CHAPTER VI

OVERALL CONCLUSION AND IMPLICATION

6.1 Overall conclusion

Nutritional programming (NP) of high-carbohydrates (HC) in Nile tilapia early life (glucose injection into yolk of larvae and HC feeding in fry) could improve the efficient utilization of carbohydrate (CHO) in later life of juvenile and adult stage, which could provide protein sparing effects. To obtain scientific information on the NPs concept of CHO in the life cycle of Nile tilapia, the effects of dietary HC stimuli in broodstock on their offspring could be an approach to deep understanding the NP strategy in fish. In pervious study, parental HC stimulation modulated the intermediary CHO metabolism in their offspring at larvae and fry stage, demonstrating the NP effects. Therefore, this study continued explore whether the effects of NP of CHO in broodstock on offspring could persist on long term in juvenile and adult offspring. Moreover, the juvenile and adult offspring were challenged with a HC diet, respectively, to exam the capacity of carbohydrate utilization. In addition, numerous studies have shown that there is an epigenetic role in the effect of NP. To investigate whether epigenetics is included in the NP effects of CHO in broodstock, the present study identified enzymes associated with epigenetic modifications at the molecular level in juvenile and adult offspring fish after they were challenged the HC diet. The main results are summarized as follows (Figure 6.1):

6.1.1 HC stimulus in broodstock had long-term effect on glucose and its related metabolism including increased HSI and triglyceride content in liver, induced hepatic gluconeogenesis and muscular glycolysis in juvenile offspring. In addition, parental HC stimulus history showed greater effects when offspring fish were challenging the HC/LP diet such as induction hepatic glycolysis and lipogenesis while suppression gluconeogenesis and amino acid catabolism, as well as induction muscular glucose transport and glycolysis, demonstrating NP effects of parental HC diet. The modulation of epigenetic modifications including the writer and eraser enzymes related to DNA methylation and histone modifications at molecular levels, indicating that epigenetics were involved in NP of dietary CHO in parental Nile tilapia.

6.1.2 Dietary HC intake in Nile tilapia broodstock induced NP that was transmitted to offspring, persisted through adulthood, and modulated CHO metabolism. CHO NPs improved the growth performance of offspring and elicited stronger CHO metabolic responses when challenged with an HC diet. The modulation of gene expression related to DNA methylation and histone modification in the adult offspring suggests that epigenetic mechanisms are involved in the NP benefits of dietary CHO in Nile tilapia broodstock. Our results suggested that NP of CHO strategy could be an application to improve the efficient utilization of CHO in later life of fish and could provide a scientific theoretical basis for the development of low cost and high-quality feed, enhance economic performance in tilapia farming.

6.1.3 Feeding HC in broodstock induced CHO response in their offspring and persisted through harvestable adulthood (week 56). These NP effects improved growth performance and pronounced intermediary CHO metabolism in offspring after challenged with plan-based CHO diets for 4 weeks (week 57-60). We found that varied CHO level could induce genes expression of enzymes related to DNA/histone methylation and histone acetylation in liver and muscle of fish. In addition, parental NP history significantly effect on mRNA level of enzymes associated with epigenetic modification in early adult offspring into harvestable adult stage. Our findings suggested that the NP effects could throughout Nile tilapia life for long term at least to week 60 and could provide protein effects with varied CHO sources, optimizing the CHO level and selecting the excellent and inexpensive source of CHO might amplify the NP effects in aquaculture. Editing the epigenetic modifications present in NP effects may be a way to facilitate the development of NP strategies.

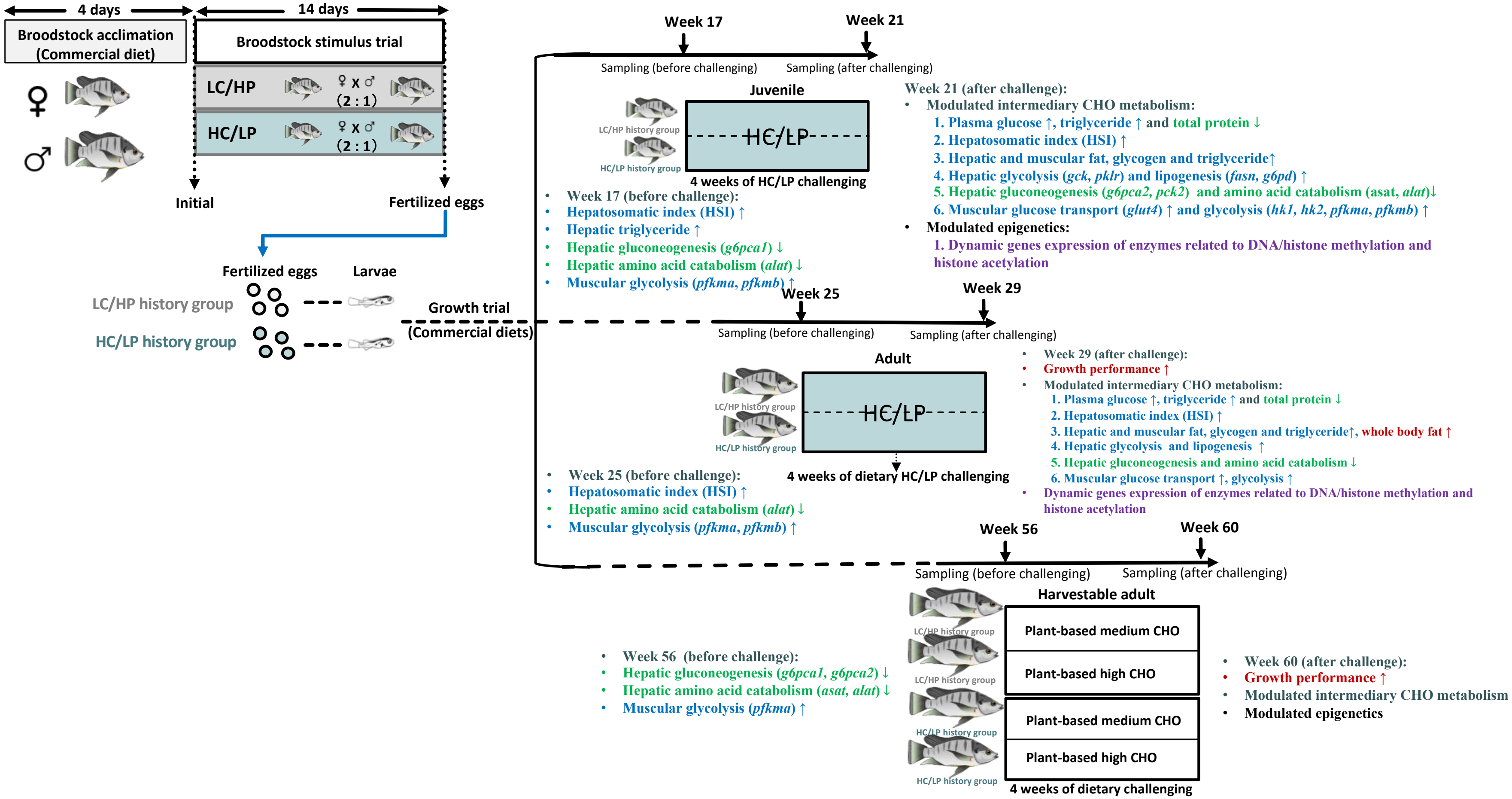

Figure 6.1 Conclusion map.

6.2 Implication

The findings from this study hold significant promise for advancing sustainable aquaculture practices by enhancing carbohydrate utilization in Nile tilapia through nutritional programming (NP) strategies. By elucidating the long-term effects of broodstock dietary carbohydrate intervention on offspring metabolism across juvenile, adult, and harvestable stages, this research could pave the way for cost-effective feed formulations that reduce reliance on expensive protein sources like fishmeal. The potential identification of epigenetic mechanisms underlying NP effects, such as DNA methylation and histone modifications, may provide novel insights into metabolic plasticity in fish, enabling targeted interventions to optimize nutrient utilization.

Future research should focus on unraveling the specific epigenetic pathways involved in mediating NP effects, including detailed analyses of DNMT, TET, and histone-modifying enzymes, to establish causal relationships between chromatin dynamics and metabolic reprogramming. Additionally, exploring the interaction between plant-based sources and NP-induced metabolic adaptations could further refine low-cost, high-efficiency feed formulations. Longitudinal studies tracking transgenerational epigenetic inheritance and metabolic resilience under varying environmental conditions would deepen understanding of NP sustainability.

The integration of NP strategies into aquaculture systems could revolutionize feed management by improving carbohydrate efficiency, reducing production costs, and minimizing ecological impacts linked to overfishing and fishmeal dependency. Ultimately, this approach may serve as a model for other economically important species, contributing to global food security and the sustainable expansion of aquaculture industries.