1. Introduction

The main effects of insulin on adipose tissue are:
- increase of the activity of lipogenic enzymes (COORE et.al.,1971; HALESTARP and DENTON, 1973).
- reduction of the lipolysis (FAIN et.al., 1966; DESAI et.al., 1973).

All these factors increase the fat deposition.

Also Thyroidea hormones show an influence on adipose tissue metabolism. For example in reduced thyroid status the lipolytic activity is impaired (CRAIG et.al., 1978; YORK et.al., 1978). Therefore it may be expected that in pigs where adipose tissue is the main site of de novo lipogenesis (O'HEA and LEVEILLE, 1969) insulin will increase and triiodothyronine (T₃) will reduce fat deposition. In German Landrace pigs these hypotheses could be confirmed by ENSINGER et.al. (1981). The authors found a highly positive correlation between plasma insulin-levels 45 minutes after feeding and percentage of fat cuts of 0.34. The correlation between plasma T₃-levels and percentage of fat cuts was -0.26 and significant.

Differences in insulin secretion have been found in lean and obese pigs where lean pigs have shown lower insulin levels. ENSINGER et.al. (1979) and ROGDAKIS et.al. (1979) postulated that the lean Piètrain pigs can be in a prediabetic status. From this it can be expected that the traits insulin secretion and fat deposition are genetically correlated.

The aim of this study is to examine correlated effects on secretion of insulin and plasma T₃-levels in pigs selected for reduced fat deposition.
FIG. 1. CORRELATIONS AND REGRESSIONS BETWEEN INSULIN AND FOOD INTAKE PER WEIGHT (U'-LINE PIGS AT 100 DAYS OF AGE)

linear coefficients: \( b = .003 \)

\( r = .053 \)

\( b_{yx} = .013 \)

\( y = 33.9 + 0.138x - 0.000072x^2 \)

FIG. 2. CORRELATIONS AND REGRESSIONS BETWEEN INSULIN AND FOOD INTAKE PER WEIGHT (E'-LINE PIGS AT 130 DAYS OF AGE)

linear coefficients: \( b = .096 \)

\( r = .311 \) (p<0.05)

\( b_{yx} = .095 \)

\( y = -23.8 + 0.405x - 0.00021x^2 \)
2. Materials and Methods

From a selection experiment 245 animals of the 5th generation were analysed. The animals belonged to either of 3 lines:
- E\(^-\): selection for low activity of NADPH-generating enzymes in backfat (biopsies at 90 and 120 days of age)
- E\(^+\): selection for high activity of NADPH-generating enzymes in backfat
- U\(^-\): selection for low backfat thickness at 85 kg of weight (ultrasonic measurement)

The experimental design was described in detail by ROGDAKIS (1982). After a five generation period of selection the E\(^-\) and E\(^+\) lines show highly significant differences as well in enzyme activities as in backfat thickness. The direct response on backfat thickness in the U\(^-\) line is 0.13 cm larger than the correlated response on this trait in the E\(^-\) line. The average phenotypic standard deviation in backfat thickness was 0.17 cm (unpublished data).

For the present investigations pigs with an age of 100 days and 130 days were fasted for 16 hours. Insulin secretion was induced by feeding all pigs for 45 minutes. Then the blood sample was taken from the vena jugularis.

Plasma insulin and T\(_3\) were measured by radio-immuno-assay. Further more glucose and urea were determined by enzymatic methods. Sex and line effects were determined by least-squares-analyses (HARVEY, 1977).

3. Results and Discussion

The results of the blood parameters are represented in table 1.

Table 1: LSQ-means of the blood parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Age days</th>
<th>E(^-)</th>
<th>E(^+)</th>
<th>U(^-)</th>
<th>E(^-)-E(^+)</th>
<th>E(^-)-U(^-)</th>
<th>E(^+)-U(^-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulin ((\mu U/ml))</td>
<td>100</td>
<td>93.96</td>
<td>198.49</td>
<td>94.59</td>
<td>0.001</td>
<td>NS</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>130</td>
<td>116.48</td>
<td>159.51</td>
<td>100.63</td>
<td>0.001</td>
<td>NS</td>
<td>0.001</td>
</tr>
<tr>
<td>T(_3) (ng/ml)</td>
<td>100</td>
<td>0.88</td>
<td>0.75</td>
<td>0.88</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>130</td>
<td>0.71</td>
<td>0.68</td>
<td>0.79</td>
<td>NS</td>
<td>NS</td>
<td>0.05</td>
</tr>
<tr>
<td>Urea (mg/100 ml)</td>
<td>100</td>
<td>26.57</td>
<td>31.19</td>
<td>24.45</td>
<td>0.001</td>
<td>0.05</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>130</td>
<td>28.64</td>
<td>30.11</td>
<td>25.13</td>
<td>NS</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>Food intake/100</td>
<td>100</td>
<td>40.46</td>
<td>44.46</td>
<td>44.80</td>
<td>0.05</td>
<td>0.05</td>
<td>NS</td>
</tr>
<tr>
<td>(g/W*)</td>
<td>130</td>
<td>42.08</td>
<td>36.98</td>
<td>46.36</td>
<td>0.05</td>
<td>NS</td>
<td>0.001</td>
</tr>
</tbody>
</table>

p* Significance of Multiple-Range-Test
Selection for low or high activity of NADPH-generating enzymes in backfat result in significant differences in plasma levels of insulin, T₃, and urea. After a five generation period of selection the pigs of the E⁻line showed higher insulin secretion, lower T₃, and higher urea levels in the plasma, compared with the E⁺-line pigs. The values of the U⁻line pigs were similar to those of the E⁻line pigs.

In the present investigation insulin secretion was induced by food intake. The food intake/W* was determined to analyse the influence of food intake on the plasma insulin level. At 100 days of age food intake/W* of the E⁻line pigs was about ten per cent lower compared with E⁺-line and U⁻line pigs. At 130 days of age the E⁺-line pigs showed the lowest food intake/W*. However the results in food intake/W* cannot explain the high differences in insulin secretion between the two enzyme lines. The correlation and regression coefficients between food intake corrected for weight and insulin secretion were calculated separately for lines and ages.

With exception of the E⁺-line pigs at 130 days of age the correlation and regression coefficients are very low and not significant. For example in Figure 1 the relations between food intake and insulin secretion for the U⁻line pigs at 100 days are represented. In Figure 2 the relations between food intake and insulin secretion of the E⁺-line pigs at 130 days are shown, where the correlation coefficients are significant. This means that with low food intake/W* an influence of the criterion food intake on insulin secretion cannot be excluded. But generally the quantity of food intake cannot explain the very high differences in insulin secretion between the selection lines, especially between the two enzyme lines. It can be assumed that the differences in insulin secretion between the two enzyme lines are affected by selection and therefore of genetic origin.

Also the plasma T₃-levels are influenced by selection. The mean of the U⁻line pigs is above and the mean of the E⁻line pigs below the average mean. These results are not in contradiction with the influences on lipolysis by T₃ as mentioned above.

Urea was measured as a parameter of protein retention. The E⁺-line pigs showed the highest mean level in urea and the U⁻line pigs the lowest one. From this it can be concluded that the E⁺-line pigs had a lower protein retention than pigs from the other two lines. This hypothesis needs further experiments to be well-established.

To summarize it can be concluded that selection over a five generation period for high or low activity of NADPH-generating enzymes in backfat or low backfat thickness result in high differences of insulin secretion and in significant differences in plasma levels of T₃ and urea.

These investigations will be continued to estimate the heritability coefficients of insulin secretion and the phenotypic and genetic correlations among insulin secretion, enzyme activity, backfat thickness and food intake.
SUMMARY

The main effects of insulin on adipose tissue are stimulation of glucose passage in adipocytes, stimulation of lipogenic enzymes, and inhibition of lipolysis. Triiodothyronine ($T_3$) takes part in lipolysis. In pigs the principal site for fatty acid synthesis is the adipose tissue. It can be expected that there exist positive correlations between fat deposition and insulin secretion and negative correlations between fat deposition and plasma $T_3$-level. 

For the present investigation of insulin-secretion and plasma $T_3$-level German Landrace pigs of the 5th generation of a selection experiment were used at an age of 100 and 130 days. The selection criterion was high (E-line) and low (E-line) activity of the NADPH-generating enzymes in backfat. A third line was selected for low backfat (U-line; ultrasonic measurement). Between the enzyme-line pigs high significant differences in enzyme activities and backfat thickness were measured. The E-line pigs showed higher insulin secretion ($p<0.001$) and lower plasma-$T_3$ levels ($p<0.05$) compared to E-line pigs. The U-line pigs showed hormone levels similar to those of the E-line pigs. The differences between the selection lines are discussed.

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Resumen

Los efectos principales de la insulina en el tejido adiposo consisten en la estimulación del paso de glucosa en células adiposas, en la estimulación de enzimas lipogenas y en la inhibición de la lipólisis. Triyodotironina ($T_3$) tiene influencia en la lipólisis. En porcinos el tejido adiposo es el sitio de importancia principal para la síntesis de ácido graso. Se espera que existan correlaciones positivas entre la deposición de grasas y la secreción de insulina tanto como correlaciones negativas entre la deposición de grasas y la concentración de $T_3$ en el plasma. Las investigaciones presentes sobre la secreción de insulina y la concentración de $T_3$ en plasma se realizó en cerdos de 100 y 130 días de edad de la raza "Deutsche Landrasse" de la 5ta generación de un experimento de selección. La selección se basó en alta (línea E+) o baja (línea E-) actividad de enzimas generadoras de NADPH en el tocino dorsal. Una tercera línea se seleccionó para disminución del diámetro del tocino dorsal (línea U-; medición ultrasonida). Las líneas E+ e E- manifestarán diferencias sumamente significantes en la actividad enzimática y diámetro del tocino dorsal. Cerdos de la línea E+ secretaron más insulina ($p<0.001$) y tenían concentraciones de $T_3$ en plasma mas bajas ($p<0.05$) en comparación con los porcinos de la línea E-. Las concentraciones hormonales de los cerdos U- e E- eran parecidos. Se discute las diferencias entre las líneas selectivas.
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