Differences Between Rats and Rabbits in their Response of Feed and Energy Intake to Increasing Dietary Fat Content

by ***A. Alhaidary*, H. E. Mohamed & A.C. Beynen***
Department of Animal Production, College of Food and Agricultural Sciences,
King Saud University, Riyadh, Kingdom of Saudi Arabia

Summary
It is common practice to use an ad-libitum feeding regimen in rat studies, even when experimental diets with different energy densities are used; a prerequisite is that the diets have identical nutrient:energy ratios. It is assumed that the rats will maintain a constant energy intake so that nutrient intake will not differ between the dietary treatments. The concept that energy requirement determines feed intake is supported by the study with rats that is described in this paper. Increasing the amounts of dietary fat (coconut fat or corn oil), and thus increasing the energy densities of the diets, caused decreasing feed intakes so that energy intakes remained unchanged. However, feeding the same diet recipes to rabbits led to increasing feed intakes, and even further enhanced energy intakes, in response to increasing concentrations of corn oil in the diet. Secondly, when the diet contained coconut fat, an increase in fat content also raised feed intake, but at higher inclusion levels there was no further increase or rather a decrease in feed intake by the rabbits. It is suggested to apply restricted feeding in rabbit studies using diets with different energy densities in order to avoid additional variables such as differences in weight gain and nutrient intake.

Introduction

From a scientific point of view there are experimental conditions in which restricted feeding of laboratory animals is preferred over ad-libitum feeding (*Beynen, 1992*). It is not uncommon that experimental treatment of the animals, or additives to their diet, affect feed intake. Ad-libitum instead of restricted feeding will then lead to treatment-related differences in feed intake, which introduces extra variables such as weight gain and nutrient intake. In certain experiments it may also lead to uncontrolled intake of feed additives such as pharmacological or toxicological agents. Clearly, the undesired introduction of additional variables interferes with the interpretation of the experimental outcomes.

**Correspondence:* Ahmed Alhaidary PhD
Department of Animal Production, College of Food and Agricultural Sciences, King Saud University, P.O. Box 2460, Riyadh 11451, Kingdom of Saudi Arabia
Tel +966 14678475
Fax +966 14678474
E-mail ahaidary@ksu.edu.sa

It is generally accepted that changes in the protein, fat and carbohydrate contents of experimental diets do not require restricted feeding, provided that the macronutrients are exchanged on an iso-energetic basis (*Beynen and Coates, 2001*). The major drive for feed intake is an energy requirement and animals normally regulate their energy intake rather than feed intake. Animals aim at a constant energy intake, the target being dependent on their age, physiological status and environmental conditions. Within experiments, animals and their environmental conditions generally are similar. This implies that nutrient intake is determined by the ratio of the amount of the nutrient to the amount of the energy in the feed. This ratio for minerals, trace elements and vitamins remains constant when macronutrients are exchanged iso-energetically (*Beynen and Coates, 2001*).
The concept that energy requirement determines feed intake is supported by a study with rats (*Van Lith et al., 1989*). The addition of various levels of fat to the diet, at the expense of iso-energetic

amounts of carbohydrates, raised the energy density of the diet, but the rats adapted their feed intake so that energy intake remained constant. However, when using the same diet recipes as those in the rat study, we recently found that the feed and energy intake response to increasing dietary energy levels was aberrant in rabbits (Alhaidary et al., 2010). The differential response of feed and energy intake by rats and rabbits to high-energy diets is relevant to laboratory animal science. Therefore, in this communication we compare and contrast the rat and rabbit data.

Materials and Methods

In the rat study, 4-week old, male rats of an outbred Wistar colony (Cpb/WU) were used. In the rabbit study, 8-week old, random-bred, male rabbits of the New Zealand strain were used. Details of housing have been described elsewhere (*Van Lith et al., 1989; Alhaidary et al., 2010*).

At the start of the experiment, the rats (6 animals per group) and the rabbits (8 animals per group) were allocated to the experimental diet compositions given in Table 1. The animals were matched so that group distributions of body weight were similar. Mean initial body weight of the rats was 118 g and that of the rabbits was 1.69 kg. The diets contained four levels of either coconut fat or corn oil as fat source. Extra fat was added to the low-fat diet at the expense of an iso-energetic amount of corn starch and dextrose in a 1:1 ratio. The diets for the rats were in meal form and those for the rabbits were in pelleted form.

The animals had free access to feed and water. The experimental period in the rat study lasted 58 days and that in the rabbit study 56 days. Body weights and feed intake were measured. The energy density of the diets was calculated on the basis of the ingredient compositions. For the rats, the following energy values for metabolisable energy were used (kJ/g): protein, 16.7; fat, 37.7; carbohydrates, 16.7. For the rabbits, we used the following values (kJ/g): protein, 16.5; fat, 35.8; fiber, 4.1; carbohydrates, 15.9.

Results

Table 2 shows that final body weights of the rats were not influenced by the amount and type of fat in the diet. In the rabbits however, body weights were

Table 1. Composition of the experimental diets.

	Weight percentage of dietary fat			
	2.0	4.1	8.6	19.4
Ingredient	g			
Corn oil	10	10	10	10
Coconut fat/corn oil	10/10	30/30	70/70	150/150
Corn starch	255.85	233.35	188.35	98.35
Dextrose	255.85	233.35	188.35	98.35
Constant components[2]	468.3	468.3	468.3	468.3
Total	1000	975	925	825
Energy density, kJ/g				
Rat diets	11.2	11.5	12.2	13.6
Rabbit diets	13.7	14.0	14.8	16.6

[1]The constant components consisted of (g): casein, 160; molasses, 100; cellulose, 150, dicalcium phosphate, 6.1; calcium carbonate, 6.2; magnesium carbonate, 0.7; magnesium oxide, 0.3; potassium carbonate, 18.0; sodium chloride, 5.0; vitamin premix, 12.0; mineral premix, 10.0. The composition of the vitamin and mineral premix has been described earlier (*Beynen et al., 1986*).

Table 2. Final body weights in rats and rabbits fed the experimental diets.

	Weight percentage of dietary fat				Significance[1]
	2.0	4.1	8.6	19.4	
Final body weight rats, kg					
Coconut-fat diets	365 ± 9	349 ± 11	370 ± 21	382 ± 12	NS
Corn-oil diets	341 ± 10	375 ± 10	349 ± 15	364 ± 16	
Final body weight rabbits, g					
Coconut-fat diets	2.92 ± 0.11	3.15 ± 0.10	3.28 ± 0.09	2.73 ± 0.16	A, T, AxT
Corn-oil diets	3.01 ± 0.12	3.27 ± 0.11	3.36 ± 0.13	3.85 ± 0.12	

Results are expressed as means ± SE for 7 or 8 rabbits or for 5 or 6 rats per dietary group. [1]Significance was calculated by analysis of variance. A = effect of amount of fat; T = effect of type of fat; AxT = effect of interaction; NS = no significant effect of amount and type of fat.

systematically lower on the coconut-fat diets than on the diets containing corn oil. Increasing the level of corn oil in the diet produced a dose-dependent increase in final body weight in the rabbits. Between 2% and 8.6 % fat in the diet, an increase in coconut fat intake raised final body weight in the rabbits, but there was a fall with the highest (19.4%) level.

Feed intake in the rats diminished with increasing fat intakes, irrespective of the type of fat (Table 3). In the rabbits the situation was different. Increasing amounts of corn oil in the diet raised feed intake. When the diet contained coconut fat, an increase in fat content from 2% to 4.1% raised feed intake. At 8.6% fat in the diet there was no further increase in feed intake and at the highest inclusion level, feed intake was reduced substantially in the rabbits.

In the rats, energy intake generally remained constant, irrespective of the type and amount of fat in the diet (Table 3). In contrast, in the rabbits the amount and type of fat in the diet influenced spontaneous

Table 3. Feed and energy intakes in rats and rabbit fed the experimental diets.

	Weight percentage of dietary fat				Significance[1]
	2.0	4.1	8.6	19.4	
Feed intake rats, g/day					
Coconut-fat diets	26.4 ± 0.5	24.4 ± 0.9	23.9 ± 0.7	22.5 ± 0.5	A
Corn-oil diets	25.2 ± 0.5	25.3 ± 0.4	22.3 ± 0.8	20.6 ± 1.0	
Feed intake rabbits, g/day					
Coconut-fat diets	85.1 ± 4.9	99.4 ± 4.4	100.0 ± 3.7	72.5 ± 4.0	A,T, AxT
Corn-oil diets	94.6 ± 5.6	103.6 ± 5.5	107.5 ± 6.1	116.1 ± 4.3	
Energy intake rats, kJ/day					
Coconut-fat diets	296 ± 6	281 ± 10	292 ± 9	306 ± 7	
Corn-oil diets	282 ± 6	291 ± 5	272 ± 10	280 ± 14	
Energy intake rabbits, kJ/day					
Coconut-fat diets	1166 ± 67	1392 ± 62	1480 ± 55	1204 ± 66	A,T, AxT
Corn-oil diets	1296 ± 77	1450 ± 77	1591 ± 90	1927 ± 71	

See legend to Table 2.

energy intake. Energy intakes were systematically lower on the coconut-fat diets when compared with the corn-oil diets. When the diet contained coconut fat, energy intake went up with increasing dietary fat levels, but at the highest dietary fat level there was a drop. The rabbits fed on the corn-oil diets displayed a dose-dependent increase in energy intake.

Discussion

When using experimental diets with different energy density, but with identical nutrient:energy ratios, an ad-libitum feeding regimen may be applied because it is expected that the animals will maintain a constant energy intake so that nutrient intake will not differ between the dietary treatments (*Beynen and Coates, 2001*). This study shows that the concept holds for rats, but not for rabbits. Variable energy densities of the diet did not affect energy intake by the rats that had free access to feed. Increasing amounts of dietary fat, and thus increasing energy densities, caused decreasing feed intakes so that energy intakes remained unchanged. In contrast, the rabbits responded with increasing feed intakes to increasing concentrations of corn oil in the diet. Thus, energy intakes were even further enhanced by increasing dietary concentrations of corn oil. It may be concluded that in studies with rabbits fed diets with different energy densities, restricted feeding is preferred over ad-libitum feeding in order to avoid additional variables such as differences in weight gain and nutrient intake.

In addition, in the rabbits, unlike in the rats, there was an effect of type of dietary fat on feed intake, energy intake and final body weight. Coconut fat versus corn oil lowered feed intake, irrespective of the type of fat in the diet. At the highest inclusion level, coconut fat produced a marked decrease in feed intake. On the other hand, increasing concentrations of corn oil in the diet were associated with increasing feed intakes. These observations point at a stimulatory effect of corn oil on diet palatability, whereas coconut fat may have an inhibitory effect. This may be taken into account when formulating experimental diets for rabbits.

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