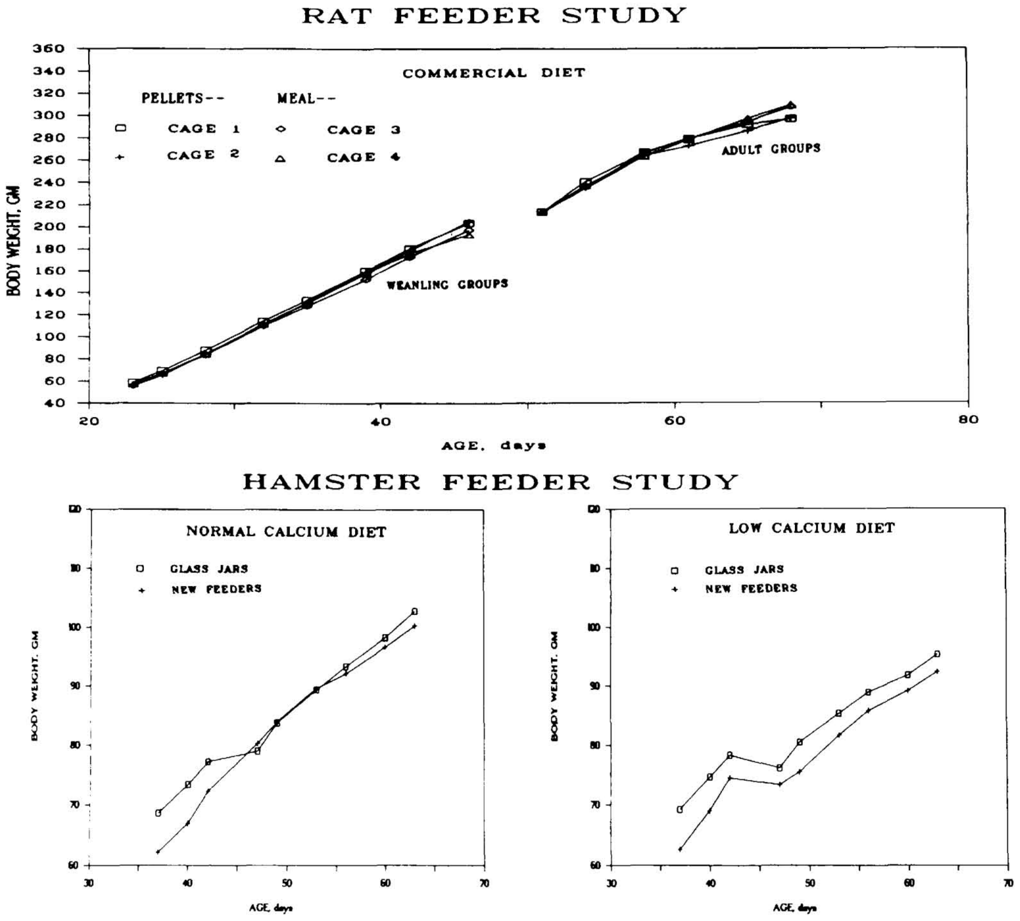

Figure 2. Growth curves for rat and hamster study.

compared to the second period (1.4%). Observation during the first period showed that spillage filled the compartment below the screen in 2-3 days at which time wastage increased since the rats did not scavenge all the food particles dropping from the food hopper. Net food intake per rat per day (bottom line) correlated with age, and the mean was greater in the second period as compared to the first. As expected, the increase in food intake for the second week was much greater for the younger, growing animals than for the older rats.

The two feeding studies are summarized in Figure 2. Mean body weight is plotted against age (days). In the rat weanling study, the growth rate over the 23-day study period was rapid for the young growing animals and did not differ between those fed pellets conventionally and those fed the same food in meal form from the new feeders. Likewise for the adult rat study, the rate of growth over the 14-day study period did not differ between test groups.

The growth curves for the hamster study over the 21-day study period are shown in the two panels at the bottom of Figure 2. Initial mean weights for the hamsters fed from glass jars were slightly greater than initial weights of those fed from the new feeders (matched weights were not necessary for the calcium absorption study). After switching to the semi-synthetic diet, the growth rate slowed for 3-4 days in all but the hamster group fed NCD. After this initial adjustment period, mean growth rate was linear and the slope similar among all animal groups.

Although the hamster chow was a very fine, self-supporting powder, the feeding hamsters agitated the food hopper sufficiently to collapse bridges and provide a continuous supply of food. Spillage and food intake were not measured systematically in this study. Hamsters frequently crawled into the glass jars and contaminated the food with urine and/or feces, and dug in the food causing large amounts of wastage in the litter. Although the glass jars are simple and economical, food intake measurements are impossible, and contamination from fecal/urinary matter is a potential health problem.

In summary, these data suggest that growth is independent of feeder, and that the new feeder provides food free of contamination and in amounts that sustains growth equivalent to that of animals fed conventionally. Based on this evaluation, the new feeder provides investigators improved conditions in which to gather food consumption data in rodent nutritional and toxicological studies. The new feeder minimizes (or eliminates) many of the problems associated with commercially available powder feeders such as food contamination, inaccurate food intake measurements, excessive attention by the investigator, and difficulties in cleaning.

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The author is considering patent application. For further information, contact the author.

REFERENCES:

1. Fullerton FR, Hunziker J, Bryant P. Evaluation of a new rat feeder for use in chemical toxicology and nutrition studies. Lab An Sc 31(3):276-279, 1981.

2. Hunziker J. A new feeder system for quantitating actual toxicant consumption by mice during feeding studies. Lab An Sc 25(1):85-87, 1975.

3. Dixon WJ, Massey FJ. Introduction to statistical analysis (4th edition). New York: McGraw, 1957.

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