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Betaine alleviates hepatic lipid accumulation via enhancing hepatic lipid export and fatty acid oxidation in rats fed with a high-fat diet

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Abstract

100 & 2 50) (*P*<0·05) (*P*<0·05) *P*<0·05) *expressions of hepatic broblast groth factor 21 (FGF21) ere increased* (*P*<0·05)

Key words:

(*N,N,N*-) (1 2). *In vivo*, (3). (1 20). (21 23) ( ), (11). (12,13). L (1 1),

Materials and methods

Animal experimental procedure

1, 1.

*

Sampling

Table 2. Primer-pairs of target genes used for real-time PCR

Gene	Forward primer (from 5′ to 3′) Reverse primer (from 5′ to 3′)	PCR product size (bp)	GenBank accession number
β-Actin	GGA AAT CGT GCG TGA CAT TA AGG AAG GAA GGC TGG AAG GAG	183	NM_031144
BHMT	GGGCAGAAGGTCAATGAAGCT ACCAATGCATCCCCTTCGT	108	NM_030850
PPARα	TGCGGACTACCAGTACTTAG CGACACTCGATGTTCAGTGC	167	M88592
FGF21	CGACAGAGGTATCTCTACACAGATGACG GATCCATAGAGAGTTCCATCTGGTTGTT	206	NM_130752
AMPK	TGTGACAAGCACATTTTCCAA CCGATCTCTGTGGAGTAGCAG	156	NM_019142·2
CPT1	GCTCGCACATTACAAGGACAT TGGACACCACATAGAGGCAG	250	AF020776

BHMT, betaine–homocysteine methyltransferase; *FGF21*, fibroblast growth factor 21; *AMPK*, AMP-activated protein kinase; *CPT1*, carnitine palmitoyltransferase 1.

(β-actin).

Western blot analysis

Statistical analysis

$P<0·05$.

Results

Assessment of body weight

($P>0·05$)

Effects of betaine on serum lipid metabolites

Table 3. Changes of body weight during 4 weeks (g)
(Mean values and standard deviations, *n* 7)

	T1		T2		T3		T4	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
0 d	100·02	0·15	100·15	0·28	99·91	0·13	99·95	0·36
7 d	150·00	2·58	148·75	3·14	152·12	3·46	149·12	3·03
14 d	202·00	5·42	205·5	6·75	207·75	7·45	206·17	7·60
21 d	228·74	16·83	244·13	17·55	227·61	26·12	253·83	31·47
28 d	290·58	9·86	296·03	14·26	287·26	15·80	305·75	25·67

T1, basal diet; T2, basal diet with betaine administration; T3, high-fat diet; T4, high-fat diet with betaine administration.

(P< 0 05)

(P< 0 05)

(P< 0 05)

Oral administration of betaine effectively alleviated the excessive accumulation of fat in the liver

(P<

21. (P<0·05)

AMPK (5).

(P<0·05) AMPK

(3).

AMPK (1)

Discussion

(2,12,2)

(5)

(2)

(5)

(30)

(31)

Betaine increased the activity, gene and protein expression of fibroblast growth factor 21, and elevated the gene expression of AMP-activated protein kinase in the liver

21

5(). (). (1),

(3) (P<0·05)

FGF21.

(P<0·05)

21 (1)

(3)

(3),

() (P<0·05)

Table 5. Effects of betaine on hepatic lipid metabolism
(Mean values and standard deviations, *n* 7)

	T1		T2		T3		T4	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
TAG (mg/g)	7·81[b]	0·66	7·47[b]	0·58	9·20[a]	1·42	7·96[b]	0·84
NEFA (μmol/g protein)	32·73[b]	9·16	39·44[b]	11·77	57·93[a]	12·76	67·08[a]	12·27
TC (mg/g)	2·21[b,c]	0·17	2·46[a,c]	0·47	2·58[a,c]	0·48	2·76[a]	0·49
Lecithin (ng/g)	1·00[c]	0·05	1·10[b]	0·05	1·04[c]	0·05	1·17[a]	0·02
14.6/aLecithinepatic1anmol/gVLDL prc								

S- *S*- (33,35)

BHMT. β- α. α, (3, 0)

et al.(1) α (1) *et al.* *PPARα* *PPARα* *CPT1* *et al.* 2 % /100 α 1 *CPT1* *et al.* *CPT1*

BHMT *BHMT* *et al.*(33) *BHMT* 1 % *et al.* 0 125 %

(A) 3·5 (B) (C)

3·0

2·5

2· 1 Tf6 0Tm-36445oT(513025 TDhibitio62(8)-26its)-3(v51ctivity of hepTc1302)-45ntio2 1 Tf28 (uneam/g 866 200401 Tm/Cs61526 Tf0164450

(2, 3). AMPK (. . 5( )),

AMPK CPT1.

CPT1

PPARα CPT1

21,

21

21

2 5% 21

21. 21 21, −/− 21 −/− 21

et al.[50] 21

3 1 (1) 1α (-γ 1α)-

21

nr

21 α 21 α 21

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(2012 12 05).

References

1. L & (201) *Amino Acids* 4 , 1 5 1
2. (200) *Am J Clin Nutr* 80, 5 5 .
3. & (2005). *J Hepatol* 4 2, 0 13.
4. , et al. (200). *Asian-Austral J Animal Sci* 22, 1 1 1
5. , et al. (2005) *Nutr Res Rev* 18, 31
6. (2010) *Clin Biochem* 4 , 3
7. , et al. (2010) *Mol Biol Rep* , 131 13
8. & (2012) *Anim Reprod Sci* 1 2,
9. (2011) *Anim Feed Sci Tech* 1 ,
10. , et al. (200) *Livest Sci* 10 , 5.
11. & (200) *Anim Feed Sci Tech* 11 , 151 15 .
12. , et al. (2001) *Am J Gastroenterol* 2 11 2 1 .
13. , et al. (2010) *Hepatology* 1, 1 1 1 2 .
14. L & (200) L *de novo* *Int J Obes Relat Metab Disord* 28, 22 3 2 .
15. & (200). *J Clin Invest* 14 , 1 15 .
16. & (2010) *Hepatology* 1,
17. , L , et al. (2012) *Chemerin* 1 2 *Mol Biol Rep* , 1 1 .
18. L- , L- , et al. (2013) 1 *Dig Dis Sci* 8, 31 320 .
19. , et al. (2013) *Food Chem Toxicol* 2, 2 2 2 .
20. , et al. (200) *Am J Physiol Gastrointest Liver Physiol* 2 , 2 .
21. , et al. (200) *J Nutr* 1 , 3 .
22. , et al. (200) *S* *Biochem Biophys Res Commun* 8, 3 .
23. , et al. (201) *Comp Clin Pathol* 2 , 1 1 1 .
24. & (1 3) 3 *ad hoc* *J Nutr* 12 , 1 3 1 51.
25. L & (2001) $2^{-\Delta\Delta}$ *Methods* 2 , 0 .
26. L , L L, et al. (201) n- n-3 *Br J Nutr* 111, 5 51.
27. , et al. (2010) *Am J Physiol Gastrointest Liver Physiol* 2 8, 3 2 .

2 . , et al. (2 00)
(Sus scrofa domestica). Comp Biochem Physiol A Mol Integr Physiol 1 , 131 1 0.
2 . & (2 00). Br J Nutr , 32 3 35.
30. , et al. (2 010) . Eur J Lipid Sci Tech 112, 2 5 303.
31. & (2 005) . Curr Drug Metab , 15 22 .
32. , et al. (2 011) S- 1 . J Biol Chem 28 , 325 32 .
33. , et al. (2 00) . J Hepatol 4 , 31 321.
3 . , L , et al. (2 00) . Asian-Austral J Animal Sci 1 , 02 .
35. , et al. (2 003) N- ( )