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THE INFLUENCE OF ASH FROM COAL GASIFICATION ON BODY WEIGHT IN RELATION TO AGE AND SEX

I. RABAR[1], T. MALJKOVIĆ[1], K. KOSTIAL[1] and A. BUNAREVIĆ[2]
Institute for Medical Research and Occupational Health[1], and Department of Pathology, Medical Faculty, University of Zagreb[2], Zagreb, Yugoslavia

ABSTRACT

The effect of ash (slag) from coal gasification on health is not yet known. In this experiment we obtained data on age and sex related sensitivity of rats exposed to ash in diet by determining changes in body weight as a preliminary indicator of health effect.

Albino rats of both sexes and different age were given diets with ash additive (1% and 5%) for various lengths of time. At the end of the experiment a gross pathological and a histological examination were performed.

An impairment of body growth, which was more pronounced in weanlings than in older rats and more in males than in females, was observed. Weight decrease was proportional to reduced food consumption. Complete or partial recovery of body weight was achieved after the rats had been transferred from the experimental to the control diet.

In animals treated with ash no morphological abnormalities were observed and no changes in morbidity, mortality, gross pathology or histological findings were recorded.

Escalating energy usage and uncertainties of the extent of fossil fuel reserves are the main problem throughout the world. It seems that in the coming decades energy demands will be greatly covered from coal combustion processes. Among conventional coal combustion and alternative processes, coal gasification is expected to provide a major contribution[4]. One of the proven processes considered as practical and feasible is the Lurgi gasification process. In Yugoslavia a coal gasification plant producing synthetic gas has been operating for several years. This is the "Kosovo" plant at Obilić near Priština with the present yearly capacity of about 500 million m^3 of clean gas, which is supposed to increase threefold in the near future[10]. The consequence of such a big production are large quantities of gaseous, liquid and solid wastes that are deposited in the environment. These wastes could directly or indirectly have an adverse effect on all kinds of living organisms, including man. One of the big gaps in our knowledge is a lack of data about health effects of wastes from coal gasification. Some reports summarize the effects of several constituents of these wastes, that have been recognized as hazardous[2,3,11], but the direct impact of these effluents on health has not yet been thoroughly investigated. We therefore

started with an intensive programme of toxicity testing of effluents from the coal gasification plant "Kosovo" in collaboration with the Environmental Protection Agency, Cincinnati, USA. The first phase of this programme included the investigation of the health effect of the solid waste i.e. ash (slag) which is a residue of brown coal combustion in the Lurgi gasifier. A preliminary analysis shows that more than 99% of this ash is inorganic and that it contains well recognized contaminants such as several toxic metals[7]. Our toxicologic studies include acute, subchronic and chronic feeding experiments as well as reproduction studies and effects on progeny.

In this study we determined body weights of animals exposed at different age and for different periods of time to diets with ash additive (1% and 5%). In some animals a histopathological analysis of the tissues was performed at necropsy.

MATERIAL AND METHODS

Ash sample and experimental diets

A sample of 1 500 kg of ash collected from the Lurgi coal gasification plant in REMHK "Kosovo" at Obilić was transferred to this Institute in Zagreb in plastic containers. The ash was dried at 80 °C for 24 hours to 4% moisture. It was then ground to particles not exceeding 50 μm in diameter (Anderson sieve). Experimental diets were prepared by adding adequate amounts of ash (1% and 5%) to the powdered control diet. The nutritional composition of the control diet was described earlier[5]. All diets were pelleted in the "Pliva" Pharmaceutical Works in Zagreb in the same way as the control diet. The analyzed content of some elements in the control diet and ash is given in Table 1. Calculated values for these elements in the experimental diets are also presented.

TABLE 1
Some elements in control diet, experimental diets and ash (μg/g)

Element	Control diet*	Diets with ash additive**		Ash***
		1%	5%	
Ca	12 000	14 791	25 954	291 070
Zn	60	60	60	56
Fe	595	1 361	4 427	77 246
Cu	49	50	51	76
Mn	164	174	216	1 200

*Analyzed by AAS at the Institute for Medical Research and Occupational Health, Zagreb
**Calculated values
***Analyzed by ASTM and AAS at the Mining Institute, Zemun

Animals

Experiment 1

This experiment was performed to investigate the effect of ash in diet via dam on offspring during the prenatal and postnatal period, and thereafter the

direct effect of various levels of ash additive in the postweaning period. Fourteen-week-old female rats were mated with males of the same age for four days. Each breeding cage consisted of eight female and four male rats. After the removal of males, female rats were divided into three groups, receiving diets with various levels of ash additive (1%, 5% and control). There were 24 females in each group. Rats were on each dietary treatment during the period of pregnancy and lactation. The animals had free access to food and tap water. Three weeks after the beginning of the mating period pregnant females were placed into individual cages. After delivery the number of young animals was recorded. One day after birth, the weight of the whole litter was taken and this value was divided by the number of animals per litter to obtain the mean birth weight of the newborn. Then the number of newborns was reduced to six animals per litter. Individual body weights of young animals were taken at the age of four weeks and thereafter every other week. Litters were weaned at twenty-one days of age, separated by sex and placed in groups of seven to eleven animals per cage. Young animals were maintained on the same diets which their mothers received during pregnancy and lactation, till the age of 14 weeks. Only 12 animals of each sex from the group receiving 5% ash in diet were transferred to the control diet at the age of eight weeks till the end of the experiment in order to establish the reversibility of the potential health effect (recovery groups). Food and water consumption was measured continuously, starting at the time when the animals were four weeks old, till the end of the experiment. Data are expressed as the mean daily consumption over the whole period per animal in each group.

Experiment 2

The purpose of this experiment was to investigate the effect of diets with various levels of ash (1% and 5%) in rats of both sexes from the age of six weeks till the age of 38 weeks. There were 20 to 50 animals per group. The rats were housed in plastic cages with stainless steel bottoms in groups of 10 to 15 animals per cage. They were fed all diets *ad libitum* and were given free access to deionized water from drinking bottles fitted with stainless steel sipper tubes. Individual body weights were recorded seven times over the experimental period.

Pathological examination

Over the entire experimental period animals were observed daily for general appearance and morphological abnormalities. Morbidity and mortality data were also recorded.

At the end of the experiment i.e. at the age of 14 weeks in Experiment 1 and at the age of 38 weeks in Experiment 2, necropsy was performed in 3–4 animals of each sex in each group. The animals were exsanguinated in ether and macroscopic observations of all organs were made. A histological examination of the liver and kidneys was performed in HE stained paraffin preparations by means of light microscopy. In males the histological examination also included the testicles.

RESULTS AND DISCUSSION

In Experiment 1 all animals survived and no morphological abnormalities were observed. Prenatal exposure to ash via dam caused significantly lower birth weights only in animals on the 5% ash level (Table 2) ($P < 0.01$). The number of newborns per litter was practically the same in all groups. In the 5% ash group the differences in weight observed at birth increased after weaning, more in

TABLE 2

Influence of ash additive to dam's diet on birth weight and number of animals per litter. Both parameters recorded within 24 hours after birth, and presented as arithmetic means ± S.E.M.

Group	Weight of newborns (g)	Number of animals per litter
Control	6.2 ± 0.1	9.0 ± 0.7
Ash 1%	6.1 ± 0.1	9.5 ± 0.5
Ash 5%	5.8 ± 0.1	8.8 ± 0.3

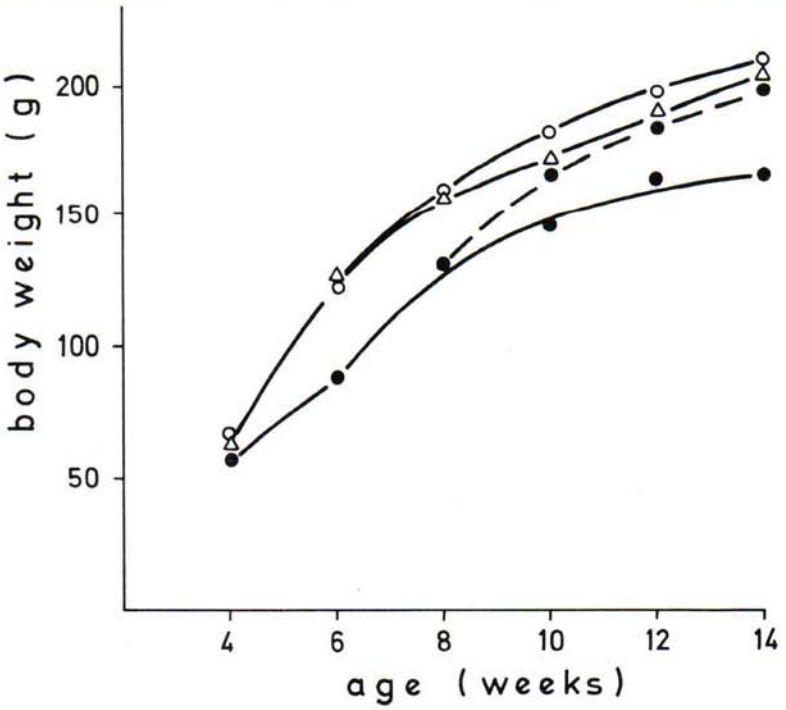

FIG. 1 – Body weights of female rats during the 10-week observation period on diets with ash additive (1% and 5%) since conception (20–50 animals in each group); open circles, solid line – control; open triangles, solid line – 1% ash; solid circles, solid line – 5% ash; solid circles, dotted line – 5% ash recovery.

males (Figure 2) than in females (Figure 1). At the age of eight weeks females had about 20% lower weights than controls, and males about 30%. These differences were maintained till the age of 14 weeks, i.e. till the end of the experiment. Animals on diet with 1% ash additive showed only a slight reduction in body weight in the postweaning period, again more pronounced in males than in females (Figures 1 and 2). In both ash treated groups the reduction in body

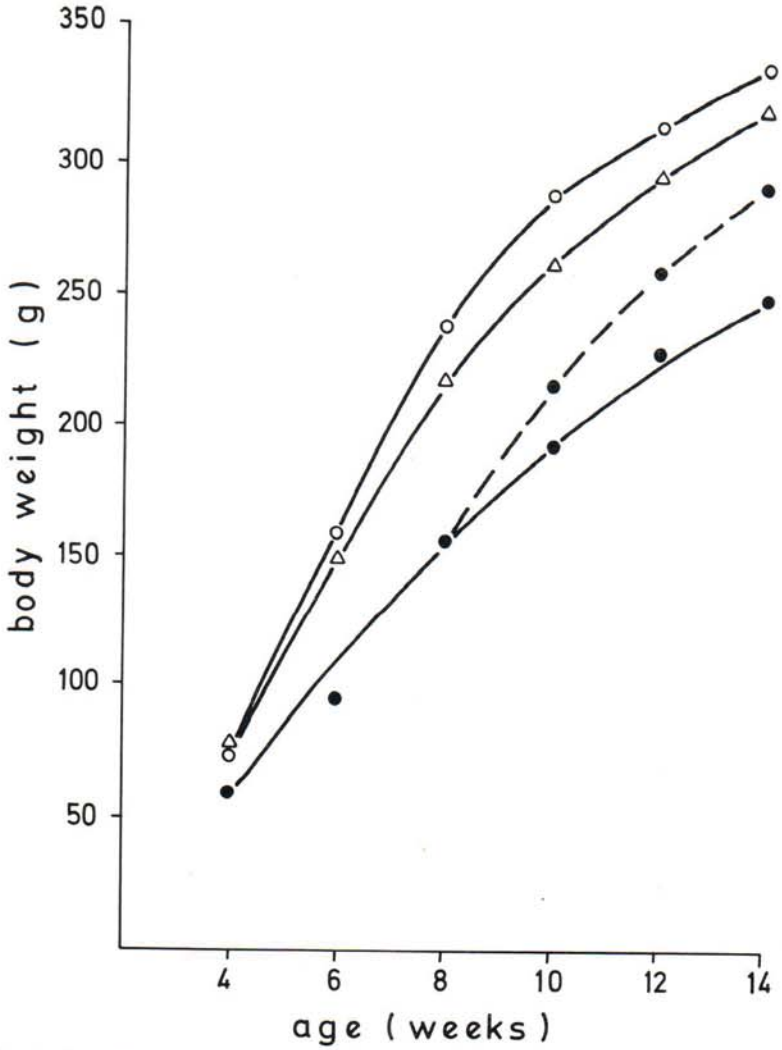

FIG. 2 – Body weights of male rats during the 10-week observation period on diets with ash additive (1% and 5%) since conception (20–50 animals in each group); open circles, solid line – control; open triangles, solid line – 1% ash; solid circles, solid line – 5% ash; solid circles, dotted line – 5% ash recovery.

weight was associated with reduced food consumption (Table 3), and also with reduced water consumption in the 5% group. In animals on 5% ash additive transferred to control diet at the age of eight weeks (recovery groups), females showed a complete and males only a partial recovery in body weight till the age of 14 weeks. Gross pathology and a histological examination of the kidneys, liver and testicles showed no changes relative to dietary treatment.

TABLE 3

Influence of ash additive to diet on average daily food and water consumption over the 10-week observation period (arithmetic means ± S.E.M.)

Group	Food (g)	Water (ml)
FEMALES		
Control	15.5 ± 0.2	28.8 ± 0.6
Ash 1%	13.3 ± 0.1	28.2 ± 0.4
Ash 5%	12.5 ± 0.2	24.7 ± 0.6
Ash 5% recovery	14.8 ± 0.5*	26.4 ± 0.7*
MALES		
Control	20.6 ± 0.2	35.0 ± 0.6
Ash 1%	17.7 ± 0.2	36.6 ± 0.5
Ash 5%	15.0 ± 0.2	29.8 ± 0.6
Ash 5% recovery	19.3 ± 0.4*	32.1 ± 1.2*

*Values for animals transferred to control diet at the age of 8 weeks till the end of the experiment.

In Experiment 2 the general appearance of rats in all groups was good. No morphological abnormalities were noticed. Mortality was less than 2% for the

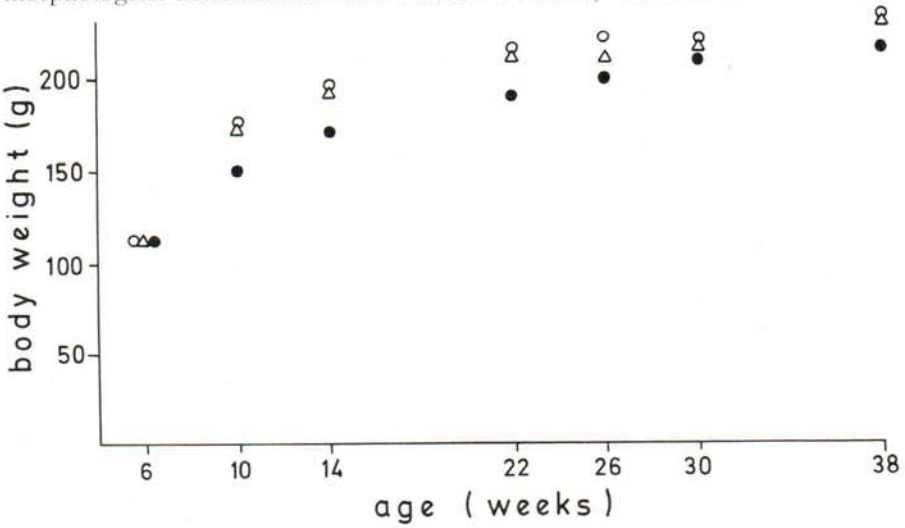

FIG. 3 – Body weights of female rats on diets with ash additive (1% and 5%) from 6 till 38 weeks of age (20–50 animals in each group); open circles – control; open triangles – 1% ash; solid circles – 5% ash.

experiment irrelevant of the dietary treatment. Treatment with 1% ash did not influence growth either in females or in males (Figures 3 and 4). Females fed the diet with 5% ash additive had slightly lower body weights than controls, whereas the inhibition of growth was again more pronounced in males. Gross pathology and a histological examination of the liver, kidneys and testicles performed at the end of the experiment i.e. at the age of 38 weeks, by routine light microscopy as in Experiment 1, showed no pathological changes relative to dietary treatment.

The growth stunting effect observed in animals on diet with ash additive was more pronounced in rats with a higher growth rate, was reversible after return to control diet and was significant only on the 5% ash level which is much higher than expected in the environment. Exposed animals showed no morphological abnormalities or other pathological changes. The results of our previous experiments indicate that the addition of ash to diet does not affect

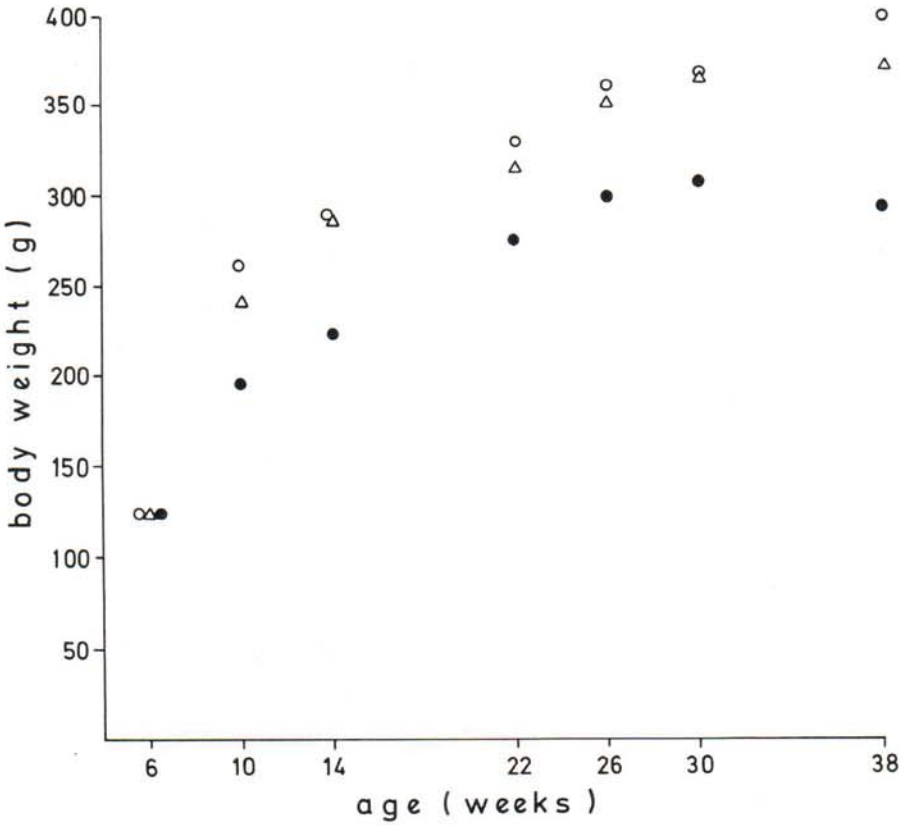

FIG. 4 – Body weights of male rats on diets with ash additive (1% and 5%) from 6 till 38 weeks of age (20–50 animals in each group); open circles – control; open triangles – 1% ash; solid circles – 5% ash.

health as indicated by normal blood values, urinary protein excretion and trace element concentration in organs of rats exposed for over 16 weeks[7]. Ash in diet had no influence on cadmium, mercury and manganese pharmacokinetics either in newborn or in adult rats[6,9]. Only the results of Blanuša and co-workers[1] show a decrease in cortical bone values in animals exposed to diets with ash additive.

In conclusion we can claim on the basis of our present and previous results[6,7,8,9] that food contaminated with ash from coal gasification is not likely to cause a severe health impairment. Experiments with a longer exposure to ash in diet which are in progress are necessary before final conclusions can be made.

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