Ability of Glycol Esters of Fatty Acid Inducing Encephalomalacia in Growing Chicks

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Free fatty acids and their glycerides with medium carbon chain length, i.e., from 6 to 14, have been reported to have ability to induce vitamin E deficiency, such as encephalomalacia, exudative diathesis and decreased plasma tocopherol level, in the chicks fed vitamin E-deficient diet.1-3) On the other hand, during the experiments carried out in this laboratory to find the possibility of using chemicals as energy source for domestic animals and poultry, it was found that 1,2-propanediol dilaurate4) and 1,3-butanediol dioctylate5) at dietary level of 10 and 8%, respectively, induced no encephalomalacia at all during the experimental period of 8 weeks.

Since the preliminary experiment in this laboratory revealed that White Leghorn chicks showed the symptoms of encephalomalacia and increased fragility of erythrocytes after feeding 1,2-propanediol dilaurate at dietary level of 15% for longer than 4 weeks, one of the reasons of the discrepancy among the observations mentioned above is suspected to be the difference in dietary level of medium carbon chain fatty acids. Another one of the reasons may be the difference in vitamin E level of basal diet used by various authors. The basal diet used in this laboratory is composed of natural feed ingredients and contains a certain amount of natural vitamin E as mentioned in the previous paper.6) Therefore, the basal diet used in this laboratory is not vitamin E-free as those used in the other laboratories.1-3)

Accordingly, experiments were designed and conducted to compare the ability of glycol esters of medium chain fatty acids and dilauryl succinate to induce encephalomalacia and to increase fragility of the erythrocytes of chicks.

**EXPERIMENTAL**

Two experiments were carried out. In Expt. 201, it was designed to check whether the samples, i.e., 1,2-propanediol dilaurate or 1,3-butanediol dioctylate, have the ability to induce encephalomalacia and at the same time to compare their nutritive value at dietary level of 15 and 20% with that of soybean oil. In Expt. 204, the ability of the samples to induce encephalomalacia was compared with that of dilauryl succinate. Composition of experimental diet in these experiments is shown in Table I.

![Fig. 1](image-url)  
**Fig. 1.** Mortality Curve of Chicks on Esters at Dietary Level of 15% in Expt. 204.
- Males on dilauryl succinate (initial number of chicks 28)  
- Females on dilauryl succinate (initial number of chicks 29)  
- Males on 1,2-propanediol dilaurate (initial number of chicks 24)  
- Females on 1,2-propanediol dilaurate (initial number of chicks 29)  
- Males on 1,3-butanediol dioctylate (initial number of chicks 30)  
- Females on 1,3-butanediol dioctylate (initial number of chicks 29)
TABLE II. GROWTH RESPONSE, INCIDENCE OF ENCEPHALOMALACIA AND HEMOLYSIS OF CHICKS ON GLYCOL ESTERS IN EXPT. 201

<table>
<thead>
<tr>
<th>Sex and sample</th>
<th>For 4 weeks</th>
<th>Encephaloma-</th>
<th>Hemolysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Body wt.</td>
<td>Feed</td>
<td>34 days</td>
</tr>
<tr>
<td></td>
<td>gain</td>
<td>intake</td>
<td>of age</td>
</tr>
<tr>
<td>Male:</td>
<td>g</td>
<td>g/kg</td>
<td>%</td>
</tr>
<tr>
<td>Soybean oil-15</td>
<td>610</td>
<td>874</td>
<td>698</td>
</tr>
<tr>
<td>1,2-Propanediol dilaurate-15</td>
<td>509</td>
<td>745</td>
<td>683</td>
</tr>
<tr>
<td>1,2-Propanediol dilaurate-15</td>
<td>-20</td>
<td>432</td>
<td>678</td>
</tr>
<tr>
<td>1,3-Butanediol dioctylate-15</td>
<td>462</td>
<td>772</td>
<td>598</td>
</tr>
<tr>
<td>1,3-Butanediol dioctylate-15</td>
<td>-20</td>
<td>477</td>
<td>693</td>
</tr>
<tr>
<td>Female:</td>
<td>529</td>
<td>786</td>
<td>673</td>
</tr>
<tr>
<td>Soybean oil-15</td>
<td>480</td>
<td>749</td>
<td>640</td>
</tr>
<tr>
<td>1,2-Propanediol dilaurate-15</td>
<td>-20</td>
<td>401</td>
<td>599</td>
</tr>
<tr>
<td>1,3-Butanediol dioctylate-15</td>
<td>456</td>
<td>722</td>
<td>632</td>
</tr>
<tr>
<td>1,3-Butanediol dioctylate-15</td>
<td>-20</td>
<td>436</td>
<td>662</td>
</tr>
</tbody>
</table>

a) Sample and its dietary level.
b) Number of dead chicks/initial number of chicks.
c) No estimation was done.

tmmercial hatchery, and reared as mentioned previously.4,5) Number of chicks fed each of the experimental diets are presented in Table II and Fig. 1. Encephalomalacia was diagnosed by the development of typical symptoms described previously,7) which was confirmed by the post-mortem examination of the brain.

At 30 days of age, 2 chicks each from the lots fed the diet containing 15% of soybean oil, 1,2-propanediol dilaurate or 1,3-butanediol dioctylate in Expt. 204 were selected at random to determine the susceptibility of the erythrocytes to hydrogen peroxide by the procedure modified in this laboratory.8)

RESULTS

Average body weight gain, feed intake and feed efficiency (gain/feed) for 4 weeks, and mortality due to encephalomalacia at 34 days of age in Expt. 201 are summarized in Table II. Comparing with the data on soybean oil, both of 1,2-propanediol dilaurate and 1,3-butanediol dioctylate at high dietary level of 15 and 20% retarded growth rate and depressed feed intake. The difference in body weight gain and feed intake between the chicks on soybean oil and the glycol esters was significant statistically (P<0.01). Little decrease in feed efficiency was observed in the chicks on the glycol esters, suggesting that the esters taken by the chicks was utilized almost equally to soybean oil. The findings agree with those reported previously.4,5)

Thirteen and 19 chicks on 1,2-propanediol dilaurate and 1,3-butanediol dioctylate, respectively, died of encephalomalacia within 34 days. Mortality of the chicks on 1,2-propanediol dilaurate and 1,3-butanediol dioctylate was significantly higher than that on standard soybean oil at 34 days of age (P<0.05 and P<0.01, respectively).

Hemolysis of the chicks on the glycol esters was higher than that of 99% upper limit of normal erythrocytes, i.e. 3.1%,8) except female chicks on 1,2-propanediol dilaurate, of which hemolysis was at normal value. As expected, hemolysis value of the chicks on soybean oil was at normal level.

Mortality of the chicks due to encephalomalacia in Expt. 204 is plotted against age of the chicks in Fig. 1. Body weight gain, feed intake and feed efficiency of the chicks for 4 weeks in Expt. 204 were similar to those corresponding in Expt. 201. Mortality of the chicks of both sexes on dilauryl succinate was significantly higher (P<0.01) than that on 1,2-propanediol dilaurate and 1,3-butanediol dioctylate at 31 days of age. Mortality on the latter 2 esters was comparable with each other.

As expected from the findings reported already,9) encephalomalacia first appeared at 13 days of age on male chicks on dilauryl succinate and the occurrence of encephalomalacia in female chicks was about 2 days later than that on male chicks. Unlike dilauryl succinate, 1,2-propanediol dilaurate and 1,3-butanediol dioctylate induced encephalomalacia at 19 and 27 days of age on male chicks, respectively, as shown in Fig. 1. The appearance of the symptoms on female chicks on the glycol esters was about 3 days later than that on the corresponding male chicks.
DISCUSSION

The findings from these two experiments clearly revealed that glycol esters of fatty acid of medium carbon chain have an ability to induce encephalomalacia and increase fragility of the erythrocytes, the typical symptoms of vitamin E deficiency. However, the ability of the esters is much weaker than that of dilauryl succinate. Since 1,3-butanediol4) and 1,2-propanediol10) at 10% dietary level, which are much higher than the dietary levels of the glycol moiety of the esters in these experiments, did not induce encephalomalacia at all, the observed effect of the esters is certainly due to fatty acid moiety of the esters. The findings agree with those reported previously with glycerol esters.1)-3)

It should be pointed out that the experimental diet was mainly composed of yellow corn, soybean meal and fish meal with considerable amount of natural vitamin E, and that main component of fatty acid composition was linoleic acid as reported previously.6) Therefore, esters of medium carbon chain fatty acids are suspected to counteract the effect of natural vitamin E as dilauryl succinate does.6)

Century and Horwitt1) suspected that medium carbon chain fatty acids might induce vitamin E deficiency through its "sparing" effect of linoleic acid, the former being metabolized faster than the latter. This explanation will be hard to be applied to the effect of dilauryl succinate to induce vitamin E deficiency, counteracting the effect of dietary vitamin E in the presence of large amount of linoleic acid.6)

Fragility of the erythrocytes of 2 female chicks on 1,2-propanediol dilaurate was normal. However, the finding may not indicate that fragility of the erythrocytes of all of the chicks on the ester is normal, because the determination was carried out at 30 days of age when no chicks showed any symptoms of encephalomalacia.

REFERENCES
2) H. Fisher and H. Kaunitz, ibid., 120, 175 (1965).