REPRODUCTIVE HEALTH OF RATS

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Abstract

In the present paper the feeding experiment with laboratory rats, conducted at the Ludwig Boltzmann Institute for Biological Agriculture from 1987-1989 is described in more detail to show the advantages, but also the difficulties of the method (Velimirov et al. 1992).

Two groups of rats (Long Evans strain), each consisting of 20 pairs, were fed with products from organic resp. conventional growing systems. After chemical analyses of all products, vitamins, minerals and trace elements were added if needed to provide nutritionally balanced diets. With 2 harvests 3 generations (6 litters) were investigated. In the first litters significantly fewer offspring were born dead or died within the first week of their lives. The survival rate until weaning time at the age of 28 days and the weight development were slightly more successful. The weight gain of the female rats in connection with litter size and pup weight during lactation was significantly higher. But the change from the feed mixture of the 1st to the 2nd harvest showed a reverse tendency in the 2nd litters of the 2nd generation, although the same diet components were used. After the adaptation to the new diet the "organic" group again displayed better results. Contradictory results are difficult to explain, because the overall impact of diets from different production systems is investigated, not effects of single components at different levels. The results are not unequivocally accepted by the scientific community, but are easily understood by the public, since the method reflects reality. The linear resp. synergistic perception of biological systems corresponds with the research objective, which is inherently different. Analysis is focussed on objects and their material nature, whereas the systemic approach tries to reveal the interactions (system dynamics) between the objects in the course of time. For a profound understanding of systems clearly both positions are needed, to compensate for the limitations of each method on its own.

Introduction

Traditionally feeding trials with laboratory animals, mostly rats, are related to negative and positive effect levels of single components, either concerned with safety issues such as the ADI values of pesticide residues or with health effects e.g. of secondary metabolites. When feeding experiments are applied to investigate possible effects of differently culitvated products, the results are not traced back to single components of the test diets. Therefore the interpretation is more difficult and might seem less accurate resp. "scientific". These approaches reflect the two faces of natural science, the reductionist approach postulating independent linear cause-effect-chains in biological systems and the holistic approach based on the knowledge of an interactive, hierarchically organised network. This latter aspect complies with the epistemological background of organic agriculture and it has been the privilege of scientists in this field to introduce holistic research methods, giving back the phenomenological and more „narrative" character to biology.

The demand for organic food is rapidly growing especially in western civilized countries. Consumers perceive organic produce as "better for you", a perception largely based on intuition rather than information. The official point of view concerning product quality maintains the notion that there is no scientific evidence of superior quality properties in organic food. Some of the factors responsible for this relatively static view point are: The lack of appropriate funding for organic research and therefore the lack of data. Also a consequence of restricted funding is the difficulty to realize comperhensive scientific designs. Due to a certain lack of understanding holisic methods, "organic" project

applications only have a chance, if they fulfill conventional scientific requirements, despite the potential discrepancy between the holistic background of Organic Farming and the linear approach of traditional science. But food composition data alone do not reveal much about how foods may be digested and metabolized in the body, only in connection with feeding studies a valuable answer can be achieved. A few relevant examples, demonstrating positive effects of organic products, are feeding experiments with rabbits (Gottschewski 1975, Edelmüller 1984, Staiger 1986), with chicken (Plochberger 1989) and with laboratory rats (Velimirov et al. 1992, Lauridsen et al. 2005). As can be seen from the last two references more than 10 years have gone by since the publication of the first rat feeding study until a new animal feeding project was granted in Danmark (Lauridsen et al. 2005), although the findings 1992 clearly indicated the favorable effects of organic feed on the reproductive health of laboratory rats and further research in this field was strongly recommended.

It is the aim of this paper to look back and present the feeding study of 1992 in order to reassess the design, the results and also to discuss the difficulties in this line of research.

The study was conducted at the Ludwig Boltzmann Institute for Biological Agriculture and Applied Ecology in Vienna from 1987-1989 by four scientists: two zoologists (myself and Karin Plochberger) one botanist (Wolfgang Schott) and one veterinary (Ulla Huspeka) and was published in 1992 (Veimirov et al. 1992).

Methods

The basic idea was to compare the effects of conventional and organic feed on the reproductive health of laboratory rats. Based on dietary presriptions for laboratory rats the test diets were composed of 11,2% oats (*Avena sativa* L.), 25,9% barley (*Hordeum vulgare* L.), 25,9% field peas (*Pisum avense L.*) and 22.2% toasted soja beans (*Glycine max*. L.). Additionally the animals were fed with fresh carrots (*Daucus carota* L., 7,4%) and common beets (*Beta vulgaris* L., 7,4%). The dry ingredients were ground and pressed into pellets and given ad libitum, whereas the fresh food was apportioned in specific amounts (180 g carrots and 130 g common beets weekly per animal). Much attention was paid to the task of finding neighbouring farmers, who were prepared to cooperate in the project and to produce the feedstuff organically resp. conventionally. The seeds were supplied to make sure, the same varieties were used. All seeds therefore were untreated. After harvest all products were routinely analyzed. In order to provide nutritionally adequate diets for both groups of animals trace elements, minerals and vitamins were added, when necessary (*Table 1*). Thus any nutritional deficiencies were compensated for so that, according to analytical standards, the diets were of equal nutritional quality. The products of two harvests were tested.

Tab. 1: Additions to food mixtures

Feed mixture 1987	
Vitamin B 12 (0,1%)	14 g each
NaCl (cattle salt) iodated (40% Na)	1,8 kg each
$CaCO_3$ (lime) (36% Ca)	6,65 kg each
Managnese oxide (62% Mn)	12 g each
Vitamin D (500,000 IE/g)	3 g to conv. feed only
Feed mixture 1988	
Vitamin D	0,5 g each
Vitamin B 12	7,2 g each
NaCl (cattle salt) iodated (40% Na)	0,9 kg each
$CaCO_3$ (lime) (36% Ca)	3,3 kg each
Managnese oxide (62% Mn)	6 g each

The test animals were inbred laboratory rats, Long Evans strain. The animals were divided into 2 groups of 20 pairs each, according to the two test diets. Each female had two litters. Rats from the first litters were chosen at random to establish the next generation. Three generations and six litters were investigated. Data about the pregnancy rate, the birth

weight and the weight development of the offspring, the rearing proportion and the weight gain or loss of the females during and after lactation were obtained.

Results

Chemical analyses

The analytical results showed either no or very small differences, which were sometimes reverse in the two harvests and were often more pronounced between the two harvests than between the two variants of the same year. When this study was done these small differences were not considered to be of great consequence, but it is now known, that there are many nutrient interactions having a much bigger effect than could be expected from the small differences observed. The same is true for toxic substances such as pesticide residues. Therefore we have to reassess the analytical results. The contents of Manganese, Iron, Zinc, Copper as well as Folic acid and Vit. K 1 were slightly higher in the organic variant 1987, but lower in 1988 as compared to the conventional feed. Biotin was always higher in the organic feed, whereas Niacin and Alpha-Tocopherol were higher in the conventional one both years. Summarizing and comparing the mineral and vitamin contents the conventional dry feed of 1988 was slightly better (*Table 2*). But all data were within the range of biological diversity.

Tab. 2: Selected results of the chemical analyses (dry ingredients)

	harvest 1987		harvest 1988	
	org	con	org	con
Ca (mg/100g)	61,6	61,4	98,3	108
Mg (mg/100g)	160	160	168,5	187,9
Mn (mg/100g)	4	3,8	2	2,4
Fe (mg/100g)	13,3	11,2	7,6	8,6
Zn (mg/kg)	32	31	34,3	44,5
Cu (mg/kg)	7,2	5,9	17,5	19,9
Cr (mg/kg)	-	-	1,3	1,8
Biotin (micro g)	169	150	181	157
Thiamine-HCl mg	8,2	8,4	13,8	13,1
Riboflavin mg	3,8	3,7	3	2,3
Pyridoxol-HCl mg	1,3	1,3	0,9	0,9
Niacin mg	28,8	32	29,2	39,5
Folic acid mg	0,64	0,59	0,45	0,52
Pantothenic acid mg	10,7	10,1	10,4	9,4
Choline mg	1930	2000	1700	1210
Vit E complex mg	13,7	16	7,2	10
Alpha Tocopherol mg	12,4	14,5	6,6	9,16
Vit K 1 micro g	199	193	20,9	29,7

The products were not analyzed for secondary metabolites, since the health-related importance was not yet generally accepted then and these analyses would have gone beyond the available funds anyway.

The conventional farmer aplpied 8 different pesticides, some of which have either been shown or are suspected to be reproductive health hazards.since The dry ingredients were analyzed for chlorinated hydrocarbons. Again no detailed attention was paid to the toxic levels, all contents were under the accepted safety limits. Since then more and more research is showing the defincencies and limitations of these safety levels particularily in connection with synergistic effect increase when dealing with so-called pesticide cocktails.

Reproduction data

The results concerning the reproductive parameters showed favorable effects of the organic feed:

- In the first litters significantly fewer offspring were born dead or died within the first week of their lives (*Figure 1*).
- The survival rate until weaning time at the age of 28 days and the weight development were slightly more successful.
- The weight gain of the organically fed female rats in connection with litter size and pup weight during lactation was significantly higher (*Figure 2*).

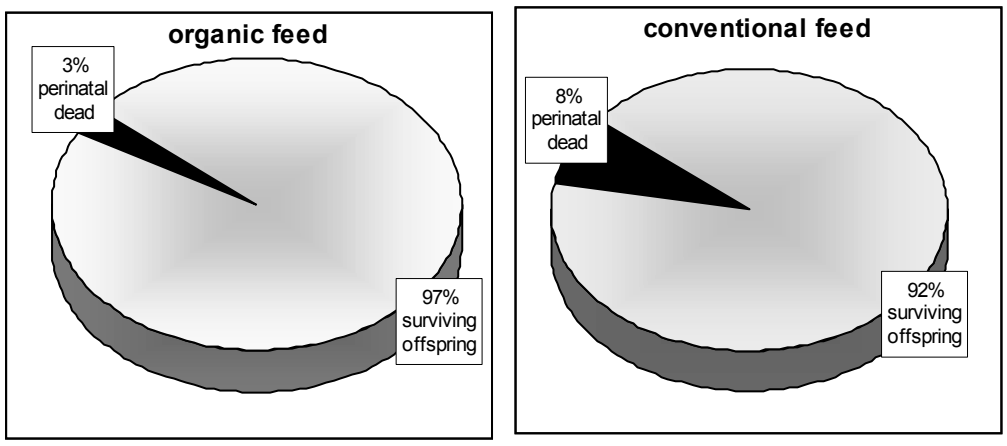

Fig. 1: Significantly less perinatal dead offspring in the organically fed group, 1st litters.

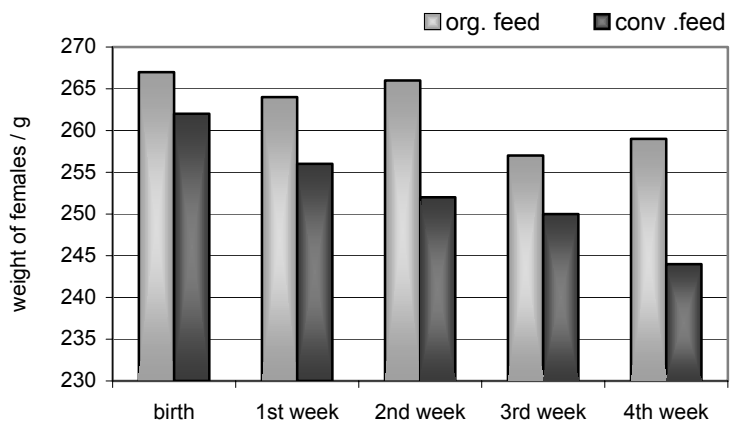

Fig. 2: Significantly higher weight gain in female rats of the organic group during lactation

Between the 1st and the 2nd litter of the 2nd generation the new feed mixture (harvest 1988) was introduced. Weight gain as well as rearing performance of the 2nd litter of F2 was better in the conventional group. After adaptation to the new feed the organic group again displayed better results than the conventional one. These contradictory results could not be explained and are a good example for the interpretation difficulties, when dealing with complex systems.

Conclusions

The design and aim of any feeding study investigating the effects of whole diets, not single components have to be clearly defined. There are basically two approaches:

The investigation is carried out to reveal indirect effects of actually applied cultivation methods (farmers) on animal health. In this case, whatever the outcome might be, the researcher is likely to encounter interpretation difficulties if he relies too heavily on analytical contents and linear cause-effect-chains. Yet this kind of study is very valuable, because it reflects reality. The interpretation should be based on phenomenological and descriptive methods.

The study is seen as a contribution to basic research. In this case the growing conditions have to be defined beforehand and the application of pesticides should be restricted (field trials). The results would then only apply to the well defined framework of growing conditions, but the outcome could be more easily interpreted according to the officially accepted scientific rules.

More attention should be paid to the contents of nonnutrients, micronutrients and pesticide residues. After the rat feeding trial more and more scientific evidence has emerged, showing that small increases of health promoting contents as well as small decreases of toxic substances in a food can have a much bigger impact than was originally expected (Worthington 1999; Soil Association 2000). Even marginal deficiencies can contribute to lower vitality.

Still, nutrient concentrations do not give clear and definite indication of their bioavailability, therefore feeding tests are essential to make up for the shortcomings of chemical analyses, when applied as exclusive parameter for the definition of nutritional food quality.

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