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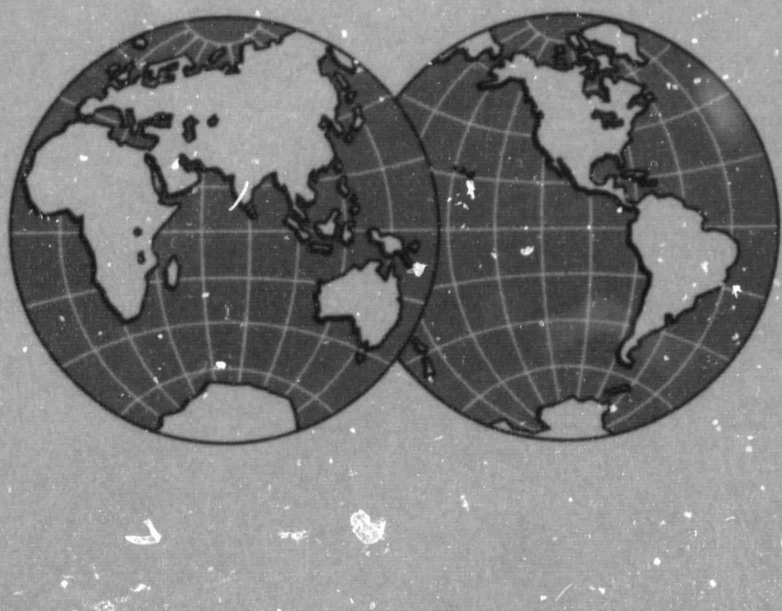

UNIVERSITY OF CALIFORNIA - BERKELEY

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EFFECTS OF THE COSMOS 1129 SOVIET PASTE DIET ON BODY COMPOSITION IN THE GROWING RAT

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ABSTRACT

A group of 6 Simonsen Albino rats 45 days of age was placed on a regimen of 40 g daily of the semi-purified Soviet paste diet used in the 18.5-day Cosmos 1129 spaceflight to support the rat subjects for various experiments on the physiological effects of weightlessness. The animals were maintained on the Soviet paste diet for 35 days, at which time their metabolic rate was measured and their body composition was determined by direct analysis. The results were compared with the same measurements made on a control group of rats of the same age, which had been kept on a standard commercial grain diet during the same period of time.

The Soviet Diet rats displayed a 10% lower mean total body mass than did the Control Diet rats at the end of the 35-day experimental feeding period, but had a mean metabolic rate that was 13% higher than did the Control Diet animals. Despite the lower total body mass and higher metabolic rate, the Soviet Diet rats contained 50% more body fat than did the Control Diet rats, so that their mean fat-free body mass was 16% less than that of the Control Diet animals.

Examination of the composition of the Soviet paste diet revealed that the essential amino acids arginine and methionine were relatively low in the diet, while lysine was relatively high. Also, sucrose constituted the major source of carbohydrate in the Soviet paste diet. The combination of these factors, together with the absence of dietary fiber in the Soviet paste diet, probably accounts for the lower fat-free body mass and higher fat content of the Soviet Diet rats.

The substantially greater deposition of body fat by the Soviet Diet rats entailed a greater release of dietary energy as heat than occurred in the Control Diet animals. Theoretical computations are presented which indicate that the higher metabolic rate measured in the Soviet Diet rats can be accounted for on the basis of the efficiencies of conversion of dietary protein, carbohydrate and fat to body fat.

The results point up the importance of rigorous control of the dietary regimen for animals to be used as experimental subjects for spaceflight studies on the metabolic effects of weightlessness.

INTRODUCTION

In January 1979 approval was given by NASA of a proposal by Grover C. Pitts, University of Virginia, Charlottesville, Nello Pace, University of California, Berkeley, and Arthur H. Smith, University of California, Davis to study the "Effect of Weightlessness on Body Mass and/or Organ Mass and Composition in the Rat" as part of the joint USA/USSR Biological Satellite Mission Cosmos "79", later designated Cosmos 1129. Contract NAS2-10195 between NASA and the University of Virginia was implemented in February 1979 to cover USA costs associated with the flight experiment, which was designated Experiment K-316.

The experiment was to comprise a detailed examination of the body composition of 5 Wistar-derived, specific pathogen free, young male albino rats from the colony of the Institute of Experimental Endocrinology of the Slovakian Academy of Sciences, Bratislava, Czechoslovakia, immediately after return from a nominal period of 20 days in Earth orbit. The Principal Investigator for Experiment K-316 was to be Arkadyi S. Ushakov of the USSR Ministry of Health, Institute of Biomedical Problems, Moscow, supported by a number of Institute Personnel. The USSR investigators had total responsibility for all flight activities, animal selection, and postflight delivery of the recovered animals to the Institute in Moscow. The dissection of the animals was to be the primary responsibility of the USA investigators, and biochemical analysis of body components was to be a shared responsibility of the USSR and USA investigators.

The design of Experiment K-316 was similar to that for other rat experiments to be flown in Cosmos 1129, as well as designs employed in previous joint Biological Satellite Missions, Cosmos 782 in 1975 and Cosmos 936 in 1977 (15,16). Nominally, rats 45 days of age are placed on 40 grams per day of a semi-purified paste flight diet 15 days before launch, given 4 times per day at 6-hr intervals in portions of 10 grams per feeding. The animals are launched at 60 days of age and sacrificed at 80 days of age shortly after reentry of the spacecraft. The paste diet is nominally 60% water and 40% dry matter, and 40 g are intended to provide 67 kcal/day of digestible energy and to meet the daily requirement for all nutrients by growing rats.

In the course of a postflight study for Cosmos 782 Experiment K-004a, Dr. Richard E. Grindeland and co-workers at the NASA Ames Research Center had found that the gain in total body mass of rats on 50 g daily of the Soviet paste diet was significantly less than that of rats fed a stock laboratory diet *ad libitum* under comparable conditions (3). Furthermore, the Soviet Diet rats seemed to contain more body fat than did the Control Diet animals, as judged from the epididymal fat pad masses of the two groups. Grindeland and co-workers came to no specific conclusion with respect to the differences observed other than to point out that while the Soviet paste diet was calorically adequate, it appeared to be different in some ingredient necessary for optimal growth. They also indicated that detailed body composition studies would be needed to define the effects of the dietary treatment on body protein, fat and water.

The results of Grindeland and co-workers strongly suggested that growing rats eating the Soviet paste diet would display a higher body fat content and a lower fat-free body mass than rats of the same age on a standard laboratory diet. Because Cosmos 1129 Experiment K-316 was concerned with the possible effects of weightlessness on body composition we deemed it essential to examine the effects of the Soviet flight diet on the composition parameters we had proposed to measure.

Accordingly, Mr. Kenneth A. Souza, Manager, Cosmos Project, NASA Ames Research Center, requested 50 kg of the Soviet paste diet from the Institute of Biomedical Problems in Moscow. Academician Oleg G. Gazenko, Director of the Institute, kindly agreed to provide the material, and through the good offices of Dr. Eugene A. Ilyin of the Institute and Dr. Milton R. Heinrich, Deputy Manager, Cosmos Project, NASA Ames Research Center, delivery to this laboratory was effected in early May, 1979. The study described below was carried out under NASA grant NSG-7336.

PROCEDURES

A total of 21 male Simonsen Albino rats 39 days of age was delivered by Simonsen Laboratories, Gilroy, California to this laboratory on 17 May 1979. The animals were housed in individual cages in a room maintained at 27° ± 0.5°C on a 12h:12h light/dark cycle, and were provided with water and Simonsen Laboratories G4.5 growth diet *ad libitum*. The animals had received the same diet before delivery by the supplier.

The animals were arbitrarily divided into 3 groups of 7 animals each and on 23 May 1979, when the animals were 45 days of age after 6 days of stabilization, two of the groups began receiving 40 g daily of the Soviet paste diet in one feeding, together with water *ad libitum*. The third group was continued on the Simonsen G4.5 diet and water *ad libitum* to serve as a control. One of the Soviet Diet groups was assigned to the body composition study, and the other was assigned to Dr. Leon Kazarian of the Wright-Patterson Air Force Base for studies in connection with Cosmos 1129 Experiment K-307.

The nominal design for the Cosmos 1129 Mission called for initiation of the Soviet paste diet feeding to 45-day-old rats 15 days before launch and during 20 days of flight, so that the rats were to be 60 days old at launch and 80 days of age at recovery. Thus, the Soviet Diet groups of the present study were fed 40 g daily of the paste diet for 5 weeks until 27 June 1971 when they were 80 days of age, and were sacrificed on that date. The group for Experiment K-307 was frozen and shipped to Dr. Kazarian.

On 26 June 1979, the day before sacrifice, 6 of the Soviet Diet group animals for the present study were placed in the EPL multiple-animal metabolic apparatus (MAMA) to measure respiratory gas exchange. The MAMA comprises individual metabolic chambers for 6 animals, and provides for automatic sampling of the exhaust gas from each chamber and measurement of oxygen and carbon dioxide partial pressures. The animals are placed in the lighted chambers at 0900 on the day of the test, and kept there for 6 hr. The mean of the 2 lowest hourly oxygen consumption rates is used to compute a standard metabolic rate as

$$MR,\ kcal/hr = 4.85\ (\dot{V}O_2,\ liters/hr).$$

On 27 June 1979 the 6 Soviet Diet rats were sacrificed and dissected for organ mass determinations and body composition analyses according to the procedures described by Pace et al. (14). On 28 June 1979 6 of the Control Diet rats were placed in the MAMA for respiratory gas exchange measurements, and on 29 June 1979 at 82 days of age they were sacrificed and dissected for organ mass determinations and body composition analyses.

After shearing the animals and measurement of individual organ masses the organs were pooled as combined viscera, and subsequently treated as one of 3 major body components. The sheared skin and the skinned, eviscerated carcass comprised the other 2 major body components. Water and fat contents of each of the 3 major components were determined by lyophilization and petroleum ether extraction, respectively. The dried, defatted residues were combined, comminuted finely and thoroughly mixed to produce a dried, defatted body powder for each animal. Analyses of 1-g portions of the powder were carried out for major body elements and creatine content.

From the analytical data it was possible to derive values for various body composition parameters. Net body mass was obtained as mass of the total body less those of hair and of contents of the gut and bladder. Body fat mass was measured as the sum of carcass, viscera and skin fat masses. Fat-free body mass was derived as the sum of fat-free carcass, viscera and skin masses. Body water mass was obtained as the sum of carcass, viscera and skin water masses. Dried, fat-free body mass was derived as the sum of dry, fat-free, carcass, viscera and skin masses. Body cell mass was computed as 228 times body potassium mass. Intracellular water mass was obtained as 0.73 times the body cell mass. Extracellular water mass was derived as body water mass minus intracellular water mass. Body protein mass was estimated as 6.25 times body nitrogen mass. Bone mineral mass was computed as 2.93 times body calcium mass. Because the bulk of the body creatine is contained in skeletal muscle, the body creatine mass serves as an index of the skeletal muscle mass.

Means were computed for each parameter from the 6 Soviet Diet rats, and from the 6 Control Diet rats. The independent sample t-test (17) was applied for each parameter to determine the statistical probability that the two means were from the same population, and $P < 0.05$ was used as the criterion that the 2 means were significantly different.

RESULTS

Total Body Mass and Food Consumption.

Total body mass was measured weekly for the 6 Control Diet rats and 6 Soviet Diet rats as shown in Table 1. Both groups were provided with water and Simonsen Laboratories G4.5 growth diet *ad libitum* from 17 May to 23 May 1979. On 23 May the Soviet Diet rats were started on 40 g of the paste diet daily with water *ad libitum*, and the Control Diet rats were continued on the Simonsen G4.5 diet and water *ad libitum* until the end of the test period 5 weeks later.

The daily paste diet consumption by the Soviet Diet rats is given in Table 2. It may be seen that only 2 of the 6 animals consumed all 40 g presented on the 1st day, while the other 4 consumed from 22 to 34 g. However, by the 2nd day all 6 animals were consuming the entire daily ration, and continued on full intake to the end of the test. The only exception was

Soviet Diet rat no. 1, whose intake faltered somewhat during the last 3-4 days.

The weekly mean total body masses for the two groups are plotted in Fig. 1. From this figure and the data in Table 3 it is evident that the growth rate of the Soviet Diet rats was markedly less than that of the Control Diet rats during the first 2 weeks of feeding the paste diet, but that the normal growth rate seemingly was restored during the subsequent 3 weeks. However, the Soviet Diet animals were still significantly smaller by about 10% at the end of the test period.

Organ System Masses.

The organ system masses of each of the 6 Control Diet rats at 82 days of age are given in Table 4. The values are a close approximation of the organ mass drained of blood, which is assumed to represent 7% of the net body mass (14). The comparable organ system masses of the 6 Soviet Diet rats at 80 days of age are listed in Table 5, and Table 6 shows the statistical comparison of the mean values in each case.

It may be seen in Table 6 that while total body mass and net body mass were significantly less by about 10% in the Soviet Diet group than in the Control Diet group, only the masses of the carcass and 4 of the visceral organ systems were significantly less in the Soviet Diet group. However, visual inspection during dissection indicated that more fat was associated with the organs of the Soviet Diet animals than was the case for the Control Diet rats.

Body Water and Fat Contents.

The water, fat, and fat-free masses of the 3 major body components, carcass, viscera, and skin, are given in Table 7 for the Control Diet rats. The blood masses shown are values computed as 7% of the net body mass, and the simplifying assumption was made that the blood contained no fat and was 100% water. The more elaborate assumption that blood comprises 82% water and 18% dry matter has been found practically neither to improve the quality of the data nor the validity of conclusions drawn. The net body composition values given in Table 7 represent the sums of the corresponding values for carcass, viscera, skin, and blood. Table 8 shows the same information for the Soviet Diet rats, and Table 9 gives the statistical comparison of the mean values for the two groups.

From Table 9 it is abundantly evident that the Soviet Diet animals contained significantly larger amounts of fat, about 50% more, than did the Control Diet rats. Furthermore, the fat-free body mass of the Soviet Diet group was significantly lower by about 16% than that of the Control Diet group. The differences in fat mass and fat-free mass were evident in all 3 major body compartments as well as in the body as a whole. Also, the body dry, fat-free mass and body water mass were lower to the same extent in the Soviet Diet rats as compared to the Control Diet rats, indicating little or no difference in the gross composition of the fat-free body mass between the two groups.

The relative contents of body fat and body water were examined more closely by considering the fractional composition of the major tissue compartments and the body as a whole. Table 10 gives the per cent fat in each component for the Control Diet animals, and the per cent of the body fat found in each component. It also lists the per cent water in the fat-free mass for each component, and the per cent of the total body water found in each component. Table 11 gives the same kind of data for the Soviet Diet animals, and Table 12 shows the statistical comparison of the mean values for the two groups.

The per cent fat in the carcass of the Soviet Diet rats was almost double that in the Control Diet animals, while the per cent fat in the viscera and skin was about half again as great. The relative distribution of the total body fat between the 3 compartments was essentially the same in the two groups, even though the Soviet Diet animals contained substantially more fat.

The per cent water in the fat-free mass was quite constant and essentially the same in the two groups. Only the fat-free viscera of the Soviet Diet rats showed a slightly, but significantly, lower percentage of water than did the fat-free viscera of the Control Diet animals. The relative distribution of the total body water among the major compartments was closely similar in the two groups, and only the per cent of the total body water represented by the blood was slightly greater in the Soviet Diet rats as compared to the Control Diet rats.

Composition of Fat-Free Body Mass.

The results of the analyses of the dry, fat-free body powder for nitrogen, calcium, phosphorus, potassium, sodium, magnesium, and creatine in terms of millimoles per gram of powder are given in Table 13 for the Control Diet rats and Table 14 for the Soviet Diet rats. The values for the dry, fat-free body mass are also given, as well as the body content of each entity expressed in grams. Body composition parameters derived from the elemental analyses are shown in the lower part of the tables.

Table 15 gives the statistical comparison of the mean values between the two groups. It may be seen that for every constituent the body content in the Soviet Diet group was significantly lower. Such a finding would be expected if the percentage composition of the fat-free body mass were the same in the two groups, and only its mass were significantly lower in the Diet rats, as already demonstrated.

In order to test this explanation, the body constituents were expressed as percentages of the fat-free body mass for the Control Diet rats in Table 16, and for the Soviet Diet rats in Table 17. The mean percentage values for the two groups were compared statistically, as shown in Table 18, and indeed it may be seen that there was only one minor difference in the elemental proportions of the fat-free body mass between the two groups. The potassium percentage was slightly, but significantly, higher in the Soviet Diet animals.

Inasmuch as our values for body cell mass, intracellular water mass, and extracellular water mass are derived wholly or in part from body potassium values, these percentages were also slightly different in the two groups. However, we ascribe little physiological significance to the differences seen in Table 18, and conclude that the fat-free body composition of the Soviet Diet rats was essentially the same as that of the Control Diet rats.

Metabolic Rate.

The means of the two lowest hourly oxygen consumption values ($\dot{V}O_2$) and carbon dioxide production values ($\dot{V}CO_2$) obtained for each of the Control Diet animals and Soviet Diet animals are given in Table 19, together with the computed values of the respiratory exchange ratio ($R = \dot{V}CO_2/\dot{V}O_2$). The metabolic rate calculated as $4.85 \times \dot{V}O_2$ is also shown, together with the metabolic intensities based on total body mass, net body mass, fat-free body mass, and body cell mass.

The mean values of the various metabolic rate parameters for the two groups of animals are compared statistically in Table 20. It may be seen that oxygen consumption rate and the metabolic rate calculated from it were significantly greater by about 13% in the Soviet Diet rats, despite the fact that they were smaller by about 10% in total body mass. Thus, the metabolic intensity per unit total body mass of the Soviet Diet rats was substantially greater by about 25%, and the metabolic intensity per unit fat-free body mass was greater by about 35%. It seems clear, therefore, that the Soviet

Diet group was more active metabolically when measured under standardized conditions than the Control Diet group, both in absolute terms and on a per unit body mass basis.

Diet Composition.

The nominal composition of the Simonsen Laboratories G4.5 growth diet fed to the Control Diet rats was provided by Dr. James Russell of Simonsen Laboratories, and is listed in Table 21. It is characterizable as a grain and meat-scrap ration.

The nominal composition of the Soviet paste diet was provided to the NASA Ames Research Center by the USSR Institute of Biomedical Problems, and is given in Table 22. It is characterizable as a semi-purified ration in which casein represents 18.8%, cornstarch represents 18.8%, and sucrose represents 41.9% of the dry matter.

Because the essential amino acid composition of the Soviet paste diet was not available, Dr. Milton R. Heinrich of the NASA Ames Research Center arranged for the analysis of a sample of the 50 kg batch used in the present diet study by Curtis and Tompkins, Ltd., of San Francisco, California (7). Curtis and Tompkins also measured the water content of the sample and several vitamin levels. Our laboratory (EPL) measured the water content of the sample, as well as the calcium, phosphorus, potassium, sodium and magnesium contents.

The nominal values of the nutrient constituents of the dry matter in the Soviet paste diet, the Curtis and Tompkins analytical values, and the EPL analytical values are shown in columns 2, 3 and 4 of Table 23. The values selected for further assessment of the Soviet diet are given in column 5 of Table 23.

It will be noted that the 50 kg batch of Soviet paste diet actually contained 65% water and only 35% dry matter, instead of the nominal 60%

water and 40% dry matter. Hence, the values in column 5 of Table 23 for composition of the dry matter were used to compute the quantity of each nutrient provided by 40 g of the paste diet based on a composition of 65% water and 35% dry matter. These values are shown in column 6 of Table 23, and represent our best estimate of the daily intake of each nutrient by the Soviet Diet rats used in the present study.

The daily nutrient requirements of growing laboratory rats published by the National Research Council (13) are given in column 2 of Table 24. Column 3 of Table 24, which duplicates column 6 of Table 23, shows the daily quantity of the nutrients provided by 40 g of the Soviet paste diet, and column 4 of Table 24 gives the percentage of the daily requirement supplied to the Soviet Diet rats.

Although most of the nutrients were made available in ample quantity, a few were apparently below the daily requirement. Thus, the essential amino acid arginine was provided at the 91% level, and methionine was provided at the 77% level. The trace element zinc was available only at the 39% level, and copper was available at the 93% level. Vitamin A was supplied at the 80% level, and choline was supplied at the 93% level.

Because the Control Diet rats were given *ad libitum* access to the Simonsen G4.5 growth diet, actual daily food consumption was not measured. However, it was assumed that the animals met at least the NRC daily caloric requirement of 57 kcal, as judged from their normal growth pattern during the course of the study.

From the data in Table 21, it may be computed that 57 kcal are provided by 17.3 g of the Simonsen G4.5 diet. Thus, the quantity of each nutrient constituent represented by 17.3 g of diet was calculated from Table 21, and the results are shown as column 5 of Table 24. Column 6 expresses these values as a percentage of the NRC daily requirement, and it may be seen that it is met in every instance. Therefore, it may be concluded that the Control Diet rats received the NRC daily requirement for all nutrients.

Digestive Tract Contents.

During dissection of the animals for organ mass measurements, the contents of the digestive tract were extruded onto a drying tray, and wet mass, water mass and dry mass were determined. The results are shown in Table 25, where it may be seen that, with one exception, the digestive tract of the Control Diet animals contained about double the mass of material found in the digestive tract of the Soviet Diet animals.

Part of the difference may be ascribable to the fact that the Control Diet was available *ad libitum*, whereas the Soviet paste diet was limited to 40 g daily. Hence, the Control Diet rats may simply have ingested more food daily than did the Soviet Diet rats.

However, it is also evident from the diet compositions shown in Tables 21 and 22 that the Simonsen G4.5 diet contains about 3% fiber, while the Soviet paste diet contains none. Thus, it could be expected that the digestive tract of the Control Diet animals would contain a greater bulk than that of the Soviet Diet rats on these grounds as well.

It is of interest to note that despite the difference in mass of the digestive tract contents between the two groups, the percentages of water and dry matter in the contents were statistically indistinguishable at the $P = 0.05$ level. However, there was a tendency for the digestive tract contents of the Soviet Diet animals to display a somewhat greater proportion of water and lesser proportion of dry matter, at the $P = 0.068$ level.

DISCUSSION

It is evident that substitution of the Soviet semi-purified paste diet for a standard laboratory animal diet resulted in a significant reduction in growth rate and change in body composition of young rats. Fig. 1 indicates that the effect on rate of gain in total body mass occurred during the first 2 weeks on the paste diet regimen, and that the normal rate was seemingly restored after that. However, examination of body composition after 5 weeks on the paste diet revealed that substantially greater quantities of body fat were present in the Soviet Diet rats, while the fat-free body mass was considerably less than that of the Control Diet animals. Thus, consideration of the accretion rate of total body mass alone, without consideration of body fat accretion rate, does not yield information on the growth rate of the fat-free body mass.

The present study was restricted to an examination of body composition in the animal subjects at only one point; namely, after the Soviet Diet animals had been on the paste diet for 5 weeks. Therefore, detailed appraisal of the effect of the paste diet on the dynamics of the growth rate cannot be made. However, our study does show that a relatively rapid, major perturbation in gross body composition of the Soviet Diet animals occurred as a result of the paste diet regimen.

Fig. 2 summarizes the percentage differences of the Soviet Diet mean values from the corresponding Control Diet mean values for the various body composition parameters measured. It may be seen that the Soviet Diet rats contained about 50% more body fat and exhibited a fat-free body mass about 16% less than did the Control Diet animals. Furthermore, it seems clear from the data in Fig. 3 that there was little to no difference in the fractional composition of the fat-free body mass between the two groups.

At the same time, as shown in Table 20, the metabolic rate of the Soviet Diet rats was about 13% higher than that of the Control Diet rats. The metabolic intensity on a unit total body mass basis was about 25% higher in the Soviet Diet animals, and on a unit fat-free body mass basis it was about 35% higher.

Fig. 4 summarizes the major differences between the Soviet Diet rats and the Control Diet rats after 5 weeks on the paste diet. The Soviet Diet animals were smaller, but had a greater body fat content and displayed a distinctly higher metabolic rate.

The physiological implications of these anomalous findings are not altogether clear. The greater obesity of the Soviet Diet rats would seem to indicate that 40 g of the paste diet daily provides more than enough calories for the animals. However, their smaller fat-free body mass suggests the possibility of either the presence of a toxicant of some kind or a nutritional imbalance in the diet.

As shown in Table 22, the Soviet paste diet contains 0.5% sorbic acid as a preservative. The LD_{50} of sorbic acid for rats is 7.36 g/kg body mass (18), so that 1.4 g of sorbic acid would represent the LD_{50} for rats with a total body mass of 188.2 g, the mean value for the Soviet Diet rats at the start of the paste diet regimen. The daily ration of 40 g of paste diet contained 0.2 g of sorbic acid, or 14% of the LD_{50}. It is possible, although not highly probable, that such a level of sorbic acid might have a perturbing metabolic effect leading to the differences observed in the Soviet Diet rats. No other potential toxicants were known to be present in the paste diet.

The likelihood of a nutrient deficiency can be explored by examination of the data in Table 24. Zinc and copper contents of the Soviet paste diet were somewhat low; however, the probability of an immediate effect within the first week on a diet deficient in these trace elements is quite small. Similarly, the slight deficiencies in vitamin A and choline contents of the Soviet paste diet could not reasonably be expected to manifest themselves in such a short time. Furthermore, in all these cases the inhibitory effects of a deficiency on general body growth would be progressive, and would not result in a body mass gain curve of the type seen in Fig. 1.

On the other hand, the deficiencies in arginine and methionine contents on the diet indicated in Table 24, together with the fact that the lysine content was almost double the daily requirement might account for some of the differences observed between the Soviet Diet and Control Diet rats. Jones et al. (10) showed that the addition of lysine to an 18% casein diet caused graded depressions in growth rate, which could be corrected by the addition of arginine. More recently, Hevia et al. (8) have shown that young rats given a high lysine diet for 2 weeks were smaller than controls and developed fatty livers, and that the effect could be overcome to a significant extent by adding extra arginine or methionine to the diet. Thus, it appears that the arginine/lysine and methionine/lysine ratios in the diet may be of considerable importance in determining the characteristics of fat and protein metabolism in the growing rat, and consequently of body composition.

From Table 24 it may be computed that the arginine/lysine ratio in the Soviet paste diet was 0.42 and the methionine/lysine ratio was 0.35. In contrast, the arginine/lysine ratio in the Simonsen control diet was 1.44 and the methionine/lysine ratio was 0.86. Comparison of these values with the NRC recommendations of an arginine/lysine ratio of 0.80 and a methionine/lysine ratio of 0.86 makes it abundantly evident that both ratios are quite low in the Soviet paste diet.

Another feature of the Soviet paste diet, as noted earlier, is the use of sucrose and cornstarch in a ratio of 2.2 to 1 as the source of carbohydrate.

It has been known for a number of years that sucrose is more lipogenic than dextrose when used in semi-purified diets. Feyder in 1935 (2) showed that young rats fed isocalorically for 15 to 29 weeks accumulated 73% more body fat when sucrose was the carbohydrate than when dextrose was given. At the same time, the sucrose-fed rats had a 9% greater fat-free body mass, so that total body mass of the sucrose-fed rats was 15% greater than that of the dextrose-fed animals. Similar results were obtained by Lamb in 1950 (12).

In 1953 Harper and Katayama (4) reported that young rats on a low protein semi-purified diet grew better when cornstarch was the carbohydrate source than when sucrose was used. In a second paper in that year Harper et al. (5) showed that sucrose-fed rats not only did not grow as well as corstarch-fed rats, but had higher liver fat contents.

More recently, Winnie et al. (19) showed that the inguinal, genital and perirenal-retroperitoneal fat pads of young rats on semi-purified diets containing cornstarch, dextrose, or fructose weighed about double the fat pads from control rats fed a standard grain ration, and that the fat pads from rats fed a sucrose semi-purified ration were 3 times as large as those from the grain ration animals. They also found that the liver fat content for the grain ration animals was 1/3 to 2/3 that measured in the semi-purified ration animals.

A third feature of the Soviet paste diet, typical of most semi-purified diets, is the absence of fiber. This is in contrast to the substantial fiber content of the Simonsen control diet. There is evidence (9) that the presence of dietary fiber slows the rate of absorption of carbohydrate from the digestive tract, particularly when it is intimately mixed with the carbohydrate as in natural grains. The result is a flattening of the postprandial glycemia, and it has been hypothesized that the lipogenic action of the accompanying release of insulin is thereby abated with a resultant decrease in fat deposition (6).

Thus, it is evident that both the relative amino acid composition of the diet and the type of carbohydrate in the diet can produce perturbations in total body composition of young, growing rats. Furthermore, it appears that the combination of low arginine/lysine and methionine/lysine ratios, the use of sucrose as the principal carbohydrate, and the absence of dietary fiber in the Soviet paste diet could well account for the higher body fat content and lower fat-free body mass of the Soviet Diet rats as compared to the Control Diet rats fed a standard grain ration.

Besides the differences in body composition between the two groups of animals, the Soviet Diet rats displayed a significantly higher metabolic rate than did the Control Diet rats. As seen in Table 20, despite their smaller body size the metabolic rate of the Soviet Diet animals was 13% higher than that of the Control Diet animals.

A possible explanation for this finding is that the Soviet Diet animals were more active physically than the Control Diet rats, perhaps because their appetite was not fully satisfied by the 40 g daily of the paste diet. However, as shown in Table 24, 40 g of the paste diet provided 60.1 kcal of digestible energy, or about 5% more than the NRC daily requirement. Furthermore, a behavioral difference between the two groups while in the metabolic chambers was not discerned.

Another possible explanation might lie in differences in the manner in which the food energy of the two diets was utilized. The caloric equivalent of the growth increments, primarily comprising added body fat and body protein, in the two groups of animals may be approximated for the 35-day experimental feeding period. If it is assumed that the 45-day-old rats at the start of the period contained 9% body fat and that 20% of the fat-free body mass was protein, reasonable values based on other body composition studies on rats of comparable age, the initial mean body composition for the two groups may be computed from the mean body masses at age 45 days given in Table 1. The final mean body masses and mean body fat masses for the two groups are found in Table 9, and the final mean body protein masses are given in Table 15. The mass increments for body fat and body protein during the 35-day feeding period are then obtained as the difference between final and initial masses. The caloric equivalents are calculated on the basis that 1 g of fat is equivalent to 9.3 kilocalories and 1 g of protein is equivalent to 4.1 kilocalories. These computations for the two groups of rats are summarized in Table 26.

Table 26. Caloric equivalents of the growth increments for the Control Diet rats and the Soviet Diet rats during the 35-day experimental feeding period.

	Initial Mass (g)	Final Mass (g)	Growth Increment Mass (g)	Growth Increment Caloric (kcal)
Control Diet Rats				
Body Fat	16.4	37.1	20.7	192.5
Body Protein	33.1	62.3	29.2	119.7
Total Body	181.8	367.3	185.5	312.2
Soviet Diet Rats				
Body Fat	16.9	56.4	39.5	367.4
Body Protein	34.3	52.5	18.2	74.6
Total Body	188.2	330.9	142.7	442.0

The dietary and caloric intakes for the two groups during the 35-day experimental feeding period may be calculated from the data given in Table 24, and as shown in Table 27 it is evident that the Soviet paste diet provided less protein and more fat than did the control diet.

Table 27. Dietary and caloric intakes by the Control Diet rats and the Soviet Diet rats during the 35-day experimental feeding period.

	Control Diet (g)	Control Diet (kcal)	Soviet Diet (g)	Soviet Diet (kcal)
Protein	133.4	533.6	108.2	432.8
Fat	31.3	281.7	54.9	494.1
Carbohydrate	295.8	1,183.2	294.3	1,177.2
Total Digestible Energy		1,998.5		2,104.1

From the caloric data in Tables 26 and 27 the classical gross energetic efficiency of the growth increment may be calculated as

$$\text{Growth efficiency} = \frac{100 \times \text{kcal growth increment}}{\text{kcal diet}}$$

For the Control Diet rats

$$\text{Growth efficiency} = \frac{100 \times 312.2 \text{ kcal}}{1{,}998.5 \text{ kcal}} = 15.6\%$$

For the Soviet Diet rats

$$\text{Growth efficiency} = \frac{100 \times 442.0 \text{ kcal}}{2{,}104.1 \text{ kcal}} = 21.0\%$$

The growth efficiency computed for the Control Diet animals is closely comparable to that cited for growing rats by Brody (1), whereas that for the Soviet Diet rats is exceptionally high.

Some of the higher efficiency of the Soviet paste diet may be a consequence of its greater fat content and the use of sucrose as a source of dietary carbohydrate. However, in all likelihood, another factor is the possible use of dietary protein to form body fat.

The conversion efficiency of dietary protein into body protein growth increment for the Control Diet rats during the 35-day feeding period is given by

$$\frac{29.2 \text{ g body protein increment}}{133.4 \text{ g dietary protein}} = 0.219 \text{ g body protein/g dietary protein}$$

The apparent conversion efficiency for the Soviet Diet rats during the same period is given by

$$\frac{18.2 \text{ g body protein increment}}{108.2 \text{ g dietary protein}} = 0.168 \text{ g body protein/g dietary protein}$$

However, it is unlikely that the actual conversion efficiency for dietary protein into body protein was different in the Soviet Diet rats from that in the Control Diet animals. Thus, if the conversion efficiency computed for the Control Diet rats is applied to the body protein growth increment of the Soviet Diet animals

$$\frac{18.2 \text{ g body protein increment}}{0.219 \text{ body protein/g dietary protein}} = 83.1 \text{ g dietary protein}$$

it is seen that only 83.1 g of the 108.2 g of dietary protein consumed by the Soviet Diet rats were used for body protein production, and that the remaining 25.1 g, or 100.4 kcal, of dietary protein were used for body fat production.

The heat released in the two groups of rats during the 35-day experimental feeding period can be estimated as indicated in Table 28 from the mean body mass during the period, which may be computed from the initial and final body masses shown in Table 26, and from the end metabolic intensity values shown in Table 20.

Table 28. Total metabolic activity of the Control Diet rats and the Soviet Diet rats during the 35-day experimental feeding period.

	Control Diet Rats	Soviet Diet Rats	Soviet-Control Difference
Mean Body Mass, kg	0.2746	0.2596	
End Metabolic Intensity, kcal/hr/kg TBM	4.08	5.11	
Total Metabolic Activity, kcal/35 days	944.1	1,114.3	170.2

Thus, the Soviet Diet rats produced 170.2 kcal more heat than did the Control Diet rats during the 35-day experimental period.

Kleiber (11) gives the partial efficiency for the synthesis of body fat from dietary carbohydrate and fat as 56%, while the partial efficiency for the synthesis of body fat from dietary protein is only 37%. Therefore, if it is assumed that the bulk of the body fat growth increment of the Control Diet rats shown in Table 26 was derived from dietary carbohydrate and fat, then 20.7 g x 9 kcal/g ÷ 0.56 = 332.7 kcal of dietary energy that was required. However, the fat itself represented 20.7 g x 9 kcal/g = 186.3 kcal of stored energy, so that the difference, 332.7 kcal - 186.3 kcal = 146.4 kcal, was the thermal increment for fat production in the Control Diet rats during the 35-day feeding period.

From Table 26 it is seen that the Soviet Diet rats laid down 39.5 g of body fat during the 35-day period. However, as developed earlier, part of this came from the utilization of 25.1 g of dietary protein. Thus, 100.4 kcal of dietary protein energy was converted to body fat energy with a partial efficiency of 37%, resulting in the deposition of 100.4 kcal x 0.37 = 40.7 kcal equivalent of fat, or 40.7 kcal/9 kcal/g = 4.5 g of body fat growth increment from dietary protein. Also, the thermal increment for fat production from dietary protein was 100.4 kcal - 40.7 kcal = 59.7 kcal.

Of the total body fat growth increment of 39.5 g, 4.5 g came from dietary protein, leaving 35.0 g of fat that was produced from dietary carbohydrate and fat. For this fat synthesis, 35.0 g x 9 kcal/g + 0.56 = 562.5 kcal of dietary energy was required. However, the fat itself represented 35.0 g x 9 kcal = 315.0 kcal of stored energy, so that the difference, 562.5 kcal - 315.0 kcal = 247.5 kcal, was the thermal increment for fat production from dietary carbohydrate and fat.

The total thermal increment for fat production in the Soviet Diet rats during the 35-day period was the sum of that from dietary protein, 59.7 kcal, and from dietary carbohydrate and fat, 247.5 kcal, or 307.2 kcal. The total thermal increment for fat production in the Control Diet rats computed above was 146.4 kcal during the same period. Hence, the Soviet Diet rats produced 307.2 kcal - 146.4 kcal = 160.8 kcal more heat than did the Control Diet rats.

Inasmuch as the metabolic heat production of the Soviet Diet animals was computed to be 170.2 kcal more than the Control Diet animals from the respiratory gas exchange measurements, and 160.8 kcal more from the dietary and body composition data, it may be concluded that the bulk of the difference in metabolic rate between the two groups is ascribable to the caloric efficiencies associated with fat deposition in the two groups of animals. Admittedly, this conclusion involves the several assumptions made in the foregoing computations, and should be verified by a properly designed metabolic energy balance study. However, it affords a plausible working hypothesis to account for the striking difference observed in metabolic rate between the Control Diet rats and the Soviet Diet rats.

The overall results of the present study point up the importance of rigorous control of the dietary regimen for animals to be used as experimental subjects in spaceflight research. In the case of the Cosmos experiments, a good measure of control was provided by the incorporation of ground, or "synchronous" control animals. However, it is not clear to what extent the results obtained in the studies represent the metabolic effects of weightlessness on nutritionally perturbed animals, as opposed to what the results might have been on animals subsisting on a more traditional diet. Only experimentation in future spaceflights can answer this question.

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REFERENCES

1. Brody, S. Bioenergetics and Growth. New York: Reinhold, 1945, p. 51.

2. Feyder, S. Fat formation from sucrose and glucose. J. Nutr., 9: 457-466, 1935.

3. Grindeland, R. E., S. H. Yang, L. Madsen and L. C. Keil. Comparison of Russian flight diet and Wayne diet on growth and growth hormone concentrations of Wistar-derived and Simonsen albino rats. NASA Ames Research Center Internal Report, December 1976.

4. Harper, A. E. and M. C. Katayama. The influence of various carbohydrates on the utilization of low protein rations by the white rat. I. Comparison of sucrose and cornstarch in 9% casein rations. J. Nutr., 49: 261-275, 1953.

5. Harper, A. E., W. J. Monson, D. A. Arata, D. A. Benton and C. A. Elvehjem. Influence of various carbohydrates on the utilization of low protein rations by the white rat. II. Comparison of several proteins and carbohydrates. Growth and liver fat. J. Nutr., 51: 523-537, 1953.

6. Heaton, K. W. Food intake regulation and fiber. In: Medical Aspects of Dietary Fiber. G. A. Spiller and R. M. Kay, editors. New York: Plenum, pp. 223-238, 1980.

7. Heinrich, M. R. Analysis of the Soviet flight diet. NASA Ames Research Center letter LB: 236-5 to Cosmos 1129 distribution, dated 14 July 1980.

8. Hevia, P., E. A. Ulman, F. W. Kari and W. J. Visek. Serum lipids of rats fed excess L-lysine and different carbohydrates. J. Nutr., 110: 1231-1239, 1980.

9. Jenkins, D. J. A. Dietary fiber and carbohydrate metabolism. In: Medical Aspects of Dietary Fiber. G. A. Spiller and R. M. Kay, editors. New York: Plenum, pp. 175-192, 1980.

10. Jones, J. D., R. Wolters and P. C. Burnett. Lysine-arginine-electrolyte relationships in the rat. J. Nutr., 89: 171-188, 1966.

11. Kleiber, M. The Fire of Life. New York: Wiley, 1961, p. 315.

12. Lamb, A. R. On the relative nutritional efficiency of sucrose and glucose in the albino rat. J. Nutr., 41: 545-554, 1950.

13. National Research Council. Subcommittee on Laboratory Animal Nutrition. Nutrient Requirements of Laboratory Animals. 3rd revised edition. National Academy of Sciences, Washington, D.C., pp. 7-37, 1978.

14. Pace, N., D. F. Rahlmann and A. H. Smith. Methodology for Estimation of Total Body Composition in Laboratory Mammals. Report No. EPL 79-1. Environmental Physiology Laboratory, University of California, Berkeley, pp. 1-41, 1979.

15. Rosenzweig, S. N. and K. A. Souza, eds. Final Reports of the U.S. Experiments Flown on the Soviet Satellite Cosmos 782. NASA Technical Memorandum 78525. NASA Ames Research Center, Moffett Field, California, pp. 1-409, 1978.

16. Rosenzweig, S. N. and K. A. Souza, eds. Final Reports of U.S. Experiments Flown on the Soviet Satellite Cosmos 936. NASA Technical Memorandum 78526. NASA Ames Research Center, Moffett Field, California, p. 1-289, 1978.

17. Snedecor, G. W. and W. G. Cochran. Statistical Methods, 6th edition. Ames: University of Iowa, pp. 102-103, 1967.

18. Windholz, M., S. Budavari, L. Y. Stroumsos and M. N. Fertig, editors. The Merck Index, 9th edition. Rahway, New Jersey: Merk & Co,, Inc., p. 1126, 1976.

19. Winnie, G., R. Schemmel, E. Rand, O. Mickelsen and G. A. Leveille. Effects of high carbohydrate diets on lipid accumulation in the rat. Am. J. Clin. Nutr., 26(7): xx (abstracts), 1973.

Table 1. Total body mass, in grams, of the 6 Control Diet Rats and the 6 Soviet Diet rats at weekly intervals during the 6-week experimental period. Daily feeding of 40 g of the Soviet Paste Flight Diet (S) to the Soviet Diet rats began on 23 May. The Control Diet rats received a standard Control Diet (C) *ad libitum* throughout.

Date	Diet	Age (d)	Animal Number 1	2	3	4	5	6	Mean	S.D.	C.V.
Control Diet Rats											
17 May	C	39	150	133	152	145	137	136	142.2	7.9	5.6
23 May	C	45	184	176	190	184	175	182	181.8	5.6	3.1
30 May	C	52	240	228	242	246	245	230	238.5	7.7	3.2
6 Jun	C	59	282	263	301	304	303	274	287.8	17.4	6.0
13 Jun	C	66	313	287	342	338	334	296	318.3	23.2	7.3
20 Jun	C	73	337	311	376	365	362	326	346.2	25.4	7.3
27 Jun	C	80	357	322	400	393	381	347	366.7	30.0	8.2
Soviet Diet Rats											
17 May	C	39	144	139	154	144	144	140	144.2	5.3	3.7
23 May	C	45	176	186	198	186	193	190	188.2	7.5	4.0
30 May	S	52	202	207	217	207	213	201	207.8	6.2	3.0
6 Jun	S	59	235	241	250	238	249	233	241.0	7.1	3.0
13 Jun	S	66	269	276	286	271	286	258	274.3	10.8	3.9
20 Jun	S	73	297	308	317	297	308	279	301.0	13.2	4.4
27 Jun	S	80	313	334	369	323	342	304	330.8	23.2	7.0

Table 2. Daily and weekly consumption, in grams, of Soviet Paste Flight Diet by the 6 Soviet Diet rats during the 5-week experimental feeding period.

Date	Animal Number 1	2	3	4	5	6	Mean	S.D.	C.V.
23-24 May 79	39	32	39	34	22	31	32.8		
24-25	40	40	39	39	37	40	39.2		
25-26	39	39	39	39	40	39	39.2		
26-27	40	40	40	39	40	40	39.8		
27-28	30	40	40	40	39	40	38.2		
28-29	40	40	40	40	40	40	40.0		
29-30 May	40	40	40	40	40	40	40.0		
23-30 May	268	271	277	271	258	270	269.2	6.2	2.3
30-31 May	40	40	40	40	40	40	40.0		
31 May-1 Jun	40	40	40	40	40	40	40.0		
1-2	40	40	39	40	39	39	39.5		
2-3	40	40	40	40	40	40	40.0		
3-4	40	40	40	40	40	40	40.0		
4-5	40	40	40	40	40	40	40.0		
5-6 Jun	40	40	40	40	40	40	40.0		
30 May-6 Jun	280	280	279	280	279	279	279.5	0.5	0.2
6-7 Jun	40	40	40	40	40	40	40.0		
7-8	40	40	40	38	40	40	39.7		
8-9	39	40	40	40	40	40	39.8		
9-10	40	40	39	40	39	40	39.7		
10-11	40	40	40	40	40	40	40.0		
11-12	40	40	40	40	40	40	40.0		
12-13 Jun	40	40	40	40	40	40	40.0		
6-13 Jun	279	280	279	278	279	280	279.2	0.8	0.3
13-14 Jun	40	40	40	40	40	40	40.0		
14-15	40	40	40	40	40	40	40.0		
15-16	40	40	39	38	39	40	39.3		
16-17	40	40	40	40	40	40	40.0		
17-18	40	40	40	40	40	40	40.0		
18-19	40	40	40	40	40	40	40.0		
19-20 Jun	40	40	40	40	40	40	40.0		
13-20 Jun	280	280	279	278	279	280	279.3	0.8	0.3
20-21 Jun	40	40	40	40	40	40	40.0		
21-22	40	40	40	40	40	40	40.0		
22-23	39	39	40	40	40	40	39.7		
23-24	37	40	40	40	40	40	39.5		
24-25	35	40	40	40	40	40	39.2		
25-26	40	40	40	40	40	40	40.0		
26-27 Jun	28	40	40	40	40	40	38.0		
20-27 Jun	259	279	280	280	280	280	276.3	8.5	3.1

Table 3. Mean total body mass differences at weekly intervals between the Soviet Diet rats and the Control Diet rats, and the probability, P, that the means are statistically the same. The vertical arrows indicate the mean masses that are significantly different at the 0.05 level, and the direction of the arrow indicates whether the Soviet Diet values are lower (↓) or higher (↑) than the Control Diet values. Feeding of the paste diet started on 23 May 1979.

Date		Soviet Diet Mean (g)	C.V.	Control Diet Mean (g)	C.V.	Difference Col.2 - Col.4 (g)	(%)	P
17 May 1979		144.2	3.7	142.2	5.6	+ 2.0	+ 1.4	0.62
23 May		188.2	4.0	181.8	3.1	+ 6.4	+ 3.5	0.13
30 May	↓	207.8	3.0	238.5	3.2	-30.7	-12.9	<0.001
6 Jun	↓	241.0	3.0	287.8	6.0	-46.8	-16.3	<0.001
13 Jun	↓	274.3	3.9	318.3	7.3	-44.0	-13.8	0.002
20 Jun	↓	301.0	4.4	346.2	7.3	-45.2	-13.0	0.003
27 Jun	↓	330.8	7.0	366.7	8.2	-35.9	- 9.8	0.043

Table 4. Organ system masses in grams of 6 Control Diet rats at age 82 days on 29 June.

Organ System	Animal Number 1	2	3	4	5	6	Mean	S.D.	C.V.
Skin	58.81	52.58	61.41	65.50	64.77	53.93	59.50	5.42	9.1
Liver	16.86	15.77	20.69	18.58	18.24	15.98	17.69	1.87	10.5
Digestive Tract	10.65	11.37	13.55	13.56	12.77	10.12	12.00	1.50	12.5
Genitalia	11.71	11.22	12.33	12.07	13.47	11.59	12.07	0.79	6.5
Abdominal Fat	3.64	6.79	5.93	10.11	8.35	2.53	6.22	2.84	45.6
Kidneys	3.25	2.99	4.24	3.57	3.67	3.05	3.46	0.47	13.5
Neck Glands	2.04	1.77	2.34	2.52	2.75	2.28	2.28	0.35	15.2
Brain	1.99	2.00	1.84	1.91	1.93	1.87	1.92	0.06	3.3
Respiratory Tract	1.95	1.92	2.07	1.69	2.48	1.96	2.01	0.26	13.0
Heart	1.07	0.98	1.27	1.06	1.10	1.09	1.10	0.10	8.7
Spleen	0.62	0.51	0.83	0.74	0.67	0.64	0.67	0.11	16.3
Bladder	0.12	0.10	0.12	0.10	0.08	0.13	0.11	0.02	16.9
Adrenals	0.071	0.075	0.066	0.075	0.096	0.074	0.076	0.010	13.5
Thyroid	0.022	0.017	0.029	0.032	0.023	0.026	0.025	0.005	21.5
Viscera	53.99	55.51	65.30	66.01	65.62	51.34	59.63	6.73	11.3
Carcass	194.31	180.28	221.29	209.91	198.19	196.65	200.11	14.05	7.0
Blood	23.12	21.70	26.19	25.70	24.73	22.72	24.02	1.78	7.4
Net Body Mass	330.23	310.07	374.19	367.12	353.31	324.64	343.26	25.48	7.4
Hair	6.57	5.52	6.63	6.48	6.50	5.33	6.17	0.58	9.5
Gut Contents	23.94	18.19	18.19	17.75	12.62	16.32	17.84	3.66	20.5
Subtotal	30.51	23.71	24.82	24.23	19.12	21.65	24.01	3.81	15.9
Total Body Mass	360.74	333.78	399.01	391.35	372.43	346.29	367.27	25.37	6.9

Table 5. Organ system masses in grams of 6 Soviet Diet rats at age 80 days on 27 June.

	Animal Number								
Organ System	1	2	3	4	5	6	Mean	S.D.	C.V.
Skin	59.11	58.53	59.97	52.19	54.10	54.79	56.45	3.17	5.6
Liver	13.42	16.19	18.14	15.13	17.67	15.36	15.98	1.75	10.9
Digestive Tract	10.60	11.87	11.41	11.44	14.50	12.13	11.99	1.33	11.1
Genitalia	9.98	9.70	10.22	11.64	11.80	9.77	10.52	0.95	9.0
Abdominal Fat	10.39	8.62	7.38	6.59	8.09	11.07	8.69	1.73	20.0
Kidneys	2.34	2.63	3.26	3.00	2.88	2.45	2.76	0.35	12.7
Neck Glands	1.68	1.92	1.92	2.32	2.04	2.13	2.00	0.22	10.9
Brain	1.87	1.83	1.60	1.67	1.75	1.95	1.78	0.13	7.3
Respiratory Tract	1.74	1.56	1.84	1.94	1.70	1.51	1.72	0.16	9.5
Heart	0.84	1.25	1.08	1.06	0.99	0.92	1.02	0.14	13.9
Spleen	0.60	0.50	0.69	0.60	0.43	0.45	0.54	0.10	18.6
Bladder	0.11	0.08	0.13	0.13	0.19	0.12	0.13	0.04	28.5
Adrenals	0.038	0.072	0.091	0.068	0.054	0.096	0.070	0.022	31.4
Thyroid	0.013	0.026	0.021	0.019	0.013	0.025	0.020	0.006	29.0
Viscera	53.62	56.24	57.78	55.61	62.10	57.98	57.22	2.87	5.0
Carcass	169.20	181.61	189.45	181.20	185.75	158.31	177.59	11.65	6.6
Blood	21.22	22.31	23.12	21.75	22.73	20.40	21.92	1.01	4.6
Net Body Mass	303.15	318.69	330.32	310.75	324.68	291.48	313.18	14.38	4.6
Hair	5.15	5.83	6.29	4.89	4.99	4.71	5.31	0.62	11.6
Gut Contents	4.66	9.92	32.37	7.53	12.19	7.56	12.37	10.12	81.8
Subtotal	9.81	15.75	38.66	12.42	17.18	12.27	17.68	10.61	60.0
Total Body Mass	312.96	334.44	368.98	323.17	341.86	303.75	330.86	23.24	7.0

Table 6. Organ system mean mass differences between the Soviet Diet rats and the Control Diet rats, and the probability, P, that the means are statistically the same. The vertical arrows indicate the mean masses that are significantly different at the 0.05 level, and the direction of the arrow indicates whether the Soviet Diet values are lower (↓) or higher (↑) than the Control Diet Values.

Organ System	Soviet Diet Mean (g)	Soviet Diet C.V.	Control Diet Mean (g)	Control Diet C.V.	Difference Col. 2 - Col. 4 (g)	Difference (%)	P
Skin	56.45	5.6	59.50	9.1	- 3.05	- 5.1	0.26
Liver	15.98	10.9	17.69	10.5	- 1.69	- 9.6	0.13
Digestive Tract	11.99	11.1	12.00	12.5	- 0.01	- 0.1	0.99
Genitalia	↓ 10.52	9.0	12.07	6.5	- 1.55	-12.8	0.012
Abdominal Fat	8.69	20.0	6.22	45.6	+ 2.47	+39.6	0.10
Kidneys	↓ 2.76	12.7	3.46	13.5	- 0.70	-20.3	0.015
Neck Glands	2.00	10.9	2.28	15.2	- 0.28	-12.3	0.12
Brain	↓ 1.78	7.3	1.92	3.3	- 0.14	- 7.5	0.034
Respiratory Tract	↓ 1.72	9.5	2.01	13.0	- 0.29	-14.7	0.040
Heart	1.02	13.9	1.10	8.7	- 0.08	- 6.5	0.33
Spleen	0.54	18.6	0.67	16.3	- 0.13	-18.5	0.070
Bladder	0.13	28.5	0.11	16.9	+ 0.02	+16.9	0.29
Adrenals	0.070	31.4	0.076	13.5	- 0.006	- 8.3	0.54
Thyroid	0.020	29.0	0.025	21.5	- 0.005	-21.5	0.12
Viscera	57.22	5.0	59.63	11.3	- 2.41	- 4.0	0.44
Carcass	↓ 177.59	6.6	200.11	7.0	-22.52	-11.3	0.013
Blood	↓ 21.92	4.6	24.02	7.4	- 2.10	- 8.8	0.031
Net Body Mass	↓ 313.18	4.6	343.26	7.4	-30.08	- 8.8	0.030
Hair	↓ 5.31	11.6	6.17	9.5	- 0.86	-14.0	0.032
Gut Contents	12.37	81.8	17.84	20.5	- 5.47	-30.6	0.24
Subtotal	17.68	60.0	24.01	15.9	- 6.33	-26.3	0.20
Total Body Mass	↓ 330.86	7.0	367.27	6.9	-36.41	- 9.9	0.027

Table 7. Water, fat, and fat-free masses, in grams, of the major body components of the 6 Control Diet rats.

Component	Animal Number 1	2	3	4	5	6	Mean	S.D.	C.V.
Carcass									
Wet Mass	194.31	180.28	221.29	209.91	198.19	196.65	200.11	14.05	7.0
Dry Mass	63.08	60.64	73.45	74.82	66.36	60.80	66.52	6.26	9.4
Water Mass	131.23	119.64	147.84	135.09	131.83	135.85	133.59	9.10	6.8
Fat Mass	10.69	12.93	14.14	20.01	13.64	7.70	13.18	4.10	31.1
Fat-Free Mass	183.62	167.35	207.15	189.90	184.55	188.95	186.93	12.82	6.9
Dry Fat-Free Mass	52.39	47.71	59.31	54.81	52.72	53.10	53.34	3.76	7.1
Viscera									
Wet Mass	53.99	55.51	65.30	66.01	65.62	51.34	59.63	6.73	11.3
Dry Mass	19.64	23.40	26.14	30.08	28.77	17.68	24.29	4.96	20.4
Water Mass	34.35	32.11	39.16	35.93	36.85	33.66	35.34	2.51	7.1
Fat	9.34	12.87	13.50	17.53	16.71	6.50	12.74	4.24	33.3
Fat-Free Mass	44.65	42.64	51.80	48.48	48.91	44.84	46.89	3.41	7.3
Dry Fat-Free Mass	10.30	10.53	12.64	12.55	12.06	11.18	11.55	1.02	8.8
Skin									
Wet Mass	58.81	52.58	61.41	65.50	64.77	53.93	59.50	5.42	9.1
Dry Mass	23.96	21.99	25.22	31.56	28.74	19.49	25.16	4.41	17.5
Water Mass	34.85	30.59	36.19	33.94	36.03	34.44	34.34	2.04	5.9
Fat Mass	9.72	9.78	10.30	17.31	14.00	5.71	11.14	4.01	36.0
Fat-Free Mass	49.09	42.80	51.11	48.19	50.77	48.22	48.36	3.00	6.2
Dry Fat-Free Mass	14.24	12.21	14.92	14.25	14.74	13.78	14.02	0.98	7.0
Blood	23.12	21.70	26.19	25.70	24.73	22.72	24.02	1.78	7.4
Net Body									
Wet Mass	330.23	310.07	374.19	367.12	353.31	324.64	343.26	25.48	7.4
Dry Mass	106.68	106.03	124.81	136.46	123.87	97.97	115.97	14.63	12.6
Water Mass	223.55	204.04	249.38	230.66	229.44	226.67	227.29	14.55	6.4
Fat Mass	29.75	35.58	37.94	54.85	44.35	19.91	37.06	12.00	32.4
Fat-Free Mass	300.48	274.49	336.25	312.27	308.96	304.73	306.20	19.94	6.5
Dry Fat-Free Mass	76.93	70.45	86.87	81.61	79.52	78.06	78.91	5.43	6.9

Table 8. Water, fat, and fat-free masses, in grams, of the major body components of the 6 Soviet Diet rats.

Component	Animal Number 1	2	3	4	5	6	Mean	S.D.	C.V.
Carcass									
Wet Mass	169.20	181.61	189.45	181.20	185.75	158.31	177.59	11.65	6.6
Dry Mass	66.28	68.75	65.37	63.42	72.13	66.45	67.07	3.02	4.5
Water Mass	102.92	112.86	124.08	117.78	113.62	91.86	110.52	11.47	10.4
Fat Mass	24.76	22.60	15.70	16.16	25.21	27.48	21.99	4.94	22.5
Fat-Free Mass	144.44	159.01	173.75	165.04	160.54	130.83	155.60	15.44	9.9
Dry Fat-Free Mass	41.52	46.15	49.67	47.26	46.92	38.97	45.08	4.01	8.9
Viscera									
Wet Mass	53.62	56.24	57.78	55.61	62.10	57.98	57.22	2.87	5.0
Dry Mass	26.91	26.35	23.88	23.99	30.78	29.03	26.82	2.74	10.2
Water Mass	26.71	29.89	33.90	31.62	31.32	28.95	30.40	2.47	8.1
Fat Mass	18.73	16.87	13.97	14.51	20.94	20.42	17.57	2.95	16.8
Fat-Free Mass	34.89	39.37	43.81	41.10	41.16	37.56	39.65	3.12	7.9
Dry Fat-Free Mass	8.18	9.48	9.91	9.48	9.84	8.61	9.25	0.70	7.6
Skin									
Wet Mass	59.11	58.53	59.97	52.19	54.10	54.79	56.45	3.17	5.6
Dry Mass	31.87	28.34	27.36	24.36	27.95	30.56	28.41	2.62	9.2
Water Mass	27.24	30.19	32.61	27.83	26.15	24.23	28.04	2.98	10.6
Fat Mass	20.31	16.16	14.05	13.29	16.83	20.47	16.85	3.04	18.0
Fat-Free Mass	38.80	42.37	45.92	38.90	37.27	34.32	39.60	4.05	10.2
Dry Fat-Free Mass	11.56	12.18	13.31	11.07	11.12	10.09	11.56	1.10	9.5
Blood	21.22	22.31	23.12	21.75	22.73	20.40	21.92	1.01	4.6
Net Body									
Wet Mass	303.15	318.69	330.32	310.75	324.68	291.48	313.18	14.38	4.6
Dry Mass	125.06	123.44	116.61	111.77	130.86	126.04	122.30	6.92	5.7
Water Mass	178.09	195.25	213.71	198.98	193.82	165.44	190.88	16.88	8.8
Fat Mass	63.80	55.63	43.72	43.96	62.98	68.37	56.41	10.56	18.7
Fat-Free Mass	239.35	263.06	286.60	266.79	261.70	223.11	256.77	22.32	8.7
Dry Fat-Free Mass	61.26	67.81	72.89	67.81	67.88	57.67	65.89	5.47	8.3

Table 9. Fat, fat-free, dry fat-free, and water mean mass differences of the major body components between the Soviet Diet rats and the Control Diet rats, and the probability, P, that the means are statistically the same. The vertical arrows indicate the mean masses that are significantly different at the 0.05 level, and the direction of the arrow indicates whether the Soviet Diet values are lower (↓) or higher (↑) than the Control Diet values.

Component		Soviet Diet Mean (g)	C.V.	Control Diet Mean (g)	C.V.	Difference Col.2 - Col.4 (g)	(%)	P
Start Total Body		188.17	4.0	181.83	3.1	+ 6.34	+ 3.5	0.13
End Total Body	↓	330.86	7.0	367.27	6.9	-36.41	- 9.9	0.027
End Net Body	↓	313.18	4.6	343.26	7.4	-30.08	- 8.8	0.030
Fat:								
Carcass	↑	21.99	22.5	13.18	31.1	+ 8.81	+66.7	0.007
Viscera	↑	17.57	16.8	12.74	33.3	+ 4.83	+37.9	0.045
Skin	↑	16.85	18.0	11.14	36.0	+ 5.71	+51.3	0.019
Body	↑	56.41	18.7	37.06	32.4	+19.35	+52.2	0.014
Fat-Free:								
Carcass	↓	155.60	9.9	186.93	6.9	-31.33	-16.8	0.003
Viscera	↓	39.65	7.9	46.89	7.3	- 7.24	-15.4	0.003
Skin	↓	39.60	10.2	48.36	6.2	- 8.76	-18.1	0.002
Blood	↓	21.92	4.6	24.02	7.4	- 2.10	- 8.8	0.031
Body	↓	256.77	8.7	306.20	6.5	-49.43	-16.1	0.002
Dry Fat-Free:								
Carcass	↓	45.08	8.9	53.34	7.1	- 8.26	-15.5	0.004
Viscera	↓	9.25	7.6	11.55	8.8	- 2.30	-19.9	0.001
Skin	↓	11.56	9.5	14.02	7.0	- 2.46	-17.6	0.002
Body	↓	65.89	8.3	78.91	6.9	-13.02	-16.5	0.002
Water:								
Carcass	↓	110.52	10.4	133.59	6.8	-23.07	-17.3	0.003
Viscera	↓	30.40	8.1	35.34	7.1	- 4.94	-14.0	0.006
Skin	↓	28.04	10.6	34.34	5.9	- 6.30	-18.3	0.002
Blood	↓	21.92	4.6	24.02	7.4	- 2.10	- 8.8	0.030
Body	↓	190.88	8.8	227.29	6.4	-36.41	-16.0	0.003
Intracellular	↓	134.79	9.2	151.82	7.2	-17.03	-11.2	0.030
Extracellular	↓	56.09	9.3	75.47	6.7	-19.38	-25.7	<0.001

Table 10. Fat and water fractions, as per cent, of the major body components of the 6 Control Diet rats.

Fraction	Animal Number 1	2	3	4	5	6	Mean	S.D.	C.V.
[Component Fat/Total Component] x 100									
Carcass	5.5	7.2	6.4	9.5	6.9	3.9	6.6	1.9	28.4
Viscera	17.3	23.2	20.7	26.6	25.5	12.7	21.0	5.3	25.1
Skin	16.5	18.6	16.8	26.4	21.6	10.6	18.4	5.3	28.9
Net Body	9.0	11.5	10.1	14.9	12.6	6.1	10.7	3.0	28.4
[Component Fat/Total Fat] x 100									
Carcass	35.9	36.3	37.3	36.5	30.7	38.7	35.9	2.7	7.6
Viscera	31.4	36.2	35.6	32.0	37.7	32.6	34.2	2.6	7.6
Skin	32.7	27.5	27.1	31.5	31.6	28.7	29.9	2.4	8.0
Net Body	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
[Component Water/Fat-Free Component] x 100									
Carcass	71.5	71.5	71.4	71.1	71.4	71.9	71.5	0.3	0.4
Viscera	76.9	75.3	75.6	74.1	75.3	75.1	75.4	0.9	1.2
Skin	71.0	71.5	70.8	70.4	71.0	71.4	71.0	0.4	0.6
Net Body	74.4	74.3	74.2	73.9	74.3	74.4	74.3	0.2	0.3
[Component Water/Total Water] x 100									
Carcass	58.7	58.7	59.3	58.6	57.5	60.0	58.8	0.8	1.4
Viscera	15.4	15.7	15.7	15.6	16.0	14.8	15.5	0.4	2.6
Skin	15.6	15.0	14.5	14.7	15.7	15.2	15.1	0.5	3.2
Blood	10.3	10.6	10.5	11.1	10.8	10.0	10.6	0.4	3.6
Net Body	100.0	100.0	100.0	100.0	100.0	100.0	100.0		

Table 11. Fat and water fractions, as per cent, of the major body components of the 6 Soviet Diet rats.

Fraction	1	2	3	4	5	6	Mean	S.D.	C.V.
			Animal Number						
[Component Fat/Total Component[x 100									
Carcass	14.6	12.4	8.3	8.9	13.6	17.4	12.5	3.5	27.7
Viscera	34.9	30.0	24.2	26.1	33.7	35.2	30.7	4.7	15.3
Skin	34.4	27.6	23.4	25.5	31.1	37.4	29.9	5.4	18.0
Net Body	21.0	17.5	13.2	14.1	19.4	23.5	18.1	4.0	22.0
[Component Fat/Total Fat] x 100									
Carcass	38.8	40.6	35.9	36.8	40.0	40.2	38.7	1.9	5.0
Viscera	29.4	30.3	32.0	33.0	33.3	29.9	31.3	1.7	5.3
Skin	31.8	29.1	32.1	30.2	26.7	29.9	30.0	2.0	6.6
Net Body	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
[Component Water/Fat-Free Component] x 100									
Carcass	71.3	71.0	71.4	71.4	70.8	70.2	71.0	0.5	0.7
Viscera	76.6	75.9	77.4	76.9	76.1	77.1	76.7	0.6	0.8
Skin	70.2	71.3	71.0	71.5	70.2	70.6	70.8	0.6	0.8
Net Body	74.4	74.2	74.6	74.6	74.1	74.2	74.4	0.2	0.3
[Component Water/Total Water] x 100									
Carcass	57.8	57.8	58.0	59.2	58.6	55.5	57.8	1.3	2.2
Viscera	15.0	15.3	15.9	15.9	16.2	17.5	16.0	0.9	5.5
Skin	15.3	15.5	15.3	14.0	13.5	14.7	14.7	0.8	5.5
Blood	11.9	11.4	10.8	10.9	11.7	12.3	11.5	0.6	5.1
Net Body	100.0	100.0	100.0	100.0	100.0	100.0	100.0		

Table 12. Mean differences between the Soviet Diet rats and the Control Diet rats, and the probability, P, that the means are statistically the same, of fat and water fractions as per cent of the major body components. The vertical arrows indicate the mean percentages that are significantly different at the 0.05 level, and the direction of the arrow indicates whether the Soviet Diet values are lower (↓) or higher (↑) than the Control Diet values.

Fraction	Soviet Diet Mean	Soviet Diet C.V.	Control Diet Mean	Control Diet C.V.	Difference Col.2–Col.4 Mean	Difference Col.2–Col.4 %	P
[Component Fat/Total Component] x 100							
Carcass	↑ 12.5	27.7	6.6	28.4	+ 5.9	+90.9	0.004
Viscera	↑ 30.7	15.3	21.0	25.1	+ 9.7	+46.1	0.007
Skin	↑ 29.9	18.0	18.4	28.9	+11.5	+62.4	0.004
Net Body	↑ 18.1	22.0	10.7	28.4	+ 7.4	+69.3	0.005
[Component Fat/Total Fat] x 100							
Carcass	38.7	5.0	35.9	7.6	+ 2.8	+ 7.8	0.067
Viscera	↓ 31.3	5.3	34.2	7.6	- 2.9	- 8.6	0.042
Skin	30.0	6.6	29.9	8.0	+ 0.1	+ 0.4	0.93
[Component Water/Fat-Free Component] x 100							
Carcass	71.0	0.7	71.5	0.4	- 0.5	- 0.6	0.066
Viscera	↑ 76.7	0.8	75.4	1.2	+ 1.3	+ 1.7	0.015
Skin	70.8	0.8	71.0	0.6	- 0.2	- 0.3	0.46
Net Body	74.4	0.3	74.3	0.3	+ 0.1	+ 0.1	0.41
[Component Water/Total Water] x 100							
Carcass	57.8	2.2	58.8	1.4	- 1.0	- 1.7	0.14
Viscera	16.0	5.5	15.5	2.6	+ 0.5	+ 2.8	0.30
Skin	14.7	5.5	15.1	3.2	- 0.4	- 2.6	0.32
Blood	↑ 11.5	5.1	10.6	3.6	+ 0.9	+ 9.0	0.008

Table 13. Body composition parameters measured or derived by analysis of the dry, fat-free body powder from the 6 Control Diet rats.

Parameter	Animal Number 1	2	3	4	5	6	Mean	S.D.	C.V.
Measured									
Dry Fat-Free Body Mass, g	76.93	70.45	86.87	81.61	79.52	78.06	78.91	5.43	6.9
Nitrogen, mmol/g DFFBM	8.98	9.01	9.26	9.17	8.95	8.71	9.01	0.19	2.1
Body Nitrogen, g	9.68	8.90	11.27	10.49	9.97	9.52	9.97	0.82	8.3
Calcium, mmol/g DFFBM	0.941	1.025	0.986	1.020	0.936	0.991	0.983	0.038	3.9
Body Calcium, g	2.90	2.89	3.43	3.34	2.98	3.10	3.11	0.23	7.4
Phosphorus, mmol/g DFFBM	0.682	0.780	0.762	0.787	0.708	0.785	0.751	0.045	6.0
Body Phosphorus, g	1.625	1.702	2.050	1.989	1.744	1.898	1.835	0.170	9.2
Potassium, mmol/g DFFBM	0.293	0.290	0.291	0.294	0.302	0.304	0.296	0.006	2.0
Body Potassium, g	0.880	0.798	0.988	0.938	0.940	0.929	0.912	0.066	7.2
Sodium, mmol/g DFFBM	0.195	0.189	0.195	0.184	0.201	0.190	0.192	0.006	3.1
Body Sodium, g	0.345	0.306	0.389	0.346	0.368	0.340	0.349	0.028	8.0
Magnesium, mmol/g DFFBM	0.0558	0.0570	0.0544	0.0568	0.0571	0.0600	0.0569	0.0018	3.[illegible]
Body Magnesium, g	0.1044	0.0976	0.1149	0.1127	0.1104	0.1139	0.1090	0.0067	6.2
Creatine, mmol/g DFFBM	0.0883	0.0809	0.0837	0.0768	0.0831	0.0815	0.0824	0.0038	4.6
Body Creatine, g	0.891	0.747	0.954	0.822	0.867	0.834	0.853	0.070	8.2
Derived									
Body Protein, g	60.50	55.63	70.44	65.56	62.31	59.50	62.32	5.15	8.3
Body Cell Mass, g	200.64	181.94	225.26	213.86	214.32	211.81	207.94	14.97	7.2
Intracellular Water Mass, g	146.47	132.82	164.44	156.12	156.45	154.62	151.82	10.92	7.2
Extracellular Water Mass, g	77.08	71.22	84.94	74.54	72.99	72.05	75.47	5.08	6.7
Bone Mineral Mass, g	8.50	8.47	10.05	9.79	8.73	9.08	9.10	0.57	7.4

Table 14. Body composition parameters measured or derived by analysis of the dry, fat-free body powder from the 6 Soviet Diet rats.

Parameter	Animal Number 1	2	3	4	5	6	Mean	S.D.	C.V.
Measured									
Dry Fat-Free Body Mass, g	61.26	67.81	72.89	67.81	67.88	57.67	65.89	5.47	8.3
Nitrogen, mmol/g DFFBM	9.14	9.26	9.08	9.09	8.94	9.04	9.09	0.11	1.2
Body Nitrogen, g	7.84	8.80	9.27	8.63	8.50	7.31	8.39	0.70	8.4
Calcium, mmol/g DFFBM	0.826	0.962	0.915	0.912	0.944	1.044	0.934	0.071	7.6
Body Calcium, g	2.03	2.62	2.67	2.48	2.57	2.41	2.46	0.23	9.4
Phosphorus, mmol/g DFFBM	0.734	0.629	0.660	0.704	0.722	0.770	0.703	0.051	7.3
Body Phosphorus, g	1.393	1.321	1.490	1.478	1.518	1.375	1.429	0.077	5.4
Potassium, mmol/g DFFBM	0.308	0.320	0.320	0.315	0.308	0.315	0.314	0.005	1.7
Body Potassium, g	0.737	0.848	0.912	0.834	0.818	0.710	0.810	0.075	9.2
Sodium, mmol/g DFFBM	0.212	0.207	0.198	0.184	0.199	0.191	0.197	0.011	5.5
Body Sodium, g	0.298	0.323	0.332	0.286	[illegible]	0.253	0.298	0.028	9.4
Magnesium, mmol/g DFFBM	0.0558	0.0578	0.0574	0.0546	0.0609	0.0559	0.0571	0.0022	3.9
Body Magnesium, g	0.0831	0.0953	0.1017	0.0900	0.1005	0.0784	0.0915	0.0094	10.3
Creatine, mmol/g DFFBM	0.0807	0.0824	0.0849	0.0840	0.0781	0.0770	0.0812	0.0032	3.9
Body Creatine, g	0.648	0.733	0.812	0.747	0.695	0.582	0.703	0.081	11.5
Derived									
Body Protein, g	49.00	55.00	57.94	53.94	53.13	45.69	52.45	4.40	8.4
Body Cell Mass, g	168.04	193.34	207.94	190.15	186.50	161.88	184.64	17.01	9.2
Intracellular Water Mass, g	122.67	141.14	151.80	138.81	136.15	118.17	134.79	12.42	9.2
Extracellular Water Mass, g	55.42	54.11	61.91	60.17	57.67	47.27	56.09	5.20	9.3
Bone Mineral Mass, g	5.95	7.68	7.82	7.27	7.53	7.06	7.22	0.68	9.4

Table 15. Body constituent mean mass differences between the Soviet Diet rats and the Control Diet rats, and the probability, P, that the means are statistically the same. The vertical arrows indicate the mean masses that are significantly different at the 0.05 level, and the direction of the arrow indicates whether the Soviet Diet values are lower (↓) or higher (↑) than the Control Diet values.

Constituent		Soviet Diet Mean (g)	C.V.	Control Diet Mean (g)	C.V.	Difference Col. 2 - Col. 4 (g)	(%)	P
Body Nitrogen	↓	8.39	8.4	9.97	8.3	- 1.58	-15.8	0.005
Body Calcium	↓	2.46	9.4	3.11	7.4	- 0.65	-20.7	<0.001
Body Phosphorus	↓	1.429	5.4	1.834	9.3	- 0.405	-22.1	<0.001
Body Potassium	↓	0.810	9.2	0.912	7.2	- 0.102	-11.2	0.030
Body Sodium	↓	0.298	9.4	0.349	8.0	- 0.051	-14.6	0.011
Body Magnesium	↓	0.0915	10.3	0.1089	6.2	- 0.0174	-16.0	0.004
Body Creatine	↓	0.703	11.5	0.853	8.2	- 0.150	-17.6	0.006
Body Protein	↓	52.45	8.4	62.32	8.3	- 9.87	-15.8	0.005
Body Cell Mass	↓	184.64	9.2	207.97	7.2	-23.33	-11.2	0.030
Intracellular Water	↓	134.79	9.2	151.82	7.2	-17.03	-11.2	0.030
Extracellular Water	↓	56.09	9.3	75.47	6.7	-19.38	-25.7	<0.001
Bone Mineral Mass	↓	7.22	9.4	9.10	7.4	- 1.88	-20.7	<0.001

Table 16. Per cent composition (g/100 g) of the fat-free body mass for the 6 Control Diet rats.

	Animal Number								
Constituent	1	2	3	4	5	6	Mean	S.D.	C.V.
Water	74.4	74.3	74.2	73.9	74.3	74.4	74.3	0.2	0.3
Dry Matter	25.6	25.7	25.8	26.1	25.7	25.6	25.7	0.2	0.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
Nitrogen	3.22	3.24	3.35	3.36	3.23	3.12	3.25	0.09	2.8
Calcium	0.965	1.053	1.020	1.070	0.965	1.017	1.015	0.044	4.3
Phosphorus	0.539	0.619	0.610	0.637	0.563	0.624	0.599	0.039	6.5
Potassium	0.293	0.291	0.294	0.300	0.304	0.305	0.298	0.006	2.0
Sodium	0.1148	0.1115	0.1157	0.1108	0.1191	0.1116	0.1139	0.0032	2.8
Magnesium	0.0347	0.0356	0.0342	0.0361	0.0357	0.0374	0.0356	0.0011	3.1
Creatine	0.297	0.272	0.284	0.263	0.281	0.274	0.279	0.012	4.2
Protein	20.1	20.3	20.9	21.0	20.2	19.5	20.3	0.6	2.7
Body Cells	66.8	66.3	67.0	68.5	69.4	69.5	67.9	1.4	2.1
Intracellular Water	48.7	48.4	48.9	50.0	50.6	50.7	49.6	1.0	2.0
Extracellular Water	25.7	25.9	25.3	23.9	23.6	23.6	24.7	1.1	4.4
Bone Mineral	2.83	3.09	2.99	3.14	2.83	2.98	2.98	0.13	4.3

Table 17. Per cent composition (g/100 g) of the fat-free body mass for the 6 Soviet Diet rats.

	Animal Number								
Constituent	1	2	3	4	5	6	Mean	S.D.	C.V.
Water	74.4	74.2	74.6	74.6	74.1	74.2	74.4	0.2	0.3
Dry Matter	25.6	25.8	25.4	25.4	25.9	25.8	25.6	0.2	0.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
Nitrogen	3.28	3.35	3.23	3.23	3.25	3.28	3.27	0.05	1.4
Calcium	0.848	0.996	0.932	0.930	0.982	1.080	0.961	0.078	8.1
Phosphorus	0.581	0.502	0.520	0.555	0.581	0.619	0.560	0.043	7.7
Potassium	0.308	0.322	0.318	0.313	0.313	0.318	0.315	0.005	1.6
Sodium	0.1245	0.1228	0.1158	0.1072	0.1135	0.1134	0.1162	0.0065	5.6
Magnesium	0.0347	0.0362	0.0355	0.0337	0.0384	0.0351	0.0356	0.0016	4.5
Creatine	0.271	0.279	0.283	0.280	0.266	0.261	0.273	0.009	3.2
Protein	20.5	20.9	20.2	20.2	20.3	20.5	20.4	0.3	1.3
Body Cells	70.2	73.5	72.6	71.3	71.3	72.6	71.9	1.2	1.7
Intracellular Water	51.3	53.7	53.0	52.0	52.0	53.0	52.5	0.9	1.7
Extracellular Water	23.2	20.6	21.6	22.6	22.0	21.2	21.9	0.9	4.3
Bone Mineral	2.49	2.92	2.73	2.73	2.88	3.16	2.82	0.23	8.0

Table 18. Mean differences in per cent composition of the fat free body mass between the Soviet Diet rats and the Control Diet rats, and the probability, P, that the means are statistically the same. The vertical arrows indicate the mean percentages that are significantly different at the 0.05 level, and the direction of the arrow indicates whether the Soviet Diet values are lower (↓) or higher (↑) than the Control Diet values.

	Soviet Diet		Control Diet		Difference Col.2 - Col.4		
Constituent	Mean	C.V.	Mean	C.V.	Mean	%	P
Water	74.4	0.3	74.3	0.3	+0.1	+ 0.1	0.41
Dry Matter	25.6	0.8	25.7	0.7	-0.1	- 0.4	0.41
Nitrogen	3.27	1.4	3.25	2.8	+0.02	+ 0.5	0.69
Calcium	0.961	8.1	1.015	4.3	-0.054	- 5.3	0.17
Phosphorus	0.560	7.7	0.599	6.5	-0.039	- 6.5	0.13
Potassium	↑ 0.315	1.6	0.298	2.0	+0.017	+ 5.9	<0.001
Sodium	0.1162	5.6	0.1139	2.8	+0.0023	+ 2.0	0.46
Magnesium	0.0356	4.5	0.0356	3.1	0.0000	- 0.1	0.98
Creatine	0.273	3.2	0.279	4.2	-0.006	- 1.9	0.41
Protein	20.4	1.3	20.3	2.7	+0.1	+ 0.5	0.70
Body Cells	↑ 71.9	1.7	67.9	2.1	+4.0	+ 5.9	<0.001
Intracellular Water	↑ 52.5	1.7	49.6	2.0	+2.9	+ 6.0	<0.001
Extracellular Water	↓ 21.9	4.3	24.7	4.4	-2.8	-11.4	<0.001
Bone Mineral	2.82	8.0	2.98	4.3	-0.16	- 5.3	0.17

Table 19. Metabolic rate measurements on the Control Diet rats and Soviet Diet rats at the end of the 5-week experimental feeding period.

Parameter	Animal Number 1	[illegible]	3	4	5	6	Mean	S.D.	C.V.
Control Diet Rats									
Total Body Mass, g	360.74	333.78	399.01	391.35	372.43	346.29	367.27	25.37	6.9
Net Body Mass, g	330.23	310.07	374.19	367.12	353.31	324.64	343.26	25.48	7.4
Fat-Free Body Mass, g	300.48	274.49	336.25	312.27	308.96	304.73	306.20	19.94	6.5
Body Cell Mass, g	200.64	181.94	225.26	213.86	214.32	211.81	207.97	14.97	7.2
$\dot{V}O_2$, liters/hr	0.319	0.287	0.330	0.308	0.302	0.304	0.308	0.015	4.8
$\dot{V}CO_2$, liters/hr	0.248	0.210	0.263	0.232	0.253	0.223	0.238	0.020	8.4
R	0.777	0.732	0.797	0.753	0.838	0.734	0.772	0.041	5.3
Metabolic Rate, kcal/hr	1.547	1.392	1.601	1.494	1.465	1.474	1.496	0.072	4.8
Metabolic Intensity, kcal/hr/kg TBM	4.29	4.17	4.01	3.82	3.93	4.26	4.08	0.19	4.6
Metabolic Intensity, kcal/hr/kg NBM	4.68	4.49	4.28	4.07	4.15	4.54	4.37	0.24	5.5
Metabolic Intensity, kcal/hr/kg FFBM	5.15	5.07	4.76	4.78	4.74	4.84	4.89	0.18	3.6
Metabolic Intensity, kcal/hr/kg BCM	7.71	7.65	7.11	6.99	6.84	6.96	7.21	0.37	5.2
Soviet Diet Rats									
Total Body Mass, g	312.96	334.44	368.98	323.17	341.86	303.75	330.86	23.24	7.0
Net Body Mass, g	303.15	318.69	330.32	310.75	324.68	291.48	313.18	14.38	4.6
Fat-Free Body Mass, g	239.35	263.06	286.60	266.79	261.70	223.11	256.77	22.32	8.7
Body Cell Mass, g	168.04	193.34	207.94	190.15	186.50	161.88	184.64	17.01	9.2
$\dot{V}O_2$, liters/hr	0.337	0.336	0.424	0.335	0.308	0.350	0.348	0.040	11.3
$\dot{V}CO_2$, liters/hr	0.227	0.268	0.370	0.277	0.235	0.268	0.274	0.051	18.6
R	0.674	0.798	0.873	0.827	0.763	0.766	0.784	0.068	8.6
Metabolic Rate, kcal/hr	1.634	1.630	2.056	1.625	1.494	1.698	1.690	0.192	11.3
Metabolic Intensity, kcal/hr/kg TBM	5.22	4.87	5.57	5.03	4.37	5.59	5.11	0.46	9.0
Metabolic Intensity, kcal/hr/kg NBM	5.39	5.11	6.22	5.23	4.60	5.83	5.40	0.57	10.5
Metabolic Intensity, kcal/hr/kg FFBM	6.83	6.20	7.17	6.09	5.71	7.61	6.60	0.72	10.9
Metabolic Intensity, kcal/hr/kg BCM	9.72	8.43	9.89	8.55	8.01	10.49	9.18	0.98	10.7

Table 20. Mean differences in the metabolic rate measurements between the Soviet Diet rats and the Control Diet rats, and the probability, P, that the means are statistically the same. The vertical arrows indicate the mean values that are significantly different at the 0.05 level, and the direction of the arrow indicates whether the Soviet Diet values are lower (↓) or higher (↑) than the Control Diet values.

Parameter		Soviet Diet Mean	Soviet Diet C.V.	Control Diet Mean	Control Diet C.V.	Difference Col.2 – Col.4 Mean	Difference Col.2 – Col.4 %	P
Total Body Mass, g	↓	330.86	7.0	367.27	6.9	−36.41	− 9.9	0.027
Net Body Mass, g	↓	313.18	4.6	343.26	7.4	−30.08	− 8.8	0.030
Fat-Free Body Mass, g	↓	256.77	8.7	306.20	6.5	−49.43	−16.1	0.002
Body Cell Mass, g	↓	184.64	9.2	207.97	7.2	−23.33	−11.2	0.030
$\dot{V}O_2$, liters/hr	↑	0.348	11.3	0.308	4.8	+ 0.040	+13.0	0.043
$\dot{V}CO_2$, liters/hr		0.274	18.6	0.238	8.4	+ 0.036	+15.1	0.14
R		0.784	8.6	0.772	5.3	+ 0.012	+ 1.5	0.73
Metabolic Rate, kcal/hr	↑	1.690	11.3	1.496	4.8	+ 0.194	+13.0	0.043
Metabolic Intensity, kcal/hr/kg TBM	↑	5.11	9.0	4.08	4.6	+ 1.03	+25.2	<0.001
Metabolic Intensity, kcal/hr/kg NBM	↑	5.40	10.5	4.37	5.5	+ 1.03	+23.5	0.002
Metabolic Intensity, kcal/hr/kg FFBM	↑	6.60	10.9	4.89	3.6	+ 1.71	+35.0	<0.001
Metabolic Intensity, kcal/hr/kg BCM	↑	9.18	10.7	7.21	5.2	+ 1.97	+27.3	<0.001

Table 21. Nominal composition and caloric value of Simonsen Laboratories G4.5 growth diet.

Ingredient	Diet %
Wheat Flour	51.48
Dehulled Soybean Flour	14.71
Yellow Corn Flour	9.80
Meat Scraps	9.80
Rice Bran	4.90
Dry Brewers Yeast	2.45
Hydrogenated Animal/Vegetable Oil	2.45
Orzan-Lignin Sulfonate Binder	2.45
Vitamin/Mineral Mixture	0.98
Table Salt	0.49
Limestone Powder	0.49
Total	100.00
Dry Matter	90.11
Water	9.89
Total	100.00
Fiber	3.06
Ash	5.48

Caloric Component	Fraction of Diet (g/g)	Component (kcal/g)	Diet (kcal/g
Carbohydrate	0.4885	4	1.954
Fat	0.0516	9	0.464
Protein	0.2204	4	0.882
Total Digestible Energy			3.300

L-Amino Acid	Diet (mg/g)	Element	Diet (mg/g)	Vitamin	Diet (µg/g)
Arginine	13.7	Calcium	10.4	A	6.86
Isoleucine	9.8	Phosphorus	8.5	B_1 (Thiamine)	14.62
Leucine	15.4	Sodium	3.7	B_2 (Riboflavin)	8.29
Lysine	11.1	Magnesium	1.9	B_6 (Pyridoxin)	7.85
Methionine	8.2	Manganese	0.110	Pantothenic Acid	24.5
Phenylalanine-Tyrosine	17.0	Iron	0.1219	Niacin	83.7
Threonine	7.8	Zinc	0.0813	B_{12}	24.0
Tryptophan	2.6	Copper	0.00975	B_{15} (Biotin)	0.204
Valine	10.5	Iodine	0.00220	D	0.081
				E	62.9
				K	0.441
				Folic Acid	1.786
				Choline	2,140

Table 22. Nominal composition and caloric value of Soviet paste diet.

Ingredient	(%)
Milk Casein	7.50
Cornstarch	7.50
Sucrose	16.75
Sunflower Seed Oil	4.25
Dry Brewers Yeast	2.50
Vitamin/Mineral Mixture	1.50
Dry Matter	40.00
Water	60.00
Total Paste	100.00

Caloric Component	Fraction of Dry Matter	Component (kcal/g)	Dry Matter (kcal/g)
Carbohydrate	0.6006	4	2.402
Fat	0.1119	9	1.007
Protein	0.1913	4	0.765
Dry Matter Digestible Energy			4.174

Preservative	%
Sorbic Acid	0.5

Element	(mg/g)	Vitamin	(μg/g)
Calcium	5.266	A	1.25
Phosphorus	5.394	B_1 (Thiamine)	4.05
Potassium	4.194	B_2 (Riboflavin)	3.90
Sodium	3.806	B_6 (Pyridoxin)	3.16
Chlorine	0.969	Pantothenic Acid	15.00
Magnesium	0.435	Niacin	30.85
Sulfur	0.698	B_{12}	30.00
Manganese	0.0563	B_{15} (Biotin)	1.000
Iron	0.1994	D	0.375
Zinc	0.00500	E	86.25
Copper	0.00500	K	1.000
Fluorine	0.00813	Folic Acid	2.000
Iodine	0.00438	Choline	1,000
Cobalt	0.00050	Inosine	50.0
Aluminum	0.00005	p-Aminobenzoic Acid	50.0

Table 23. Analytical results and values adopted for the composition of the dry matter in the Soviet paste diet used in the present feeding study.

Nutrient	Nominal Value	Curtis & Tompkins Analysis	EPL Analysis	Value Used	Quantity in 40 g of Paste
PASTE	(g/g)	(g/g)	(g/g)	(g/g)	(g)
Water	0.600	0.652	0.646	0.650	26.0
Dry Matter	0.400	0.348	0.354	0.350	14.0
DRY MATTER					
Carbohydrate	0.601	--	--	0.601	8.41
Fat	0.112	--	--	0.112	1.57
Protein	0.191	0.221	--	0.221	3.09
				(kcal/g)	(kcal)
Digestible Energy				4.29	60.1
L-Amino Acid	(mg/g)	(mg/g)	(mg/g)	(mg/g)	(mg)
Arginine	--	5.83	--	5.83	82
Asparagine	--	16.43	--	16.43	230
Glutamic Acid	--	51.05	--	51.05	715
Histidine	--	5.94	--	5.94	83
Isoleucine	--	9.32	--	9.32	130
Leucine	--	18.09	--	18.09	253
Lysine	--	14.03	--	14.03	196
Methionine	--	4.93	--	4.93	69
Phenylalanine-Tyrosine	--	15.75	--	15.75	221
Proline	--	27.10	--	27.10	379
Threonine	--	8.64	--	8.64	121
Tryptophan	--	6.54	--	6.54	92
Valine	--	12.92	--	12.92	181
Element	(mg/g)	(mg/g)	(mg/g)	(mg/g)	(mg)
Calcium	5.27	--	6.71	6.71	93.9
Phosphorus	5.39	--	7.74	7.74	108.4
Potassium	4.19	--	5.64	5.64	79.0
Sodium	3.81	--	4.51	4.51	63.1
Chlorine	0.969	--	--	0.969	13.56
Magnesium	0.435	--	0.474	0.474	6.64
Sulfur	0.698	--	--	0.698	9.77
Manganese	0.0563	--	--	0.0563	0.788
Iron	0.1993	--	--	0.1993	2.791
Zinc	0.00500	--	--	0.00500	0.0700
Copper	0.00500	--	--	0.00500	0.0700
Fluorine	0.00813	--	--	0.00813	0.1138
Iodine	0.00438	--	--	0.00438	0.0613
Cobalt	0.00050	--	--	0.00050	0.0070
Aluminum	0.00005	--	--	0.00005	0.0007

(continued)

Table 23 (continued)

Nutrient	Nominal Value	Curtis & Tompkins Analysis	EPL Analysis	Value Used	Quantity in 40 g of Paste
Vitamin	(μg/g)	(μg/g)	(μg/g)	(μg/g)	(μg)
A	1.25	1.029	--	1.029	14.4
B_1 (Thiamine)	4.05	10.89	--	10.89	152.5
B_2 (Riboflavin)	3.90	4.14	--	4.14	58.0
B_6 (Pyridoxin)	3.16	10.20	--	10.20	142.8
Pantothenic Acid	15.00	--	--	15.00	210
Niacin	30.85	65.7	--	65.7	920
B_{12}	30.00	--	--	30.0	420
B_{15} (Biotin)	1.000	--	--	1.00	14.0
D	0.375	--	--	0.375	5.25
E	86.25	--	--	86.3	1,208
K	1.000	--	--	1.00	14.0
Folic Acid	2.000	--	--	2.00	28.0
Choline	1,000	--	--	1,000	14,000
Inosine	50.0	--	--	50.0	700
p-Aminobenzoic Acid	50.0	--	--	50.0	700

Table 24. Per cent of daily requirement for nutrients by growing rats met by 4(g of the Soviet paste diet, and by 17.3 g of the Simonsen Laboratories G4.5 diet.

Nutrient	NRC Daily Requirement	40 g Soviet Paste Diet	% of Daily Requirement	17.3 g Simonsen G4.5 Diet	% of Daily Requirement
Digestible Energy, kcal	57.0	60.1	105	57.1	100
Protein, g	1.80	3.09	172	3.81	212
Fat, g	0.75	1.57	209	0.893	119
Carbohydrate, g	—	8.41	—	8.45	—
L-Amino Acid, mg					
Arginine	90	82	91	237	263
Asparagine	60	230	383	—	—
Glutamic Acid	600	715	119	—	—
Histidine	45	83	184	—	—
Isoleucine	75	130	173	170	227
Leucine	113	253	224	266	235
Lysine	105	196	187	192	183
Methionine	90	69	77	142	158
Phenylalanine-Tyrosine	120	221	184	294	245
Proline	60	379	632	—	—
Threonine	75	121	161	135	180
Tryptophan	22.5	92	409	45	200
Valine	90	181	201	182	202
Element, mg					
Calcium	75	93.9	125	180	240
Phosphorus	60	108.4	181	147	245
Potassium	54	79.0	146	—	—
Sodium	7.5	63.1	841	64.2	856
Chlorine	7.5	13.56	181	—	—
Magnesium	6.0	6.64	111	32.9	548
Sulfur	4.5	9.77	217	—	—
Manganese	0.750	0.788	105	1.903	254
Iron	0.525	2.791	532	2.109	402
Zinc	0.180	0.0700	39	1.406	781
Copper	0.075	0.0700	93	0.1687	225
Fluorine	0.015	0.1138	759	—	—
Chromium	0.00450	—	—	—	—
Iodine	0.00225	0.0613	2,720	0.0381	1,693
Selenium	0.00150	—	—	—	—

(continued)

Table 24 (continued)

Nutrient	NRC Daily Requirement	40 g Soviet Paste Diet	% of Daily Requirement	17.3 g Simonsen G4.5 Diet	% of Daily Requirement
Vitamin, µg					
A	18	14.4	80	119	661
B_1 (Thiamine)	60	152.5	254	253	422
B_2 (Riboflavin)	45	58.0	129	143	318
B_6 (Pyridoxin)	90	142.8	159	136	151
Pantothenic Acid	120	210	175	424	353
Niacin	300	920	307	1,448	483
B_{12}	0.75	420	56,000	415	55,333
$B_{1?}$ (Biotin)	(2.25)	14.0	622	3.53	157
D	0.375	5.25	1,400	1.40	373
E	450	1,208	268	1,088	242
K	0.75	14.0	1,867	7.63	1,017
Folic Acid	15	28.0	187	30.9	206
Choline	15,000	14,000	93	37,022	247

Table 25. Mean differences in digestive tract contents between the Soviet Diet rats and the Control Diet rats, and the probability, P, that the means are statistically the same. The vertical arrows indicate the mean values that are significantly different at the 0.05 level, and the direction of the arrow indicates whether the Soviet Diet values are lower (↓) or higher (↑) than the Control Diet values.

Parameter	Animal Number 1	2	3	4	5	6	Mean	S.D.	C.V.
Control Diet									
Wet Mass, g	23.26	17.38	17.76	16.95	12.49	16.20	17.34	3.47	20.0
Dry Mass, g	6.77	4.98	4.41	4.21	2.74	3.87	4.50	1.34	29.8
Water Mass, g	16.49	12.40	13.35	12.74	9.75	12.33	12.84	2.17	16.9
% Water	70.9	71.3	75.2	75.2	78.1	76.1	74.5	2.8	3.8
% Dry Matter	29.1	28.7	24.8	24.8	21.9	23.9	25.5	2.8	11.0
Soviet Diet									
Wet Mass, g	4.39	9.84	(32.25)*	7.20	12.19	7.56	8.24	2.94	35.7
Dry Mass, g	0.96	2.42	(9.09)*	1.53	2.92	1.59	1.89	0.78	41.3
Water Mass, g	3.43	7.42	(23.16)*	5.67	9.27	5.97	6.35	2.17	34.1
% Water	78.1	75.4	(71.8)*	78.7	76.0	79.0	77.4	1.6	2.1
% Dry Matter	21.9	24.6	(28.2)*	21.3	24.0	21.0	22.6	1.6	7.2

*Value omitted from mean

Parameter	Soviet Diet Mean	Soviet Diet C.V.	Control Diet Mean	Control Diet C.V.	Difference Col.2 - Col.4 Mean	Difference Col.2 - Col.4 %	P
Wet Mass, g	↓ 8.24	35.7	17.34	20.0	-9.10	-52.5	0.001
Dry Mass, g	↓ 1.89	41.3	4.50	29.8	-2.61	-58.1	0.004
Water Mass, g	↓ 6.35	34.1	12.84	16.9	-6.49	-50.5	<0.001
% Water	77.4	1.6	74.5	3.8	+2.9	+ 4.0	0.068
% Dry Mater	22.6	7.2	25.5	11.0	-2.9	-11.6	0.068

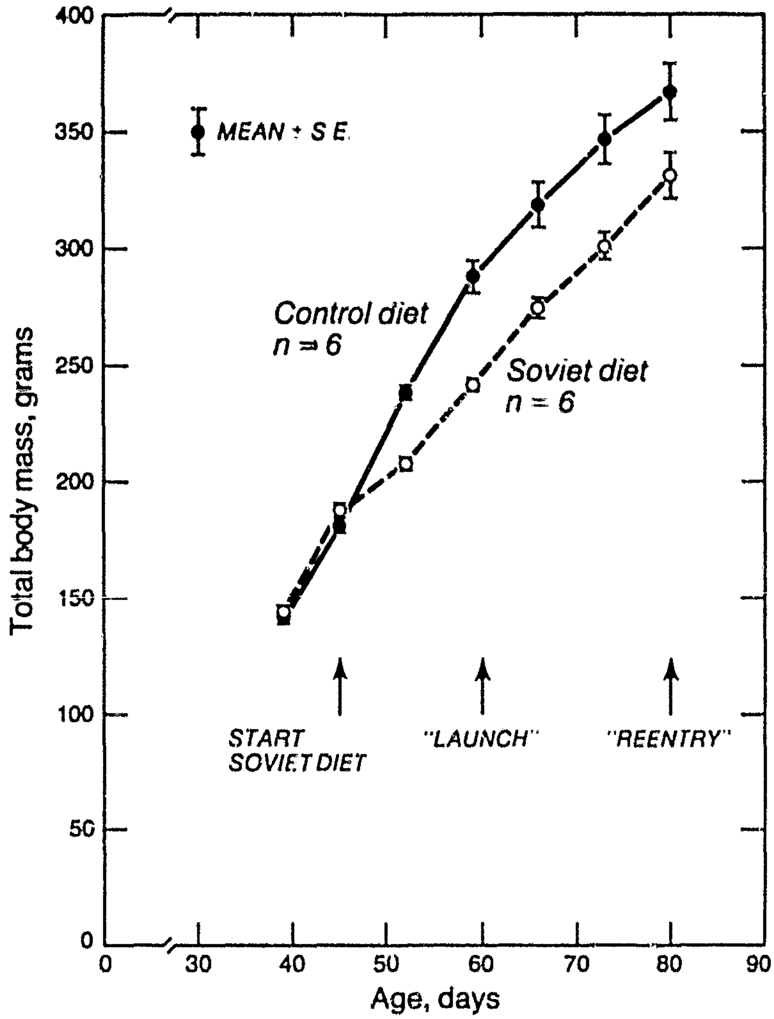

Fig. 1. Mean ± standard error of total body mass as a function of age during the period of the study for the 6 Control Diet rats (closed circles) and the 6 Soviet Diet rats (open circles). The Control Diet rats were given Simonsen G4.5 growth diet *ad libitum* throughout the test period. The Soviet Diet rats were given 40 g daily of the paste diet starting at age 45 days until the end of the test period.

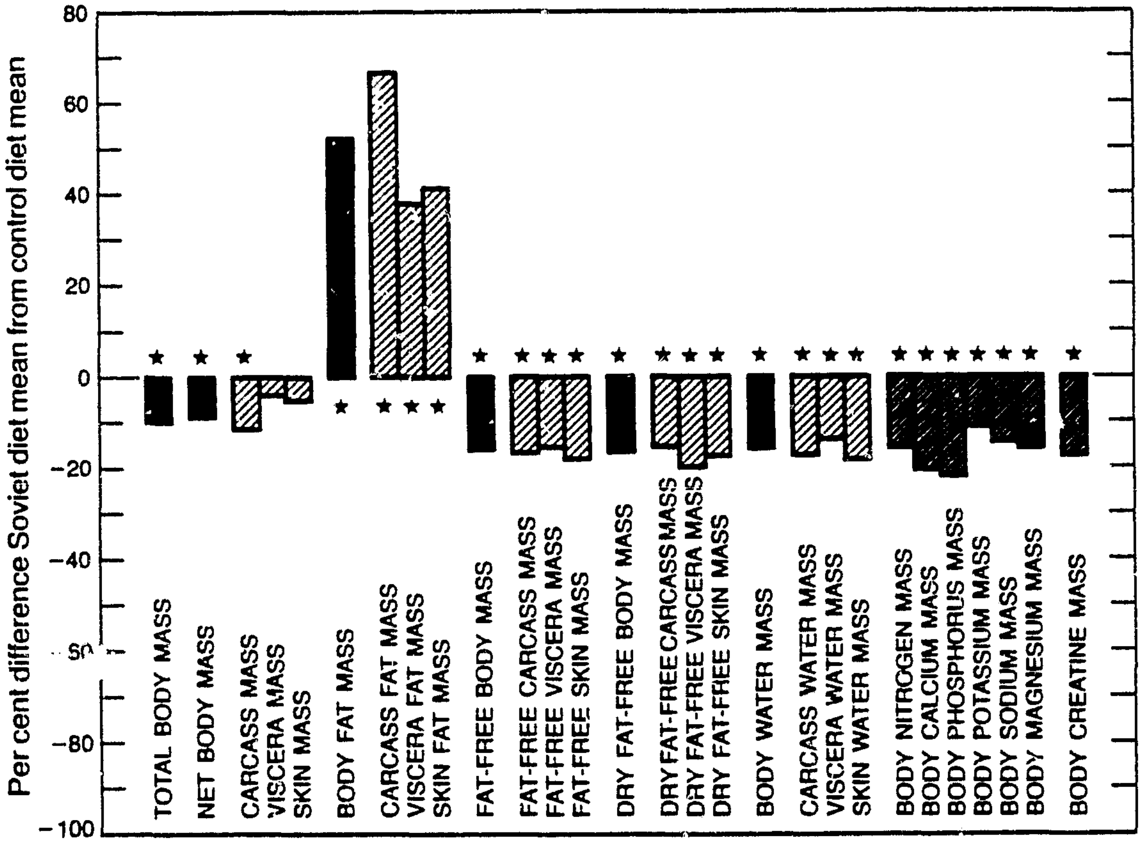

Fig. 2. Percentage difference of the mean value for the Soviet Diet rats from the mean value for the Control Diet rats, for each body composition parameter measured at the end of the test period. The mean values statistically significantly different at the 0.05 level are indicated by a star.

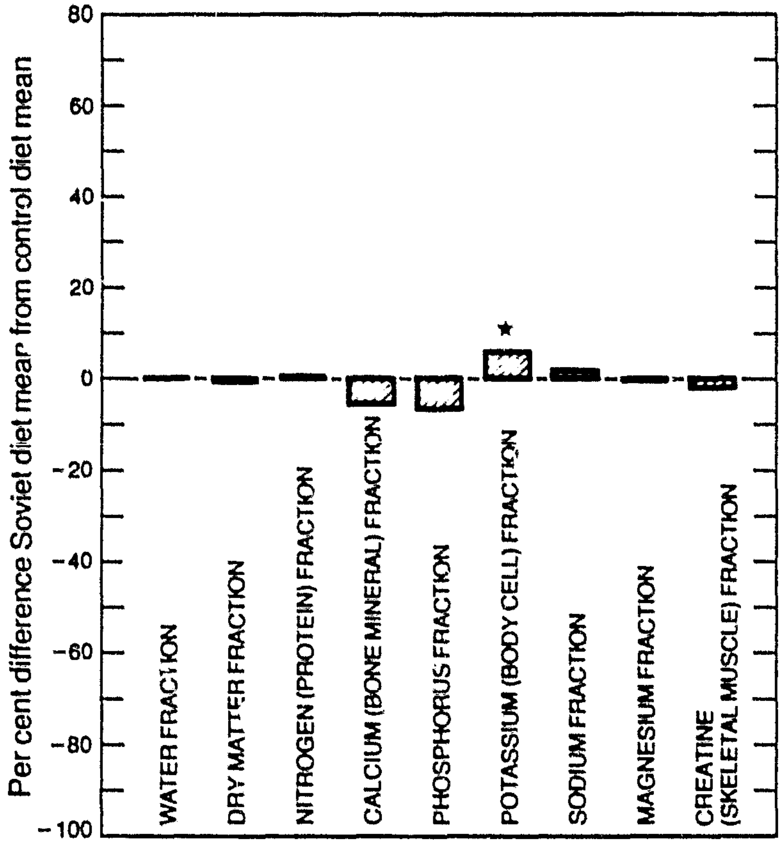

Fig. 3. Percentage difference of the mean value for the Soviet Diet rats from the mean value for the Control Diet rats, for the fractional composition of the fat-free body mass. The mean value statistically significantly different at the 0.05 level is indicated by a star.

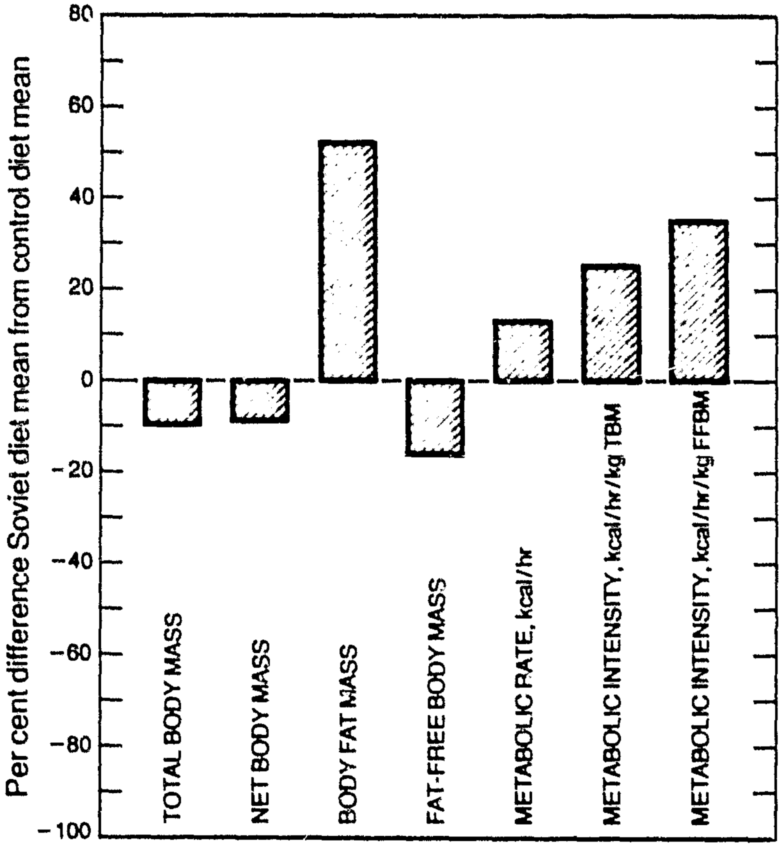

Fig. 4. Percentage difference of the mean value for the Soviet Diet rats from the mean value for the Control Diet rats, for the major parametric differences observed between the two groups. All are statistically significant at the 0.05 level.