Studies on the elucidation of central functions of taurine to regulate body temperature, food intake and stress response in neonatal chicks

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Title　：Studies on the elucidation of central functions of taurine to regulate body temperature, food intake and stress response in neonatal chicks
(ニワトリヒナの体温、摂食およびストレス応答を制御するタウリンの中枢機能の解明に関する研究)

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Thesis Summary

Environmental stressors in poultry such as heat stress, social isolation stress, cold stress, etc. negatively affect poultry performance, health and welfare. These stressors cause physiological alterations, behavioral changes, production declining, tissue and intestinal damage, and high mortality. Several strategies have been adopted to reduce the environmental stressors in poultry production through managemental and nutritional approaches. Amino acids are getting attention nowadays as a novel approach to mitigate stress responses in poultry. In this study, a novel role and functional mechanism of taurine has been investigated to mitigate stress response in neonatal chicks.

In this study, the thermoregulatory role of taurine was examined through intracerebroventricular injection of this amino acid in neonatal chicks. Central taurine was found to induce a dose-dependent hypothermia and reduced food intake in neonatal chicks under thermoneutral temperature (CT). Further, it was found that taurine-induced hypothermia was attenuated by co-injection of picrotoxin (inhibitor of γ-aminobutyric acid $_A$ ($GABA_A$) receptor), which indicate that taurine mediates hypothermia via $GABA_A$ receptor. Central taurine changed plasma metabolites under high ambient temperature (HT), suggesting that brain taurine may regulate peripheral metabolism under HT.

Second, the roles of brain amino acid metabolism and monoamine metabolism in taurine-induced hypothermia were investigated. It was found that central taurine increased diencephalic tryptophan (the precursor of serotonin (5-HT)), 5-HT and its metabolite 5-hydroxyindoleacetic acid concentrations. Moreover, central taurine decreased diencephalic concentration of tyrosine (the precursor of L-DOPA, which converts to dopamine and norepinephrine (NE)). However, the NE concentration in the brainstem and its metabolite 3-methoxy-4-hydroxyphenylglycol in both the brainstem and diencephalon were increased after 30 min following central injection of taurine. Brain histidine (the precursor of histamine) concentration was increased while, glutamate, proline, arginine, ornithine, isoleucine, leucine, valine and methionine concentrations were decreased following central injection taurine. I further found that fusaric acid (dopamine hydroxylase inhibitor) completely and para-chlorophenylalanine (tryptophan hydroxylase inhibitor) partially attenuated taurine-induced hypothermia. These results indicate that NE and 5-HT mediate taurine-induced hypothermia. Furthermore, changes of several amino acid concentration by central injection of taurine further suggest that amino acid metabolism may change to contribute in the process of hypothermia.

Third, central taurine attenuated hyperthermia and stress behaviors in chicks induced by social isolation stress and corticotropin-releasing factor (CRF). Central taurine attenuated the action of CRF, a major regulator of hypothalamic–pituitary–adrenal axis activity in the central nervous, through inducing sedative and hypnotic effects. The mechanism was likely to involve the repartitioning of amino acids to different metabolic pathways. In particular, brain leucine, isoleucine, cysteine, glutamate and glycine might have been mobilized to cope with acute stressors.

Forth, thermoregulatory behaviors following taurine administration were investigated in heat-exposed chicks under fasting condition and the involvement of mitochondrial thermogenic genes in the process was examined. Central taurine afforded thermotolerance under 35°C at 30 min after central injection. In addition, the thermotolerance effect of taurine appeared until 15 min under 40°C with a quick initiation of heat dissipation behaviors; panting and wing dropping compared with control birds. Central taurine upregulated avian uncoupling protein and avian peroxisome proliferator-activated receptor γ coactivator-1α under CT and HT. However, avian adenine nucleotide translocase and carnitine palmitoyltransferase-I in chicks were downregulated under CT and HT. These results elucidated a novel role of taurine to afford thermotolerance to alleviate heat stress in chicks, and the changes in mitochondrial thermogenic genes could possibly be involved with the taurine-induced thermoregulation.

In conclusion, the present study revealed a novel nutritional factor, taurine to alleviate heat stress and isolation-stress response in chicks. Furthermore, the central regulatory mechanisms of taurine provided a better understanding between thermoregulation, appetite regulation and stress response, which has far-reaching implications in a multitude of species and biological contexts.