Strain Difference in the Embryonic Viability in the Rat Fed the High Energy Diet

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(Received September 19, 1974)

To elucidate the mechanism of and to study the method preventing the high embryonic loss in swine, the authors are investigating to obtain some basic informations on this aspect using rats.

The embryonic loss in swine is estimated to be 30 to 50% on full term of pregnancy¹⁾. Approximately 70% of the total embryonic loss occurs prior to day 25 of pregnancy²⁾.

High energy intake in swine has usually led to an increased ovulation rate and a higher percentage of embryonic loss^{3,4)}. Approximately 70% of the total loss (32%) in gilts fed the high energy diet occurred prior to day 25 of pregnancy⁵⁾. The authors found that most of the total embryonic loss in the rats fed the high energy diet occurred in the first third of pregnancy⁶⁾ and the loss during this stage was affected by dietary calorie-protein ratios⁷⁾.

This study was designed to determine the strain difference in the embryonic viability in the rats fed the high energy diet.

Materials and Methods

Two diets differing mainly in digestible energy contents were used in this experiment. The high energy diet was composed of casein 22.6%, corn starch 35.6%, glucose 5.0%, cellulose powder 5.1%, soybean oil 27.0%, vitamin mixture 0.5%, mineral mixture 4.0%, choline chloride 0.1% and Cr_2O_3 0.1%. The low energy diet was composed of casein 22.6%, corn starch 19.4%, glucose 5.0%, cellulose powder 43.3%, soybean oil 5.0% and the same amount of other ingredients as in the high energy diet. Crude protein content in both diets was 20.2%, and digestible energy contents were 5.0 and 2.7 kcal/g, respectively.

Three in-breds of the Wistar, Donryu and Sprague-Dawley strains (purchased from Matsumoto Jikken Doubutsu Kenkyusho, Kimizu-shi, Chiba) and their crossbreds were used in this experiment. The female rats (205~240 g in body weight) were placed with mature male overnight from about 5 p.m. on the day when the rats showed pro-estrus, and vaginal smears were checked for finding sperms on the next morning. Feeding of experimental diets started at about 10 a.m. on the day sperms were noted in vaginal smears (day 0 of pregnancy). The rats were housed in individual cages after mating. The feeding level was 15 g a day. All the rats completely consumed the diet fed. Animals were killed on day 7 of pregnancy. Uteri and ovaries were inspected for the number of implants and corpora lutea, respectively. The survival rates were expressed as percentage of the number of implants to the number of corpora lutea.

Strain Difference in the Embryonic Viability

Table 1. Strain difference in the embryonic viability

$\text{♀} \times \text{♂}^1$	Energy level	No. of rats	No. of corpora lutea	No. of implants	Survival rate
					%
D $\times$ D	Low	6	15.7 $\pm$ 1.5 a ²	14.8 $\pm$ 1.0 a, b ²	94.9 $\pm$ 4.3 a ²
D $\times$ D	High	15	16.3 $\pm$ 1.2 a	13.6 $\pm$ 1.4 a	83.2 $\pm$ 4.4 b
D $\times$ W	High	8	15.5 $\pm$ 1.5 a	13.5 $\pm$ 1.6 a	87.3 $\pm$ 8.0 a, b
D $\times$ S D	High	9	15.7 $\pm$ 1.2 a	15.4 $\pm$ 0.9 b	99.3 $\pm$ 2.0 c
S D $\times$ D	High	7	14.1 $\pm$ 0.7 a	13.1 $\pm$ 0.7 a	93.2 $\pm$ 4.2 a
S D $\times$ W	High	7	13.4 $\pm$ 0.8 a	13.0 $\pm$ 0.6 a	97.0 $\pm$ 3.8 a
S D $\times$ S D	High	8	14.6 $\pm$ 1.4 a	13.8 $\pm$ 1.5 a	94.0 $\pm$ 4.0 a
W $\times$ D	High	6	14.3 $\pm$ 1.9 a	13.7 $\pm$ 2.0 a	95.4 $\pm$ 5.5 a
W $\times$ W	High	11	13.9 $\pm$ 1.4 a	13.0 $\pm$ 1.4 a	93.4 $\pm$ 2.3 a
W $\times$ S D	High	6	14.3 $\pm$ 1.0 a	13.8 $\pm$ 0.8 a	96.7 $\pm$ 5.3 a

1. D: Donryu, W: Wistar, SD: Sprague-Dawley
2. Mean $\pm$ S.D. Means within a same column not followed by the same letter (a, b or c) are significantly different ($P < 0.05$)

Results and Discussion

The results are shown in Table 1. The results distinctly demonstrated that the decrease rate of the embryonic viability in the inbred line of the Donryu strain rats fed the high energy diet was markedly larger than the other inbred lines or cross breds. However, this loss in the Donryu strain rat was significantly ($P < 0.001$) decreased by the cross-breeding of Donryu strain (♀) $\times$ Sprague-Dawley strain (♂). This fact may be explained by heterosis. The embryonic survival rate in the cross bred of the Donryu strain (♀) $\times$ Wistar strain (♂) was slightly increased compared with that in the inbred line of the Donryu strain. Further, the embryonic survival rate in the inbred line of the Donryu strain rats fed the high energy diet was significantly ($P < 0.001$) lower than that of this strain fed the low energy diet. This result clearly demonstrates that the large embryonic loss in this strain is caused by the effect of feeding of the high energy diet.

These results suggest that elucidating the genetical differences between the strains showing the largest and the smallest responses in the embryonic loss in the rats fed the high energy diet holds a key to solve the mechanism of the embryonic loss caused by feeding of the high energy diet.

The authors are greatly indebted to Dr. K. KAMEOKA, Head of Nutrition, for supervision, Drs. T. SUGIE and T. KOMIYAMA in this institute and Dr. K. MIURA in National Institute of Animal Health for helpful discussion. The authors are also indebted to Miss T. KISHI for her help in language and Mrs. F. USUI for care of the animals.

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SAITOH and TAKAHASHI

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