Yeast Grown on n-Paraffin as Future Poultry Feed

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Yeast grown on n-paraffin, which will be referred to the yeast in this paper, is considered one of the most promising protein sources for domestic animals and poultry in Japan, where more than half of the protein used for feed is imported from foreign countries, and where technology of fermentation is well developed. However, production of animal protein food, i.e., meat and eggs, by feeding the yeast to poultry means that human beings eat n-paraffin, a product of petrolium refining, though very indirectly through the yeast and then through domestic animals and poultry. Therefore, the possible presence of any toxicity or any adverse effect in the yeast should be examined carefully before using the yeast as protein feed, although brewer's yeast and yeast grown on sulfite waste liquor has been used as feedstuffs for a long time.

To study the possible adverse effect in yeast, a 4-year research project was designed in 1969 and started in 1970 by the Ministry of Agriculture and Forestry, Japan. The project was completed in 1973, and most of the data obtained were published in 1975. In this paper, brief description on the experiments carried out in the project and on the related experiments are presented.

Experimental design of the national project

Since many studies had already been carried out on the nutritive value of the yeast before the time when the national project was designed, indicating that the yeast grown on n-paraffin had no ill effect on growth of rats, pigs and chicks[8], and on egg production of laying hens per year[4,5], the main purpose of the project was decided to study whether the yeast feeding causes any trouble on reproductive ability of cocks and hens over a period of several generations. It was known that the yeast as a poultry feed is low in sulfur-containing amino acid[9], high in phosphorus, low in calcium and also low in vitamin B_{12}[7], though the yeast is rich in water-soluble vitamins, protein and energy. Based on these information, the experiments, illustrated briefly in Fig. 1, had been conducted in 6

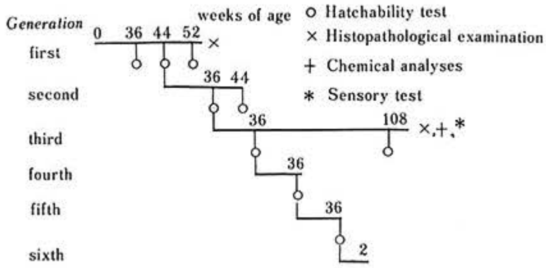

Fig. 1. Scheme of multi-generation feeding experiment

prefectural experiment stations. In each of the stations, at least 200 female and a number of male one-day-old White Leghorn chicks were divided into 2 groups, one receiving a diet containing 15% of the yeast and the other receiving a control diet. In the laying house, each of the groups of hens were mated or artificially inseminated with the cocks fed the same diet as the hens. At the age shown in Fig. 1, eggs laid by the hens fed each of the diets were incubated. Ten hens each fed each of the diets in each of the stations were sacrificed for histopathological examination, taking samples from 25 organs.

The offspring of the second hatchability test were reared as the second generation in exactly the same manner as the first generation. The offspring of the second, third and fourth generations were reared in the same way as their parents, except that 40 hens each for the fourth and fifth generation were reared instead of 100 each for the first to third generation. The offspring of the fifth generation were reared on the conventional feed in each of the stations for two weeks.

Feeding experiments with the hens of the first to the fifth generation were terminated at 52, 44 or 36 weeks of age as shown in Fig. 1, with one to three hatchability tests.

Sixty hens of the third generation fed each of the two diets were reared further for longer than two years to get the samples for histopathological examination. Before terminating this long-term feeding experiment, one hatchability test was carried out and samples of the meat and eggs for chemical analyses and for taste test were obtained.

Four kinds of yeast grown on n-paraffin from four domestic manufacturers were used in this experiment, of which chemical and amino acid compositions and nutritive value were determined in the author's laboratory beforehand[3]. Since the yeast is rich in odd-numbered fatty acids[6], the lipid in the yeast was extracted by hot methanol and chloroform. The extract had no adverse effect on growth of chicks[14].

Results of multi-generation feeding experiments

The performance of the hens of each generation on the four kinds of yeast was analyzed statistically. No significant difference was observed between the hens on four kinds of yeast, and the effects of yeast feeding was similar among five generations. Therefore, the data are combined irrespective of the kind of yeast and generation of the hens, and presented in Table 1[13,15-17,21].

Table 1. Performance of hens in multi-generation test

	Control	Yeast
No. of chicks[1]	2,811	2,797
At 20 weeks of age		
Body wt. gain kg	1.45	1.39**[2]
Food intake kg	8.10	7.88**
Food/gain	5.58	5.65
Viability %	96.5	96.2
Sexual maturity		
Age, 50% lay day	166	168**
Egg wt. 50% lay g	45.9	46.7**
Laying performance		
Egg production %	58.6	57.2
Feed intake g/day	108	108
Egg wt. g	52.8	52.7
Body wt., 36 weeks kg	1.79	1.74**
Viability %	95.0	96.8**
Hatchability test		
No. of egg set	23,568	23,574
Fertility %	92.3	93.6*
Hatchability %	78.6	80.7**

1 Total number of males and females.
2 Significantly different, *: 5% level: **: 1% level.

Consistent trends of slightly slower growth rate, lower feed intake, delayed maturity with heavier initial egg weight were associated with the yeast diet as summarized in Table 1. On the other hand, feed conversion (feed/gain) and viability during the growing stage were almost identical between the hens fed the two diets.

From the data of an experiment carried out later in the author's laboratory[20], it was concluded that the depressed growth and retarded sexual maturity of the chicks fed the yeast diet in this multi-generation experiment were mainly due to the unbalance in calcium and phosphorus levels in the yeast diet, resulting the lowered appetite of the chicks. When dietary nutrients levels, such as levels of energy, protein, sulfur-containing amino acids, calcium and phosphorus, as well as all the other minor nutrients are carefully adjusted, growth rate and feed intake of the chicks fed either the control or the yeast diet were almost exatcly identical[12,20].

As shown in Table 1, performance of the hens during the laying stage was almost identical between the hens fed the two diets, except that those fed the yeast diet had a significantly lighter body weight at 36 weeks of age, which was certainly the result of lighter body weight at maturity.

More than 47,000 eggs were set in incubation and better fertility and hatchability were observed on the yeast diet. The difference was small, being 1.3 and 2.1% on an average respectively, but was significant statistically.

On post-mortem and histopathological examinations, no abnormality due to yeast feeding was observed[1,19,22].

Among the data for the hens of the third generation after 36 weeks of age, only the difference in egg production was significant statistically. Average hen-housed production of the hens fed the yeast diet was 3.5% higher than that of the control diet. Since the daily

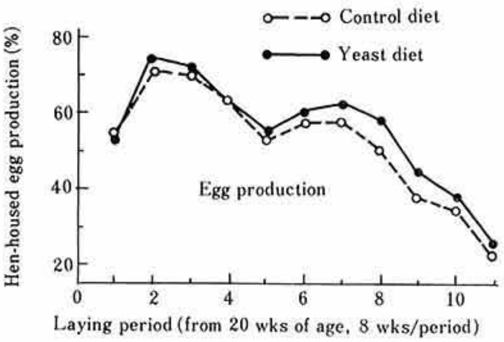

Fig. 2. Change in egg production

feed intake was almost the same, average feed conversion (feed/egg) on the yeast diet was lower than that on the control diet. Change in egg production is presented in Fig. 2. A difference in egg production between the hens fed either the two diets was apparent after the seventh period, when the hens were about one and a half years of age and the egg production started to decrease.

No difference was observed in yolk index and Haugh unit of eggs on the control and yeast diets[19]. Yolk color of the eggs on the yeast diet was slightly inferior to that on the control diet, although it was 9.1 on an average by the Roche color fan, indicating a favorable color[19]. The finding is easily understood because of the lack of pigment in the yeast.

Yeast grown on n-paraffin has a specific flavour which if transferred to the meat and eggs produced on yeast would spoil the quality as food. Accordingly, sensory tests were carried out on the meat and eggs of the hens of the third generation[18]. Each of 116 test panels were asked to taste three samples each of the meat and eggs and to indicate which was different from the other two samples. The percentage of correct answers among the persons finding an odd sample was close to the probability of answering correctly by random choice, i.e., 1/3. It was concluded that dietary yeast has little influence on the flavour of the meat and eggs.

Information on the content of nucleic acids

Table 2. Content of nucleic acid and heavy metals

sample		No. of sample	Total nucleic acid	Heavy metals			
				Hg	Cd	Pb	As_2O_3
			%	ppm	ppm	ppm	ppm
Yeast		4	9.0	.015	.07	.25	.30
Control diet		4	1.2	.02	.08	.35	.27
Meat:	Control	6	.5	.01	.01	.10	.12
	Yeast	6	.5	.01	.01	.10	.10
Egg:	Control	6	.1	.02	—	.16	—
	Yeast	6	.1	.01	—	.11	—
Sensitivity limit				.01	.01	.05	.1

Table 3. Content of polycyclic aromatics

Sample		No. of sample	3, 4-Benz-pyrene	20-Me-chol-anthrene	Pyrene	1, 2, 5, 6-Dibenz-anthracene
			ppb	ppb	ppb	ppb
Yeast		4	.01—.18	—[1]	—	+[2]
Control diet		4	.09[3]	—	—	—
Meat:	Control	6	—	—	—	—
	Yeast	6	—	—	—	—
Egg:	Control	6	—	—	—	—
	Yeast	6	—	—	—	—
Sensitivity limit			.05	10	10	10
Detection limit			.01	1	1	1

1 Not detected.
2 Over detection limit and under sensitivity limit.
3 Value of one sample. Values of the other three were +.

and heavy metals in the yeast and the control diet, and in the meat and eggs on either the control or yeast diet is presented in Table 2, and that on polycyclic aromatic compounds in Table 3.

Discussion

Since the yeast grown on n-paraffin is a novel protein source, anxiety has been expressed on the safety of the meat and eggs produced on the yeast. Possible toxic substances derived from raw materials for yeast fermentation, such as polycyclic aromatic compounds, which are suspected to be carcinogenic, and heavy metals, does not increase their content in the meat and eggs over the levels in those on the control diet as shown in Tables 2 and 3. Among the substances produced by the yeast itself, nucleic acids, which are suspected to cause human gout, has no influence on the nucleic acids content of the meat and eggs as shown in Table 2. Odd-numbered fatty acids are naturally distributed in animal body and are metabolized normally via propionyl Co. A, so that they have no adverse effect[2]. Some people are discussing further that some unidentified substance in the yeast, not determined in the project mentioned above, might be harmful for humans through meat and eggs. One of the purposes of the multi-generation experiment is to study the possibility of such substance. As shown in Table 1 and Fig. 2, no evidence was obtained indicating the presence of such unidentified toxic substance.

High hatchability of the eggs on the yeast diet should be pointed out. Since almost all of deformed chicks can not hatch by breaking their egg shell, higher hatchability on the yeast diet than that on the control indicates little possibility of teratogenic effect of the yeast. Furthermore, since one fertile ovum grows to baby chicks during 21 days by taking only egg yolk and egg white to food, there may be no trouble to take such an egg as food for human.

Besides the possible adverse effect of the yeast, which is unlike to exist as discussed above, unknown vital factor or factors in the yeast is indicated to keep high viability with high egg production. The factor is especially effective when the hens were suffered from Marek's disease, and when the hens were getting older. The findings are very meaningful in practical meat and egg production.

Summary

Research works carried out in Japan on yeast grown on n-paraffin by Japanese manufactures were briefly introduced.

The followings conclusions were obtained.

1. Yeast grown on n-paraffin is an excellent source of protein, energy and phosphorus for poultry, except sulphur amino acids and vitamin B_{12} of which content in yeast is low for poultry feed, resembling the nutritive nature of soybean meal.

2. No evidence was obtained indicating that the yeast contains such a large quantity of toxic substance that the meat and eggs produced by the yeast feeding are injurious to human health. No data was obtained suggesting that the yeast feeding is unfavourable to production of meat and eggs of good quality.

3. It is suggested that the yeast contains some vital factor or factors which keeps hens on the yeast healthy and productive.

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