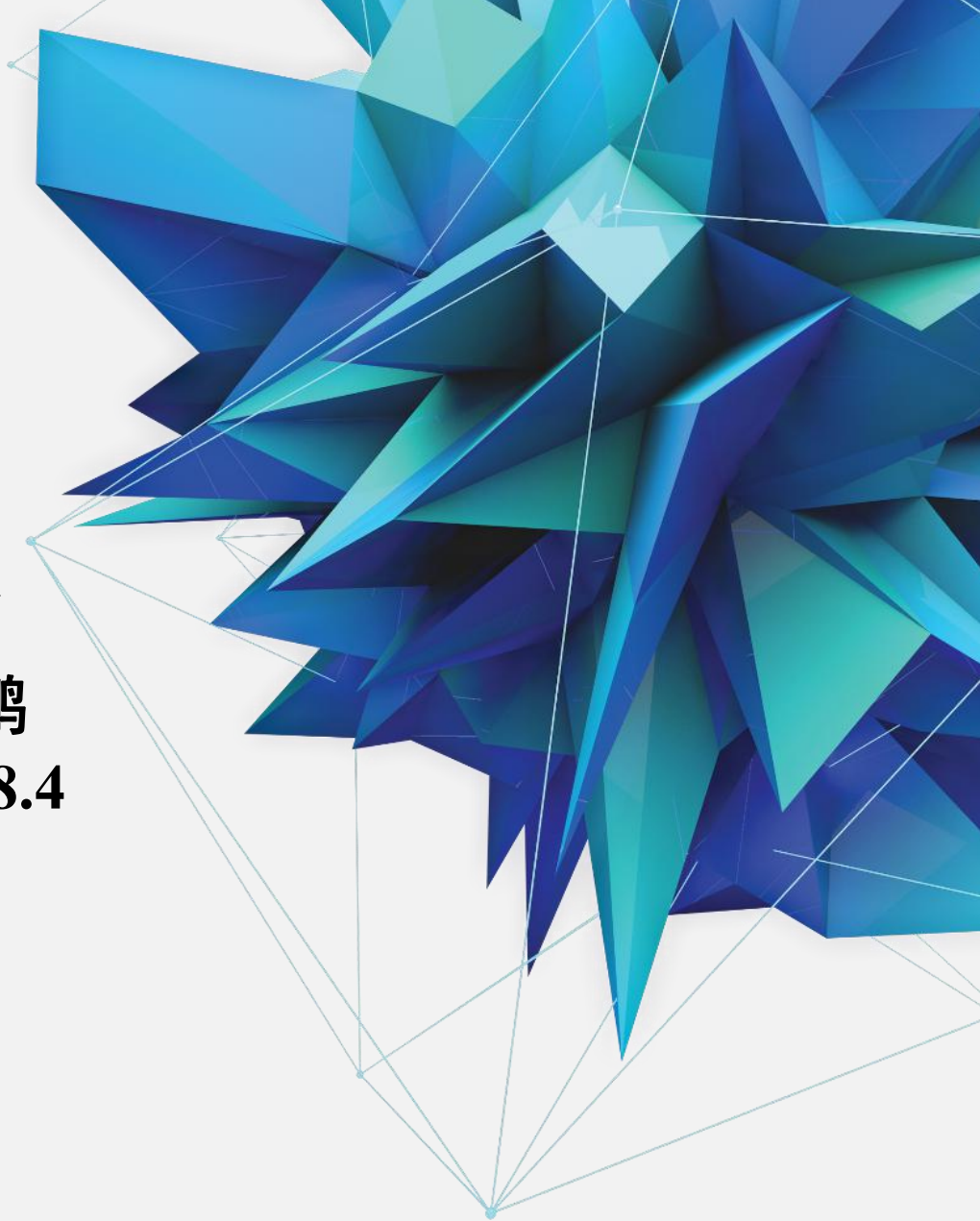
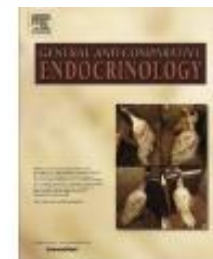


# 读书报告

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汇报人：邓大鹏  
时 间：2018.8.4





## Different regulation of insulin on glucose and lipid metabolism in 2 strains of gibel carp



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### ABSTRACT

To test the hypothesis that response to insulin by regulating glucose and lipid metabolism in gibel carp A strain may be different from that in DT strain, bovine insulin was injected into both strains of gibel carp after previous fasting for 48 h. The results showed that insulin induced hypoglycemia at 3 h in 2 strains, and that this was coupled with increased expression of glucose transporters (GLUT2 in the liver and GLUT1, GLUT4 in the muscle) and glycolytic enzyme (HK2 in the muscle) in both strains. Insulin induced increased glycolysis (GK) and fatty acid oxidation (ACO3 in the liver and CPT1a, ACO3 in the muscle) in the DT strain. Conversely, very strong lipogenic capacity, as indicated by higher mRNA levels of transcription factor of fatty acid anabolism (SREBP1) and lipogenic enzymes (ACC, ACLY, and FAS) and decrease lipolytic capacity as indicated by lower mRNA levels of fatty acid oxidation enzymes in the liver (ACO3) and muscle (CPT1a and ACO3) detected in the A strain after insulin injection. Higher plasma insulin levels and decreased plasma free fatty acid levels were detected at 8 h post insulin injection in A strain induced hypoglycemia. However, plasma glucose levels returned to baseline and no effect on fatty acid

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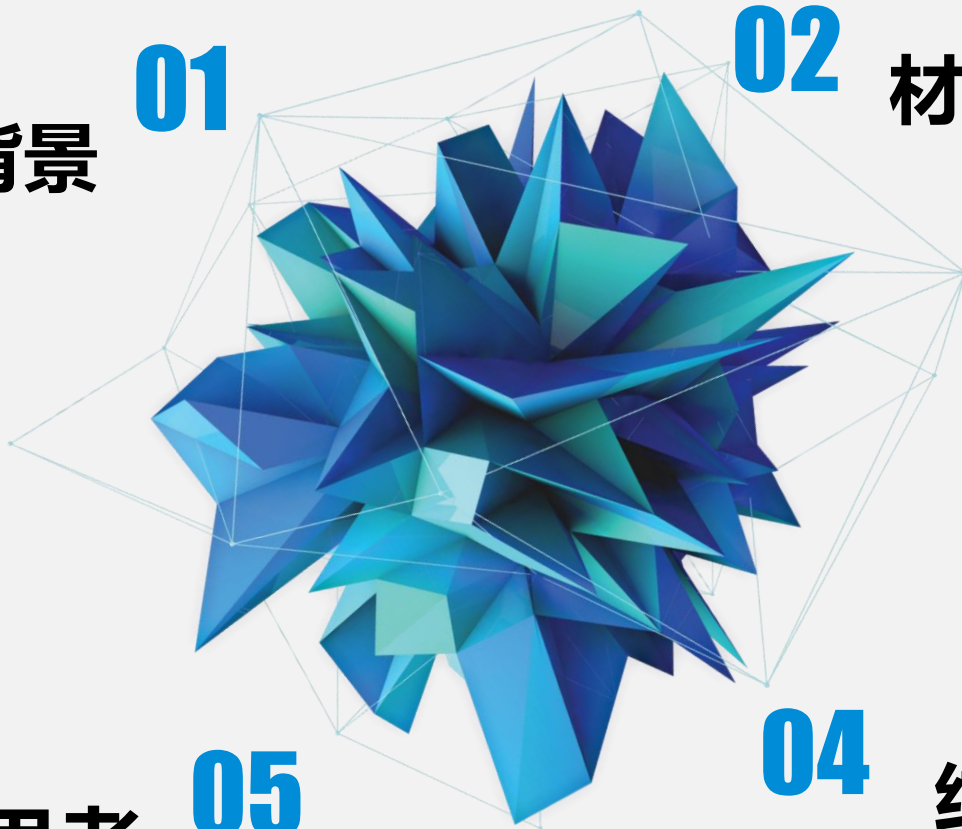
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# 研究背景

鲫鱼（*Carassius gibelio*）是中国最重要的经济淡水养殖品种之一，不同品种的鲫鱼，存活率、生长速度等存在差异，这种差异可能与其自身利用碳水化合物能力有关。



胰岛素是胰脏内胰岛 $\beta$ 细胞分泌的一种蛋白质激素，在葡萄糖的代谢过程中具有重要的作用。本文以CASⅢ品种、Dongting品种为研究对象，采用腹腔注射胰岛素的方法，探究胰岛素对糖代谢和脂代谢的调节作用。



# 材 料 与 方 法

实验鱼, A品种 ( $48.4 \pm 1.6\text{g}$ ),  
DT品种 ( $58.4 \pm 1.3\text{g}$ )

禁食48h, 腹腔注射牛胰岛素( $100\mu\text{l}/100\text{g}$ )或等  
体积的生理盐水

注射后0、3、8、12h, 抽血、取肝脏和肌肉组织

糖  
原  
含  
量

血  
液  
指  
标

葡  
萄  
糖  
转  
运  
蛋  
白

糖  
酵  
解

糖  
异  
生

脂  
肪  
合  
成

脂  
肪  
酸  
氧  
化





## 研究内容与结果

**Table 1**  
Primers used for PCR

Function classifications	Gene name	Sense and antisense primer (5'-3')	Genbank accession number	Product size
Internal reference	$\alpha$ -tubulin	TCCTTCAACACCTTCTTCAGTGAGAC AGCTGCTCAGGGTGAACAGC	JX4135181	134 bp
	Elongation factor 1 alpha (EF-1 $\alpha$ )	GTTGGAGTCAACAAGATGGACTCCAC CTTCCATCCCTGAACCAGCCCAT	AB056104	198 bp
Glycolysis	Glucokinase (GK)	GAGGAGATGCGTAAGGTGAGCT TTTCATACAGCTGATGTCCAGGTT	KX898498	167 bp
	Hexokinase 2 (HK2)	TATGAGAAGATGATCAGCGGGATGTACC ATCACACGTGCTGCTGATCAAGCCCA	KX898499	225 bp
	6-phosphofructokinase (6PFK) (Liver)	ACACCGATGCCG CAGAACCA TCGATCTCTCCGGTACATACTCG	KX898500	105 bp
	6-phosphofructo-1-kinase (6PFK) (Muscle)	TAGCTATCATGAACGTTGGAGCTCC CTTGCCTGTCCAGCCTCCAACA	KX898501	180 bp
	Pyruvate kinase (PK) (Liver)	GCATCTGTGTCTGCTGGACATCGA TGAGAGCCGTGAGAGAAGTTCAGTC	KX898502	144 bp
	Pyruvate kinase (PK) (Muscle)	ATCATGGAGGCCAGCGATGGCAT GGCTCTTGATCATGCTCTCCAACAT	KX898503	167 bp
	Glucose transport	Glucose transporter type 1 (GLUT1)	CACTGTTGTCTCTGTTTGTGG AGATTGCTATGATGCTAATGTAGGACATC	KY328741
Glucose transporter type 2 (GLUT2)		CTCGTGGATGAGCTACCTCAGCAT CCCTGACTGAAGATCTCCGCCA	KX898504	111 bp
Glucose transporter type 4 (GLUT4)		CACTCTCTGTGGCCTCTTCTCCAT TCACCAACATACATGGGCACCAATCCT	KY328742	241 bp
Gluconeogenesis	Glucose-6-phosphatase (G6Pase)	CCTTACTGGTGGTCCATGAGACT TGGGCCG GTCTCACAGGTCAT	KX898505	90 bp
	Fructose 1,6-bisphosphatase (FBPase)	CACAAATGTTACAGGTGACCAGGTGAA AATGTTGAAGAGCCATCCAGAGGGT	GU593002	193 bp
	Phosphoenolpyruvate carboxykinase (PEPCK)	AGACAAACCCTCATGCCATGGCAAC GGGTCTATGATGGGGCACTGG	KX898506	226 bp
Lipid synthesis	Sterol regulatory element binding protein 1 (SREBP1)	GGCCCTCTACTGCGTGGACA ACCACCATTGGAGTGAGGGTCAC	KX898507	194 bp
	ATP citrate lyase (ACLY)	AGTTTGGCCACGCTGGAGCTTGT CCCAGCTCATCGAAGCTCTTGG	KX898508	112 bp
	Acetyl-CoA carboxylase (ACC)	GAGCTGTCTATCAGAGGAGACTTCA GACGCTCGCCTGCATCTTCT	KF499584	139 bp
	Fatty acid synthase (FAS)	CCACACCATGACCCACAGCT CTGGGTCTTTACTGAAGGCCTCT	KF511494	158 bp
Fatty acids $\beta$ -oxidation	Carnitine palmitoyl transferase 1 isoform a (CPT1a)	GAAGCTCATCAGGCTGTGGCCTT TTCAGGAGTGAAGTCCGGAGAG	KX898509	113 bp
	Acyl-CoA oxidase 3 (ACO3)	TGTGGAGGACACGGTTACCTTGC AGTTGCTGGTCTGCTGCAGAAGG	KX898510	115 bp

# 血浆代谢物水平

Plasma metabolite	Post-injection time	A strain		DT strain		P		
		Saline	Insulin	Saline	Insulin	Injection	Strain	I × S
Insulin (µg/L)	3 h	-	196.44 ± 11.95 <sup>A</sup>	-	166.89 ± 8.19 <sup>A</sup>	-	0.07	-
	8 h	-	17.39 ± 4.05 <sup>B</sup>	-	0.69 ± 0.09 <sup>B</sup>	-	<0.01	-
	12 h	-	3.34 ± 0.77 <sup>C</sup>	-	0.61 ± 0.09 <sup>B</sup>	-	<0.01	-
Glucose (mmol/L)	0 h	1.70 ± 0.08	1.70 ± 0.08 <sup>A</sup>	2.33 ± 0.18	2.33 ± 0.18 <sup>A,B</sup>	-	0.03	-
	3 h	2.19 ± 0.14 <sup>b</sup>	1.12 ± 0.15 <sup>cB</sup>	3.13 ± 0.37 <sup>a</sup>	0.96 ± 0.15 <sup>cC</sup>	<0.01	0.23	0.03
	8 h	2.09 ± 0.09 <sup>b</sup>	0.67 ± 0.15 <sup>cB</sup>	2.68 ± 0.11 <sup>a</sup>	2.56 ± 0.18 <sup>aA</sup>	<0.01	<0.01	<0.01
	12 h	2.06 ± 0.15 <sup>b</sup>	2.13 ± 0.18 <sup>bA</sup>	2.71 ± 0.09 <sup>a</sup>	1.92 ± 0.14 <sup>bB</sup>	0.02	0.16	<0.01
Triglycerides (mmol/L) 甘油三酯	0 h	0.62 ± 0.12	0.62 ± 0.12	2.18 ± 0.04	2.18 ± 0.04	-	<10 <sup>-4</sup>	-
	3 h	0.60 ± 0.20	0.75 ± 0.17	2.10 ± 0.12	2.24 ± 0.08	0.35	<0.01	0.96
	8 h	0.43 ± 0.12	0.51 ± 0.11	1.99 ± 0.06	2.35 ± 0.07	0.03	<0.01	0.14
	12 h	0.61 ± 0.16	0.82 ± 0.12	2.38 ± 0.05	2.49 ± 0.08	0.16	<0.01	0.67
Free fatty acids (mEq/L)	0 h	0.25 ± 0.04	0.25 ± 0.04 <sup>A</sup>	0.64 ± 0.06	0.64 ± 0.06 <sup>B</sup>	-	<10 <sup>-3</sup>	-
	3 h	0.35 ± 0.07	0.09 ± 0.01 <sup>B</sup>	0.59 ± 0.08	0.14 ± 0.03 <sup>C</sup>	<0.01	<0.01	0.69
	8 h	0.34 ± 0.05 <sup>C</sup>	0.07 ± 0.01 <sup>dB</sup>	0.62 ± 0.04 <sup>b</sup>	0.90 ± 0.08 <sup>aA</sup>	0.83	<0.01	<0.01
	12 h	0.26 ± 0.03	0.27 ± 0.05 <sup>A</sup>	0.85 ± 0.15	0.93 ± 0.04 <sup>A</sup>	0.59	<0.01	0.68

注射胰岛素3h后，鲫鱼A和DT中胰岛素水平较高，之后显著性下降，说明其均能对外源胰岛素能产生有效的响应；血糖均下降，呈现低血糖状态，而恢复到基础水平用时不同，说明两者调节血糖稳态的能力不同；与A品种相比，DT品种甘油三酯含量高，这可能与其遗传背景。

# 肝脏和肌肉中糖原含量

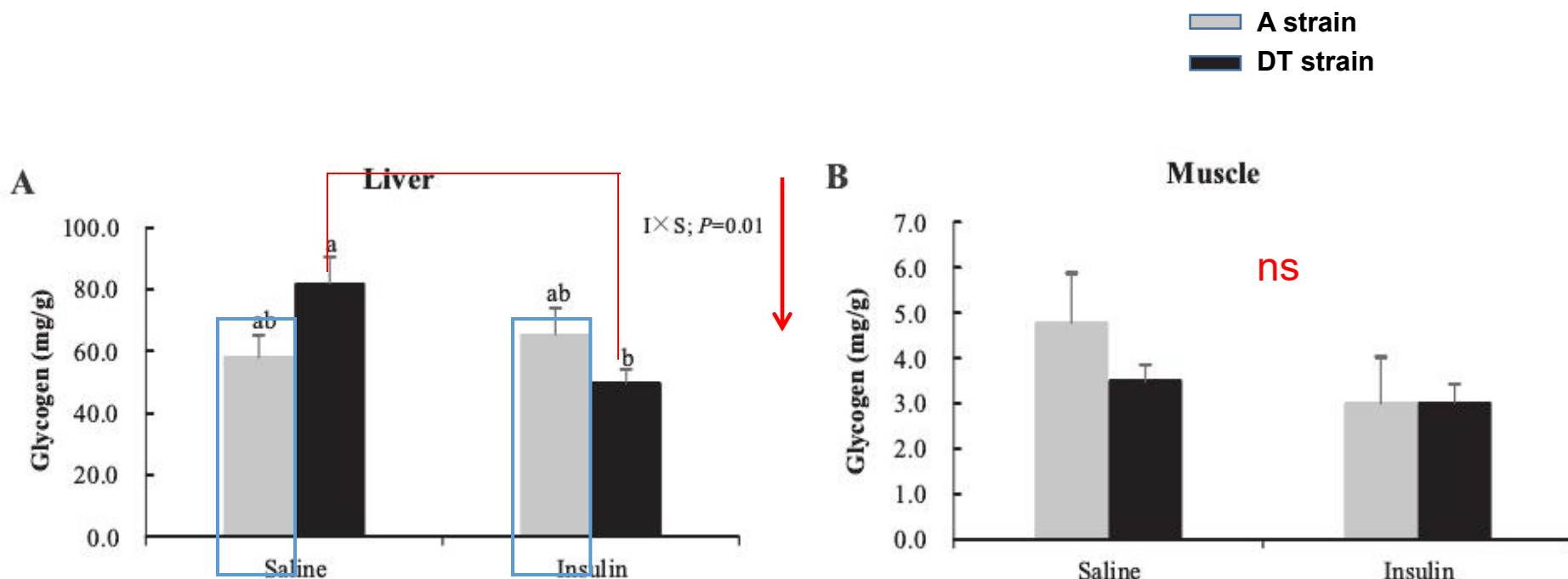


图1

胰岛素注射后，鲫鱼A品种肝糖原含量无明显变化，说明肝脏组织对胰岛素缺乏有效的响应；DT品种糖原含量显著性下降，这可能与DT品种8h血糖恢复有关，而肌糖原两者均无变化，说明肌肉组织对胰岛素缺乏有效的响应。

# 葡萄糖转运蛋白的表达量

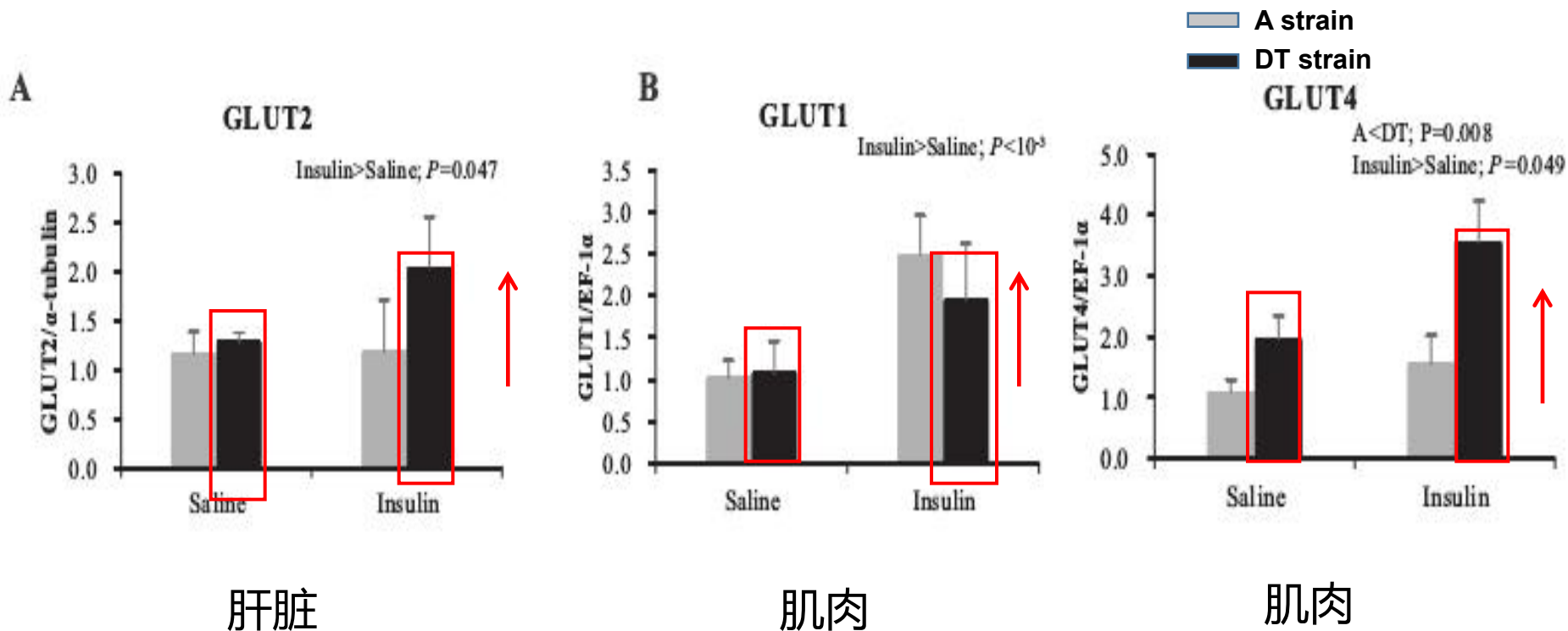
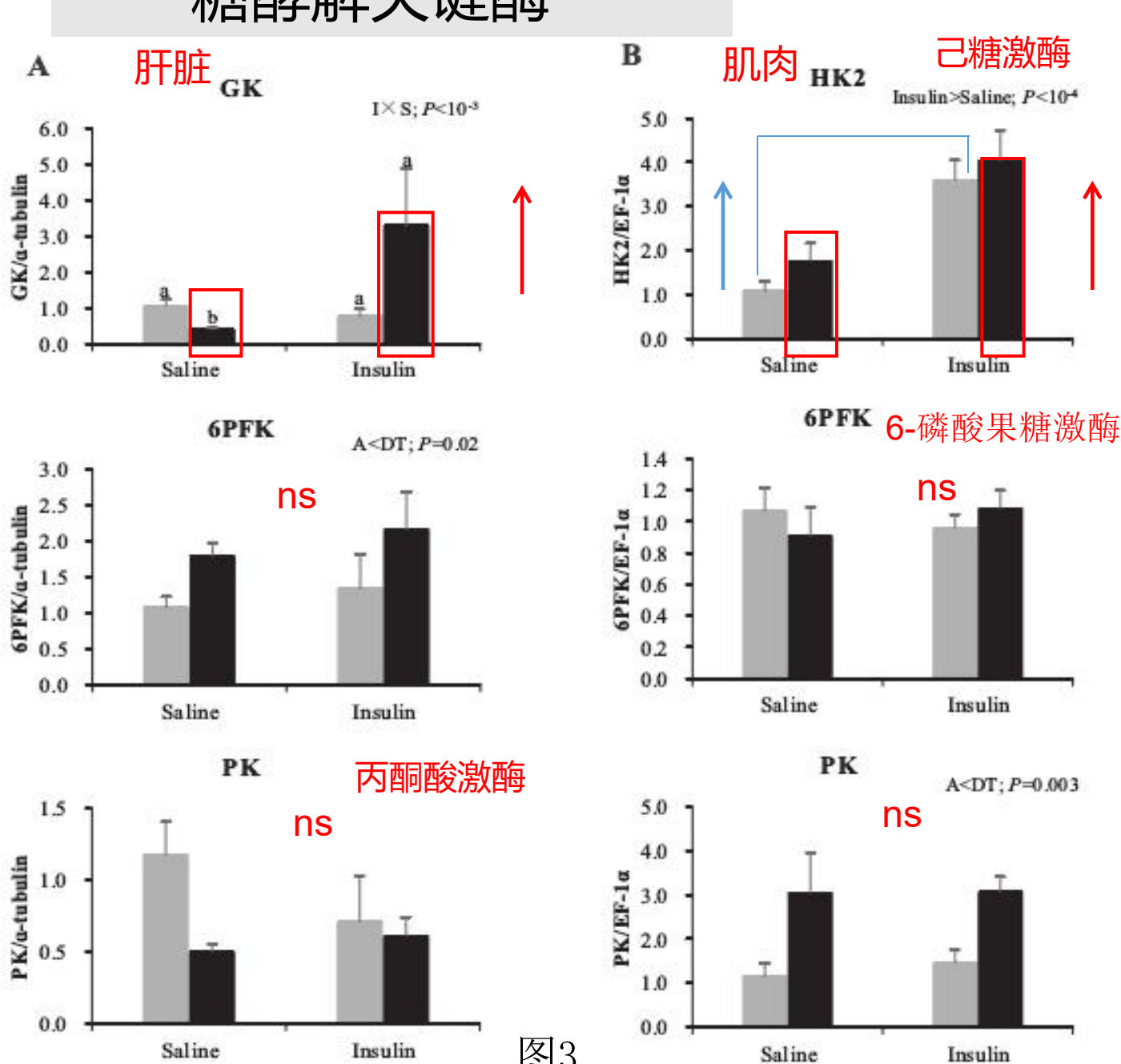


图2

注射胰岛素后，两种鲫鱼肝脏中Glut2和肌肉中Glut1、Glut4表达量增加，说明胰岛素能促进肝脏和肌肉对葡萄糖的吸收，这也是胰岛素注射后，出现低血糖的原因。

# 糖酵解关键酶



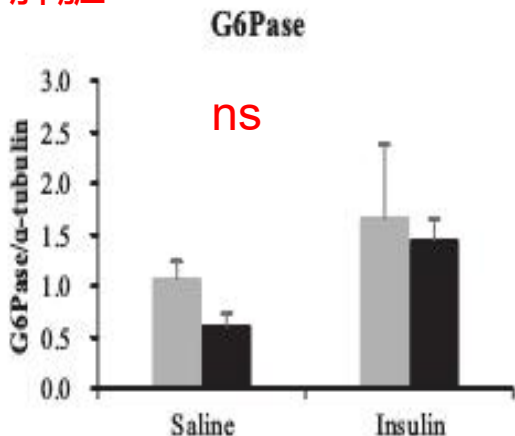
Legend:  
█ A strain  
█ DT strain

鲫鱼DT肌肉  
 肝脏中HK2表达量  
 均增加，而A品种  
 仅肌肉中GK表达  
 量均增加，说明胰  
 岛素通过HK2和  
 GK的表达促进糖  
 酵解，而6PFK,PK  
 表达量无明显变化，  
 说明胰岛素利用这  
 两种酶对葡萄糖稳  
 态调节的能力较弱。

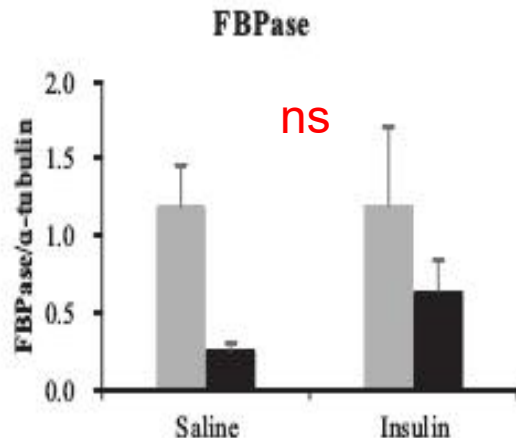
图3

# 糖异生关键酶

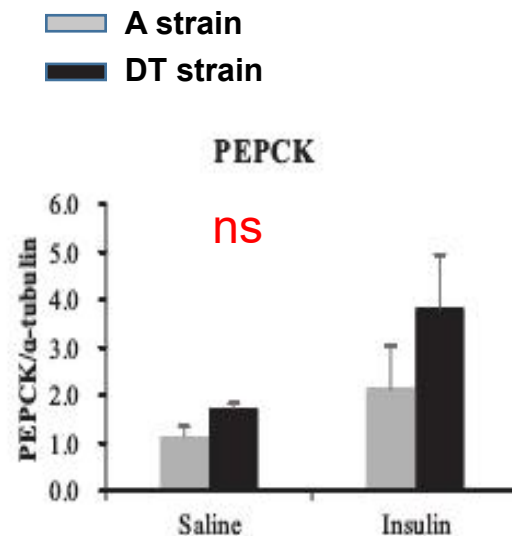
肝脏



葡萄糖-6-磷酸酶



果糖-1,6-双磷酸酶



磷酸烯醇式丙酮酸激酶

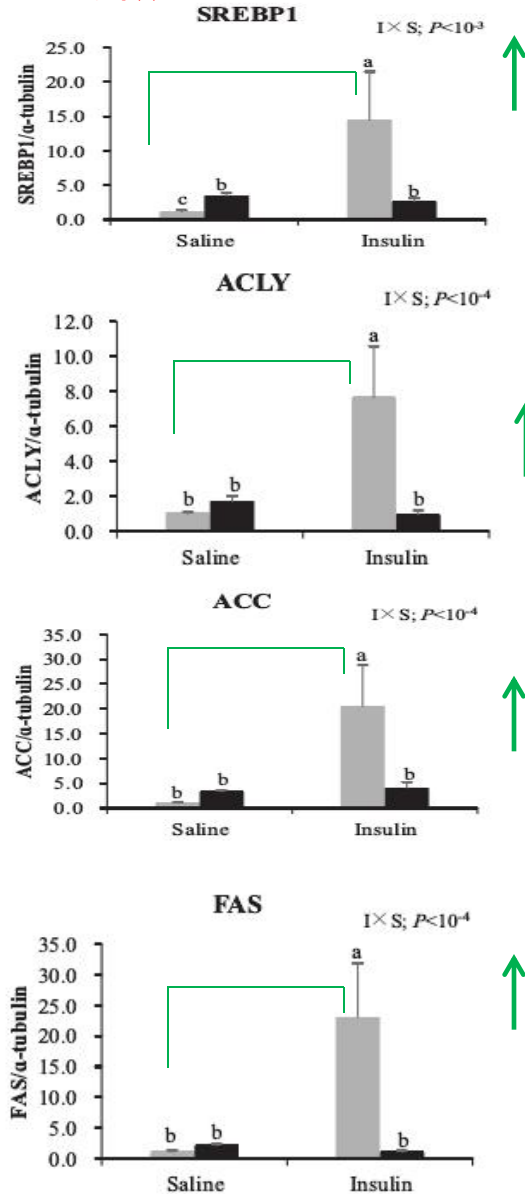
图4

注射胰岛素后，G6Pase、FBPase、PEPCK表达量均未发生明显变化，说明胰岛素诱导的低血糖症不是通过调控糖异生过程产生的。

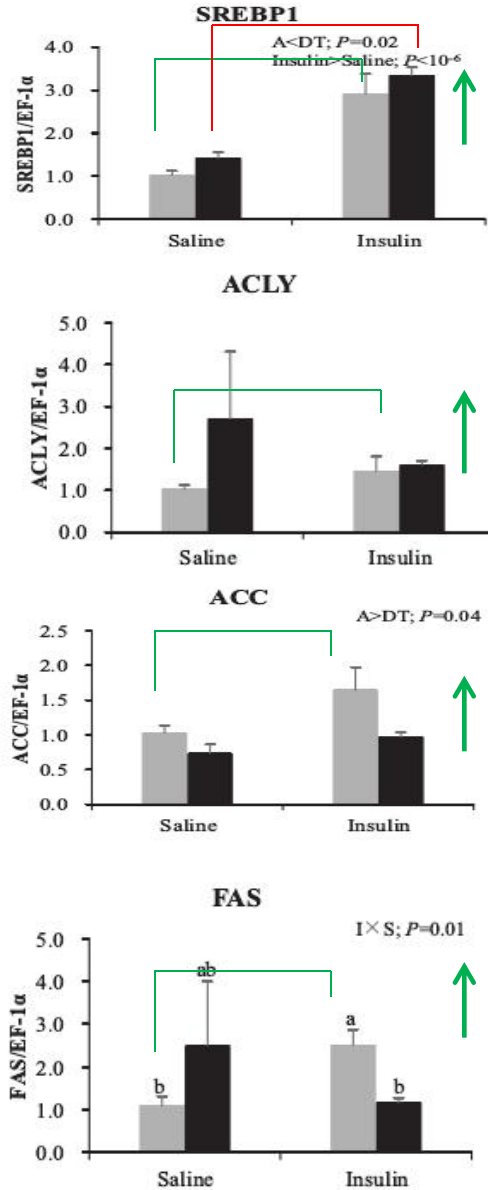
# 脂肪合成相关酶

— A strain  
— DT strain

A 肝脏



B 肌肉



固醇调节元件结合蛋白1

ATP柠檬酸裂解酶

乙酰辅酶A羧化酶

脂肪合成酶

A品种所有酶表达量均增加，而DT品种仅肌肉中SREBP1表达量增加，说明胰岛素均能诱导脂肪的合成，但调控方式存在差异。

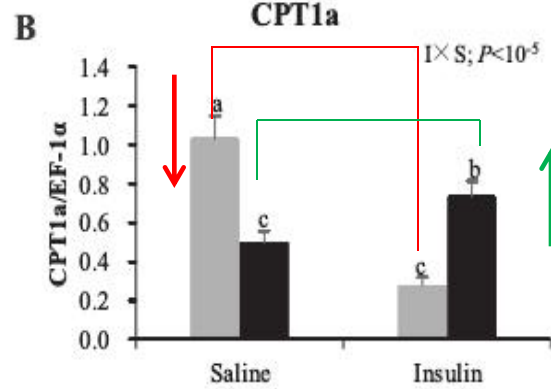
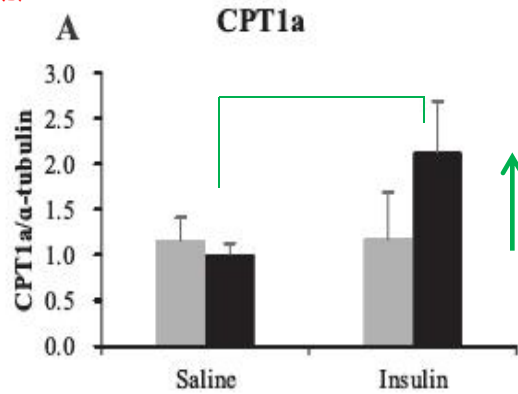


# 脂肪酸氧化相关酶

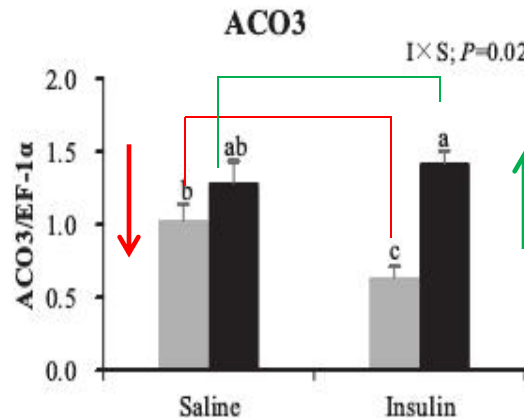
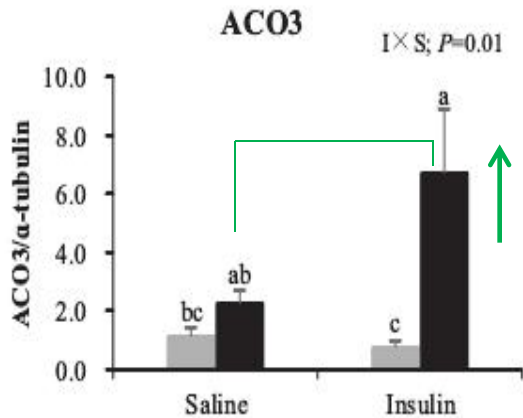
肝脏

肌肉

■ A strain  
■ DT strain



棕榈酰基转移酶1A



酰基辅酶A氧化酶3

鲫鱼A品种肌肉中的CPT1a和ACO3表达量显著性降低，而在肝脏无明显变化，说明胰岛素在该品种中抑制脂肪酸的氧化；鲫鱼DT品种肌肉中，CPT1a表达量显著性升高，在肝脏中也具有升高的趋势，说明胰岛素在该品种中促进脂肪酸的氧化，两者变化可能与血浆中游离的脂肪酸水平有关。

图6



**04**

# 结 论

不同基因型的鲫鱼，胰岛素对其糖代谢和脂代谢的调节机制存在差异性。



**思 考**

1.本文所做研究较为全面，条理清晰，这为我们如何设计类似实验提供了参考。

2.本文是胰岛素对不同基因型鲫鱼糖代谢和脂代谢影响的研究，这有助于提高我们对胰岛素调节与遗传背景之间相互作用的认识。



请各位老师批评指正