CHAPTER 5

Discussion

5.1 Growth performance

The present study showed a clear positive effect of fishmeal supplementation by fish protein hydrolysates on rearing growth performance of Asian red-tail catfish. All growth parameters measured, e.g. total weight gain, average daily gain, specific growth rate, protein efficiency ratio and feed conversion ratio were significantly ($P<0.01$) improved with increased FPH supplementation up to 10% in the diet. It has to be cleared in further studies if the failing of an additional growth effect when supplementing 15% has some negative impact on metabolic efficiency. The improved growth performance with increased FPH supplementation requires only a lower increase in feed input. The 8% higher final weight in the FPH100 group e.g. demanded only an additional total feed intake of 6.08g or 4.3%. This improvement in feed efficiency was postulated to be due to the better balance of peptides and proteins in digestion and absorption (Hevrøy *et al.*, 2005). Specific growth rate is a good indicator of protein quality (Deng et al., 2011), but is also controlled by essential environmental factors like temperature and oxygen supply. The growth performance of Asian red-tail catfish in this study with a range of specific growth rate between 2.79 – 2.86%/d for the different feeding groups reached a higher level as compared to other experiments with the same species: 0.45–0.53%/d, (Prasertwattana *et al.*, 2005), 1.48 – 2.98 %/d (Deng et al., 2011) and to experiments with other catfish species: 1.70 – 1.94%/d (Ahmad, 2008) 0.33 – 1.61%/d (Giri *et al.*, 2011). The much higher specific growth in comparison to a previous study with rearing Asian red-tail catfish at the same experimental site (Singpa and Gatphayak, 2014) mainly can be attributed to more constant and higher water temperature and an improved functionality of the closed recycling test system with stable water qualities. This is not at least indicated by the high survival rate with nearly no losses and no incidence of disease. Palatability is often used to explain observed differences in feed intake and growth performance (Reis *et al.*, 1989) with special

relevance to the first day of exposure to new feed. During the first feeding days the fish have to adjust to a new feed, new smell and taste. Thus the potential attractive properties of fish hydrolysate might explain to some extent the observed increase in feed intake and growth performance in studies in which fishmeal is replaced by fish hydrolysate. (Hevrøy *et al.*, 2005) also in the actual study a tendency of higher feed acceptance of the FPH-diets could be observed. Finally the increased feed intake results in improved feed conversion rate (FCR) with a decrease with from 1.79 (control) to 1.71 (FPH100), which can be attributed to the enhanced weight gain of the fish fed with 10% hydrolysate diet.

The studies on feeding fish hydrolysate in salmon rearing diets at low - medium inclusion levels of ≈ 10% can beneficially replace fishmeal (Refstie et al., 2004); (Hevrøy et al., 2005). Exceeding a specific level, however show reduced growth and feed efficiency (Espe *et al.*, 1999); (Hevrøy *et al.*, 2005). This underlines the existence of an optimum level for replacement of fishmeal by fish hydrolysates in fish rearing diets as indicated also in the present study by the lack of further growth increase in the FPH150 group.

Also for rearing of sea bass larvae (Kotzamanis *et al.*, 2007) reported that the incorporation of fish protein hydrolysates in the diet at a concentration of 10% effectively improved growth, survival and the intestinal development. The 10% FPH diet exceeded clearly the benefits of diets with higher replacement rates of 19%. A similar trend was observed by (Cahu *et al.*, 1999) who found that replacing 25% of fishmeal with a commercial FPH facilitated the onset of the adult mode of digestion in developing sea bass larvae, while replacement rates of 50% and 75% led to a reduction in larval growth.

FPH supplementation effected growth performance of fish due to its high protein content of hydrolysate ranging between 60% - 90% of total weight (Choi *et al.*, 2009, Dong *et al.*, 2008, Khantaphant *et al.*, 2011). In addition the amino acid composition of FPH is important because of the nutritional value and the influence on the functional properties (dos Santos *et al.*, 2011).

5.2 Carcass quality

Fish meat is a source of high quality protein, vitamins, and essential minerals. Information on fish chemical composition is highly relevant for the standardization of food products based on nutritional criteria. The quality of fish carcass is a necessary factor to define the preparation process of the products and cuts (Melo et al., 2013). Further, information on the processing yield may be of great help for fish quality control and for improving the efficiency of the processing chain (Maciel *et al.,* 2013). Studies on the effect of growth performance on carcass yield fillet percentage may greatly improve sales value and profits. In this study, the only ≈ 1/3 of the increase in final weight of the FPH100 feeding group can be recovered in increased fillet yield. The majority of the weight increase was due to higher weights of head, viscera and liver. Most likely these findings are to be explained by evaluating carcasses at a very early growth stage of the fish, which normally are marketed at 20 times higher weights. The early growth stage at slaughter also is indicated by slight gonadal development which did not allow a reliable sex determination. For marketable sized fish of related species channel catfish (*Ictalurus punctatus*), and blue catfish (*Ictalurus furcatus*) (Argue *et al.,* 2003) reported a fillet percentage of 49.5% and 44.4% respectively. For channel catfish (*Ictalurus punctatus*), with an average body weight of 600g to 800g (Bosworth et al., 2004) reported head weight of 22% to 25%, viscera weight of 11% to 13%, fillet yield of 45% to 48%. These results on carcass composition on marketable sized fish of related catfish species are very similar to carcass composition of the young Asian red-tail catfish in the present study. Thus the information gained on carcass composition in this study might give a useful indication of the carcass composition for the marketable sized fish of this species.

In comparison to tilapia the most cultured fish of the region, the Asian red-tail catfish showed a better carcass quality with about 10% higher fillet percentage. According to study of Dunham *et al.* (1985), tilapia (*Oreochromis* spp) showed an average fillet yield of 31.0%, ranging between 28.9 and 33.6%, supplemented by 36.0% for head and viscera, 8.0% for skin, 22.0% for bone residues and 3.0% for other wastes.

5.3 Meat Quality

According to the results obtained in this experiment, increasing FPH levels had little effect on muscle composition with regard to the protein content ($P<0.05$). Obviously the muscle protein content is highly genetically controlled and very specific for the species cultured. With an average of 17% protein content the sampled Red-tail Catfish are ranking in the lower middle of the most important cultured species, a bit higher than giant catfish 16.88% (Chaijan *et al.*, 2010), Tilapia 13-16% (Hanley, 1991) but lower than Baca catfish (*Pangasius bocourti*)**,** 17.23% (Thammapat *et al.*, 2010). A number of studies across the fish species underline the fact that muscle protein content is less influenced by external feeding since it is mainly dependent on intrinsic factors such as the fish species, variety and size (Berge and Storebakken, 1996, Shearer, 1994).

However the significant reduction in muscle lipid content of ≈2.7% for the experimental feeding groups independent from the FPH groups indicates an obviously retarding effect of FPH in the diet on lipid retention. A reduction of lipid content by ≈ ⅕ has to be considered a positive impact on the nutritional value of meat from red-tail catfish. With a lipid content of well 10% for the FPH feeding groups still remains high and characterize these fish as member of "Fat Fish Species".

Also for other fish species FPH diets lead to a reduced muscle lipid content. In Tilapia muscle lipid content fell below 5% with increased FPH level (Abdul-Hamid *et al.*, 2002). For turbot (*Scophthalmus maximus*) juveniles (Peres and Oliva-Teles, 1999) reported a lipid content of a group fed FPH combined diet which was significantly lower than in a group fed a basal diet. However no significant differences between the feeding groups regarding the whole body composition could be observed. In sea bass (*Dicentrarchus labrax*) studies indicate that only dietary lipid level may influence the carcass lipid level, whereas the dietary protein or ash level does not affect the same elements of the body carcass when the fish weight is taken into account (Lupatsch *et al.*, 2001). The reason for changes in protein and lipid contents in the fish body could be linked to changes in the synthesis and/or deposition rate of protein and lipid in the muscle (Abdel-Tawwab *et al.*, 2006)

Outer flesh quality characteristics are gaining increasing concern to the aquaculture industry as total production increases. It is usually defined in terms of product freshness, appearance, taste, smell, firmness, juiciness and process characteristics. The desired flesh characteristics for particular species varies between markets and may differ significantly for raw, and processed products cooked, salted, smoked, dried fish etc. (Kong et al., 2007, Kaushik et al., 1995). The actual study did not indicate any negative impact of FPH-diets on the product freshness of Asian red-tail catfish. The measured pH values ranging between 6.67 – 6.72 for 45 minute and 6.29 – 6.36 for 24 hours are within the range of perfect product quality. According to (Ludorf and Meyer, 1973) the pH value should be between 6.00–6.50 for fresh fish, and the upper limit of acceptability is 6.80–7.00. Intrinsic factors of importance in flesh quality include texture, colour and fat content (Kong et al., 2007, Færgemand et al., 1995, Fauconneau et al., 1995, Gjedrem, 1997). The color analysis is the most important and the most definitive amongst the sensory analyses for assessing the flesh quality of fish. According to our results, Asian red-tail catfish meat fed FPH-diets in tendency show a slightly darker bluish appearance especially of the skin, even though the value of L* a* b* were not significantly different. The measured flesh brightness values in this study are slightly higher compared to flesh color of Asian red-tail catfish cultured in pond and in fiber tanks reported by (Singpa and Gatphayak, 2014). In this study no significant difference was found in flesh color between fish cultured in tanks and ponds, however the skin of the pond fish were significantly darker with L* (bright color), a* (red color), b* (blue color) values of 29.22, 2.14, 12.72 than fish cultured in fiber tanks with L* a* b* values of 32.79, 1.81, -1.46. However, for the time being skin colour obviously has no impact on the market value.

5.4 Immune response

The innate immune system of fish is considered to be the first line of defense against a broad spectrum of pathogens and is more important for fish as compared with mammals. Lysozyme level or activity is an important index of innate immunity of fish and is ubiquitous in its distribution among living organisms (Jollès and Jolles, 1984). Recent studies have suggested that polypeptide fractions found in fish protein hydrolysates may stimulate factors in fish important for disease resistance (Murray et al., 2003). The fish lysozyme has substantial antibacterial activity over mammalian

lysozymes not only against Gram-positive bacteria but also against Gram-negative bacteria in the absence of complement (Itami et al., 1992). Therefore in this study the lysozyme level was employed as a tolerance indicator at the end of the experiment and of a possible stimulation of the immune system by FPH-diets. The measured volume of lysozyme in the blood of the experimental fish was slightly increased, but with values ranging between 2.27 – 2.42 µg/ml still very low in comparison with other investigations. (Kumari and Sahoo, 2005) found serum lysozyme levels as indicator of non-specific immune responses and disease resistance by feeding high vitamin C diets in Asian catfish (*Clarias batrachus)* ranging from 7.5 to 12.94 µg/ml for the different treatment groups. For common carp (*Cyprinus carpio*). (Li et al., 2007) reported a very high lysozyme activity of 151.28 µg/ml, for Indian Grass Carp (*Labeo rohita*) Sahoo et al.(2005) lysozyme levels of 2.85–10.80 µg/ml. It is well established that the immune system of fish can be severely affected by various stress conditions. Factors such as stocking density, periodic handling, transport, water quality or the use of anesthetics are the most common causes of stress for cultured fish in commercial intensive aquaculture (Saurabh and Sahoo, 2008) and are eventually immunosuppressive. Lysozyme activity could depend on the degree of stress, intensity and its duration and type of stressors (Yildiz, 2006). (Möck and Peters, 1990) reported that rainbow trout stressed by transport or acute water pollution had significantly reduced serum lysozyme levels. (Caruso and Lazard, 1999) reported that plasma lysozyme activity of Nile tilapia stressed by social pressure was lower than for unstressed fish. In contrast, (Demers and Bayne, 1997) reported that, following exposure to a handling stressor, lysozyme activity was significantly increased in rainbow trout. Enhanced serum lysozyme activity, on the other hand, was observed in carp infected with Aeromonas punctata (Siwicki and Studnicka, 1987). Thus the lower lysozyme volumes measured in this study might to some extent result from the high stocking densities with >50kg/80 l tank at the end of the experiment and reduced biological clearance of the recycled water causing immunosuppressive effects.

Regarding the immune stimulation of FPH-diets in the actual study a positive trend could be observed up to a level of FPH100-diet even though the increase from 2.27 to 2.42 µg/ml was not statistically significant. Little information is available for the effect of FPH-diets on lysozyme activity. (Murray *et al.*, 2003) e.g. did not find any

difference on lysozyme activity for rearing coho salmon on practical diets on a fishmeal based diet (control) compared with various diets on processed hydrolysated fish by-products. (Raa, 1996) believed that it is necessary to administer the correct amount of hydrolysate to have an effect on immune stimulation.

5.5 Further study

Fish protein hydrolysates have been tested successfully for their potential application as high protein content, balance amino acid profiles, easily absorbed and utilized for various metabolic activities, due to its high potential can be an interested alternative protein source, replacement of fish meal by FPH in high level are suggested for the next study. As red tail catfish is omnivorous species, high protein level diets (crude protein should not be lower than 35%) are recommended to be optimum on growth of red-tail catfish, especially in juvenile period.

Regarding to increase of FPH level effected meat quality, low muscle fat. The replacement of FPH should be continued to the market size in order to confirm the result in chemical composition of fish lipid, As well as the sensory evaluation should be performed.