

**Effect of feeding on a diet containing varying amounts of *Rhaponticum carthamoides* hay meal on selected morphological parameters in rats**

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**Abstract.** Effects of diet meal containing 10, 20, 30 and 50% of *Rhaponticum carthamoides* hay meal on the increase of body weight, growth and development of selected internal organs and behaviour of animals were examined. The 10% diet, which is preferable from both health and economical viewpoints, stimulated the growth of testes, while the body growth curve was similar to that of animals fed on a conventional diet. The diet with 20% *Rhaponticum* resulted in high variability of the weight of testes. Effects of tested diets on the body weight and food consumption were different in males and females.

INTRODUCTION

The importance of 20-hydroxyecdysone (20E) for insects is clearly defined. However, this substance also occurs in numerous plants (Bergamasco & Horn, 1983; Sláma, 1980) and its importance for these plants has not been explained. In 1993, Sláma presented a view that plants use 20E to protect themselves against insects.

*Rhaponticum carthamoides* Wild is a medicinal plant which contains a range of active substances. Phytosteroids, and particularly 20E, are considered the carriers of pharmacological properties which are very close to those of the ginseng (Bucharov & Shcherbak, 1967). Roots of this plant are used in production of medicines claimed to have stimulative effects in the treatment of the nervous system, physical and psychological exhaustion, chronic alcoholism and sexual activity disorders (Zemlinski, 1958; Saratikov, 1947; Turova, 1967; and others). The experiments on laboratory animals showed activation and increased performance of striated muscles and the central nervous system, and improved blood supply of muscles through accelerated blood flow (Sal'nik, 1966; Syrov et al., 1975; and others).

The investigations carried out in recent years revealed that the above-ground portion of this plant contains similar stimulative substances as those found in the root. Due to this the currently unused above-ground phytomass aroused interest from the viewpoint of its utilization in animal nutrition. The aim of our experiments was to investigate influence of a varying content of *Rhaponticum* hay meal in the diet on selected physiological and morphological parameters in rats.

## MATERIAL AND METHODS

The experiment was carried out using rats of the strain SPF Wistar. Thirty female and thirty male rats of average weight  $35 \pm 5$  g were divided to 10 groups ( $n = 6$ ) and placed individually to experimental cages. They were kept in 12 hrs daylight regime and 50–60% relative humidity and temperature  $22 \pm 1^\circ\text{C}$ . The animals were offered water and food ad libitum. The basic ration consisted of Larsen's diet of the following composition: 60% wheat, 11% dried whole milk, 15% sweet caseine, 4% wheat germs, 2% soya, 4% vitamin dried cakes, 0.6% dry yeast, 1.6% calcium carbonate, 0.8% vitaplastin F and 1% konvit NEO. To 10 kg of this diet 750 g of soya oil, 250 g of fish oil and 250 g of fodder salt were added.

Food of experimental animals was complemented with 5–50% of *Rhaponticum* hay meal. Nutrient composition of Larsen's diet and the hay meal is summarized in Table 1.

TABLE 1. Nutrient composition of Larsen's diet and *Rhaponticum* hay meal.

	% of Larsen's diet	% of hay meal
Dry matter	90.44	91.1
Water	9.56	7.9
N substances (N = 6.25)	28.61	13.95
Crude fibres	3.16	16.87
Ash	5.31	14.49*
Fat	3.85	2.32
Proteins	27.43	11.03
Undigestible N substances	3.55	6.68
Reducible sugars	—	3.94
Total sugars	—	5.93
BNVL	49.51	44.47
Digestible N substances	25.05	7.27
Digestible proteins	23.88	4.35
Nonproteinaceous N subst.	1.18	2.92

\* The content of macroelements in  $\mu\text{g}/\text{kg}$  hay meal.

Na	K	Ca	P	Mg	Cd	Pb	Zn	Cu	Fe	Mn
7.3	18.61	16.67	2.26	0.71	6.0	3.7	31.8	8.6	939.8	5.5

The experiment started after a 7-day adaptation period, during which all animals were fed on the basic Larsen's diet. In the feeding experiment, which lasted 21 days, animals were offered the diets containing *Rhaponticum* hay meal (see Table 1). The consumption of feed and weight gains were determined weekly. During the experiment the overall health state of animals and their behaviour were observed. After the experiment all animals were weighed, killed, and subjected to post mortem examination of internal organs. The organs were cleared of surrounding tissue, weighed, and sampled for histological examination which was carried out employing common histological methods. In the results we present both the absolute and relative (in % of total body mass) weight of examined organs.

Because of the limited space available for animal rearing, the experiment was divided to two stages. In the first stage the experiments were carried out on males while the females were dealt with in the second stage. Since the experiments with males revealed a pronounced difference when the hay meal content was increased from (10%) to (20%) a lower dose (5%) was tested in the females.

## RESULTS

The effect of individual diets on examined qualitative and morphological parameters was demonstrated as follows:

### Weight gain and consumption of feed

Comparison of measured values revealed that the effect of experimental diets differed between the sexes.

Males: Weight gains and consumption of feed in groups A (0%) and B (10%) was on the same level. However, with increasing content of the tested hay meal in the diet (groups C–E) a decrease of the amount of consumed feed accompanied with an abrupt decline of the body weight was recorded (Table 2).

Females: Contrary to males, they reacted with a moderate decrease of body weight starting from the group D (30%). The measured values of feed consumption had, as opposed to males, a rising tendency, increasing from the group A up to the group E (see Table 2).

TABLE 2. Average weight gain and consumption of feed in grams  $\pm$  SD (n = 6).

Group	A	B	C	D	E	
Content of <i>Rhaponticum carthamoides</i> (%)	0	10	20	30	50	5
Consumption of feed in males	384.00 $\pm$ 21.18	351.17 $\pm$ 17.44	327.33 $\pm$ 33.52	312.83 $\pm$ 16.43	278.83 $\pm$ 19.47	—
Weight gain in males	124.83 $\pm$ 13.54	122.67 $\pm$ 15.10	97.83 $\pm$ 14.36	85.83 $\pm$ 10.76	66.50 $\pm$ 7.36	—
Consumption of feed in females	318.33 $\pm$ 16.6	328.17 $\pm$ 18.0	334.50 $\pm$ 22.1	332.50 $\pm$ 7.29	—	320.83 $\pm$ 21.71
Weight gain in females	111.33 $\pm$ 5.49	108.00 $\pm$ 6.61	100.83 $\pm$ 8.25	90.20 $\pm$ 6.42	—	103.66 $\pm$ 10.70

### Spleen and liver

The weight of the liver, acting as a detoxication organ, and of the spleen, functioning as a haemopoietic one, decreased proportionally to the body weight decrease (Tables 3 and 4). Even the diet containing 50% of the tested meal, considered to be a lethal dose prior to the experiment, failed to affect negatively the anatomical structure of the examined organs.

TABLE 3. Average weight of liver in individual groups in grams  $\pm$  SD (n = 6).

Group	A	B	C	D	E
Content of <i>Rhaponticum carthamoides</i> (%)	0	10	20	30	40
Males	10.72 $\pm$ 1.28	11.38 $\pm$ 1.16	9.11 $\pm$ 2.06	8.36 $\pm$ 0.63	7.30 $\pm$ 0.52
Relative weight	5.56 $\pm$ 0.28	6.05 $\pm$ 0.58	5.48 $\pm$ 0.94	5.53 $\pm$ 0.27	5.62 $\pm$ 0.40
Content of <i>Rhaponticum carthamoides</i> (%)	0	10	20	30	5
Females	10.83 $\pm$ 0.67	10.21 $\pm$ 0.54	10.07 $\pm$ 0.66	9.74 $\pm$ 0.64	10.68 $\pm$ 1.29
Relative weight	5.99 $\pm$ 0.27	5.80 $\pm$ 0.21	5.88 $\pm$ 0.40	6.08 $\pm$ 0.12	6.21 $\pm$ 0.38

TABLE 4. Average weight of spleen in individual groups in grams  $\pm$  SD (n = 6).

Group	A	B	C	D	E
Content of <i>Rhaponticum carthamoides</i> (%)	0	10	20	30	40
Males	0.56 $\pm$ 0.0	0.55 $\pm$ 0.01	0.47 $\pm$ 0.09	0.43 $\pm$ 0.10	0.32 $\pm$ 0.09
Relative weight	0.29 $\pm$ 0.01	0.29 $\pm$ 0.05	0.28 $\pm$ 0.04	0.28 $\pm$ 0.05	0.24 $\pm$ 0.06
Content of <i>Rhaponticum carthamoides</i> (%)	0	10	20	30	5
Females	0.59 $\pm$ 0.10	0.53 $\pm$ 0.06	0.50 $\pm$ 0.08	0.47 $\pm$ 0.06	0.47 $\pm$ 0.09
Relative weight	0.32 $\pm$ 0.06	0.29 $\pm$ 0.03	0.29 $\pm$ 0.04	0.29 $\pm$ 0.03	0.28 $\pm$ 0.04

### Kidneys

The weight of kidneys, given individually for each animal, is in Table 5. The table indicates that the values of measured parameters increased moderately with the increasing concentration of hay meal in the diet.

TABLE 5. Average weight of kidneys (left and right) in individual groups (n = 6).

Group	A	B	C	D	E
Content of <i>Rhaponticum carthamoides</i> (%)	0	10	20	30	40
Males					
Weight in g $\pm$ SD					
left	0.87 $\pm$ 0.07	1.07 $\pm$ 0.05	0.97 $\pm$ 0.08	0.90 $\pm$ 0.11	0.81 $\pm$ 0.03
right	0.93 $\pm$ 0.06	1.07 $\pm$ 0.06	0.97 $\pm$ 0.10	0.91 $\pm$ 0.11	0.80 $\pm$ 0.06
Relative weight in % $\pm$ SD					
left	0.45 $\pm$ 0.02	0.56 $\pm$ 0.03	0.59 $\pm$ 0.06	0.59 $\pm$ 0.05	0.62 $\pm$ 0.04
right	0.48 $\pm$ 0.02	0.57 $\pm$ 0.04	0.59 $\pm$ 0.06	0.60 $\pm$ 0.04	0.61 $\pm$ 0.05
Content of <i>Rhaponticum carthamoides</i> (%)	0	10	20	30	5
Females					
Weight in g $\pm$ SD					
left	0.96 $\pm$ 0.06	0.93 $\pm$ 0.06	1.05 $\pm$ 0.08	0.98 $\pm$ 0.03	0.92 $\pm$ 0.10
right	0.94 $\pm$ 0.04	0.92 $\pm$ 0.03	1.00 $\pm$ 0.09	0.96 $\pm$ 0.04	0.89 $\pm$ 0.08
Relative weight in % $\pm$ SD					
left	0.53 $\pm$ 0.03	0.53 $\pm$ 0.03	0.61 $\pm$ 0.07	0.61 $\pm$ 0.03	0.61 $\pm$ 0.03
right	0.52 $\pm$ 0.02	0.52 $\pm$ 0.03	0.58 $\pm$ 0.04	0.59 $\pm$ 0.04	0.51 $\pm$ 0.03

### Caecum and the large intestine

Within the post mortem examination of males pictures were taken after the opening of the abdominal cavity. Pictures showed an increase of the caecum area with the increasing content of hay meal. This was the reason why the second experiment on females included, besides the observation of liver and spleen, also examination of the weight of caecum and the large intestine and of their histological structure. The obtained values are presented in Table 6. Obtained results show a moderate increase of values in individual groups with increasing content of *Rhaponticum* hay meal in the diet.

TABLE 6. Average weight of empty caecum and large intestine in individual groups expressed in grams  $\pm$  SD (n = 6).

Group	A	B	C	D	E
Content of <i>Rhaponticum carthamoides</i> (%)	0	10	20	30	5
Caecum					
Females	0.35 $\pm$ 0.08	0.37 $\pm$ 0.08	0.39 $\pm$ 0.07	0.39 $\pm$ 0.01	0.37 $\pm$ 0.10
Rel. weight	0.19 $\pm$ 0.04	0.20 $\pm$ 0.04	0.22 $\pm$ 0.05	0.24 $\pm$ 0.01	0.21 $\pm$ 0.07
Large intestine					
Females	0.91 $\pm$ 0.15	0.95 $\pm$ 0.15	1.09 $\pm$ 0.13	1.03 $\pm$ 0.11	0.96 $\pm$ 0.14
Rel. weight	0.50 $\pm$ 0.08	0.54 $\pm$ 0.09	0.62 $\pm$ 0.04	0.64 $\pm$ 0.07	0.56 $\pm$ 0.06

### Sexual organs

The weight of sexual organs was investigated only in male rats. The reason for this was that the ovaries of rat females are so small that it is impossible to separate them from the surrounding tissue in a way which could ensure that the determined weight is exclusively the weight of the ovarian tissue. The obtained values of testes are summarized in Table 7.

TABLE 7. Average weight of testes (left and right) in individual groups of male rats (n = 6).

Group	A	B	C	D	E
Content of <i>Rhaponticum carthamoides</i> (%)	0	10	20	30	50
Weight in g $\pm$ SD					
left testicle	0.96 $\pm$ 0.12	1.04 $\pm$ 0.11	0.78 $\pm$ 0.29	0.87 $\pm$ 0.23	0.73 $\pm$ 0.16
right testicle	0.96 $\pm$ 0.12	1.05 $\pm$ 0.11	0.80 $\pm$ 0.29	0.89 $\pm$ 0.24	0.73 $\pm$ 0.16
Weight in % $\pm$ SD					
left testicle	0.49 $\pm$ 0.05	0.55 $\pm$ 0.07	0.47 $\pm$ 0.18	0.57 $\pm$ 0.15	0.55 $\pm$ 0.12
right testicle	0.49 $\pm$ 0.05	0.55 $\pm$ 0.07	0.48 $\pm$ 0.18	0.58 $\pm$ 0.16	0.55 $\pm$ 0.12

The values measured within the groups A, B and E were more or less uniform. Interesting results were obtained in group C (20%), Table 8, and group D (30%). The diets used in the latter groups had an individual effect on each of the animals as a result of which total weight of both testes ranged from 0.44 g to 2.12 g.

TABLE 8. Weight of testes of the group C in grams  $\pm$  SD.

Animal No.	1	2	3	4	5	6
Left testicle	0.99	0.66	0.75	1.04	1.04	0.22
Right testicle	1.02	0.65	0.78	1.02	1.08	0.22

### Histology of internal organs

Common histological methods were used to examine histological structure of internal organs. None of the examined samples showed signs of histopathological changes.

## DISCUSSION AND CONCLUSIONS

Addition of *Rhaponticum* hay meal to rats' diet exerted slightly different effect on males and females. A varying effect on body weight increase and food acceptance in dependence on sex has previously been recorded by Šelepová (1989, 1993) in experiments with pigs and rabbits receiving diets containing 10% *Rhaponticum* hay meal. Similarly as in the present study, the hay meal stimulated higher increase in body weight in males than in the females. The investigation of the growth of internal organs provided neither answer nor explanation of this reality. The growth of internal organs was the same in both sexes. The weight of spleen and liver decreased proportionally with the decrease of the body weight in individual groups. A moderate increase of the weight of kidneys in the direction from group A to group C may be explained by the statements of Saratikov (1947) about diuretic effects of *Rhaponticum carthamoides*. This increase was, however, the same in both sexes.

The moderate increase of weight of the large intestine and caecum in the direction from group A to D may be ascribed to the increasing content of crude fiber in the diet. Due to the long-term domestication and breeding of laboratory rats their physiology of digestion is very close to that of monogastric animals in which the requirements on acceptable concentrations of crude fibers are lower and stricter than in polygastric animals. Despite the slight differences in the weight of investigated internal organs none of measured values exceeded the physiological range.

The obtained results and visual observations indicated that the animals of the group B (10%) of both sexes were in the best health state. Saratikov (1947) was the first scientist who provided a proof of tonic properties of *Rhaponticum carthamoides*. His data revealed that the administration to animals of the preparation obtained from this plant decreased their fatigue. An increase of mobility and an improvement of overall health state upon administration of *Rhaponticum* preparation was recorded by Turova (1967) and Saratikov (1947).

The growth curve of animals of group B of both sexes was similar to that of animals fed the conventional diet. For this reason, until the cause of different effect of *Rhaponticum* on different sexes is elucidated, we recommend the diet containing 10% *Rhaponticum* for feeding to farm animals. With regard to the fact that diets C (20%) and D (30%) had profound effects on the growth of testes, we consider them unsuitable for consumption by infantile animals intended for breeding.

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