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GROWTH PERFORMANCE AND POST-HARVEST QUALITY OF GIFT TILAPIA REARED IN TWO DIFFERENT CULTURE SYSTEMS

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ABSTRACT

The growth performance, feed utilization, sensory evaluation, proximate and fatty acid composition of Genetically Improved Farmed Tilapia (GIFT) reared in different aquaculture systems (tank and cage culture in pond) were examined in a 126-day feeding trial. Throughout the feeding trial, fish were fed commercial tilapia feed twice a day at 3% of their body weight. Significantly higher final body weight, weight gain, daily growth rate, viscerosomatic and hepatosomatic indices were yielded in GIFT tilapia cultured in pond than in tank. In contrast, GIFT tilapia cultured in tank showed significantly higher survival rate than GIFT tilapia cultured in pond. Higher positive scores of sensory evaluation test were observed in both treatments, indicating the good acceptance of consumers towards GIFT tilapia. Meanwhile, higher contents of 20:5n-3 and 22:6n-3 of GIFT tilapia fillets from tank culture system than those cultured in cage were mainly influenced by significantly different size of fish and maturity factor during harvest. In general, it can be concluded that the performance of GIFT tilapia reared in pond culture system was better than those in tank culture system with benefits of early harvest and faster growth rate. On the other hand, tank culture system also has its own advantages in terms of higher survival rate and better fatty acid profile.

Key words: Aquaculture systems, freshwater fish, GIFT, tilapia, growth performance, sensory quality

INTRODUCTION

The origin of the Genetically Improved Farmed Tilapia (GIFT) strain of Nile tilapia *Oreochromis niloticus* was described in detail by Ponzoni *et al*. (2005) and Nguyen *et al*. (2007). GIFT tilapia has been disseminated to at least 11 countries in Asia and a fully pedigreed population based on the sixth generation of GIFT was established in Malaysia in 2002 (Gupta & Acosta, 2004; Ponzoni *et al*., 2008). The increasing interest in the farming of GIFT strain tilapia is mainly due to its many advantages such as rapid growth rate, high fillet yield, and good disease resistance capability (Dey *et al*., 2000; Qiang *et al*., 2012). Traditionally, tilapia has been cultured in earthen ponds under extensive and semi-intensive systems (El-Sayed, 2006). In general, GIFT tilapia was reported to perform well across common farming conditions and environments (Nguyen *et al*., 2011).

Even though freshwater aquaculture in Sabah, Malaysia is not growing as rapid as the mariculture sector, it is still considered a very important sector especially in tackling the issue with food security. With the frequent occurrence of harmful algae bloom in the West Coast of Sabah, the local people have to turn to other protein sources which include the freshwater fishes. Therefore, boosting the freshwater aquaculture sector in the West Coast of Sabah is seen as an agenda to be considered seriously by the government. However, the expansion of aquaculture in Malaysia is being increasingly constrained by problems closely linked to the large expanse of land required for intensive aquaculture in pond. Therefore, promotion of urban aquaculture such as using tank culture system is given more attention these days. There are various debates among researches on these ideas. Tank culture production should be able to minimize the impact on degradation of land. While others prefer the traditional way as it maximizing profits to the fish farmers and economically cheaper than the urban

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aquaculture system. Previous researchers have studied the effects of culture systems basically on tank shape and volumes in relation to growth performance of fish (Kolkovski *et al*., 1995), evaluation of lipid and fatty acid of GIFT tilapia in a semi-intensive systems (Al-Souti & Claereboudt, 2014), performance of GIFT tilapia in fresh and seawater (Ridha, 2014) and evaluation on GIFT tilapia reared in cages and grown under natural conditions in reservoir (De Silva *et al*., 2015). However, the performances of the fish in both culture systems have not been adequately investigated to prove the significant eligibility between the current ideas of fish farming in Malaysia. Thus, this study aimed at determining the performances of GIFT tilapia in cage (pond) and tank culture systems including their growth, survival rate and post-harvest quality and fatty acids composition.

MATERIALS AND METHODS

Culture systems

Two aquaculture systems were tested in the present study, namely tank culture and cage culture in pond. The tank culture and cage culture in pond experiments were conducted at the Borneo Marine Research Institute, Universiti Malaysia Sabah and Tasik Riwak Ranch, Sipitang Sabah, respectively. The experimental tank was ractangular in shape with length = 0.8 metre, width = 0.8 metre and depth = 1 metre; volume = 512 litre and supplied with aeration system. The cages (3 mm mesh size) were also constructed with the same shape and dimension with the tanks. The cages were placed in an earthen pond measuring 44 x 27 metre, and approximately 2 metre depth with water inlet and outlet fully dependent on the river flow nearby. Water quality assessment on salinity, dissolved oxygen (DO), temperature and pH was done throughout the trials using YSI handled multiparameter meter (EUTECH PCD650) before every feeding session. Nutrient analysis consist of Nitrate, Nitrite & Ammonium were tested once in every 2 weeks using Aquamerk Test Kit (Table 2). Meanwhile, plankton samples were collected from the ponds with a plankton net (50 µm mesh size) and fixed with 10% formalin for identification by using a light microscope (compound and stereo microscope) which was then subjected to various identification sources; books and websites (Cronberg & Annadotter, 2005; Sardet, 2015).

Feeding trials and performance analysis

GIFT tilapia juveniles were obtained from the Freshwater Aquaculture Station Marakau Ranau, Sabah. Stocking density was set at 50 fish/tank or cage. The average weight of fish in tanks and cages were 4.52 ± 0.01 g and 5.40 ± 0.30 g, respectively. This slight initial weight difference was due to the different stocking day as a result of distance challenges (different experimental location). GIFT tilapia were hand-fed at 3% of body weight using floating tilapia feed (Cargill Feed Sdn. Bhd., Malaysia) containing 32% of crude protein, 4% of crude fat, 6% crude fiber and 12% of moisture. Table 1 shows the fatty acid composition of the commercial feed. Feeding was done in two sessions per day at around 8 am in the morning and at 4 pm in the afternoon. The total length and weight of all the fish were measured every two weeks. Weight gain, daily growth rate (DGR), percentage weight gain, specific growth rate (SGR), survival rate, feed intake, feed conversion ratio (FCR), hepatosomatic index (HSI) and viscerasomatic index (VSI) were calculated using the following formula:

Weight Gain = Average final weight – average initial weight

Daily Growth Rate, DGR = Total weight gain – culture days

Percentage Weight Gain = (Average final weight – Average initial weight)/ (Average initial weight) x 100%

Specific Growth Rate, SGR = Log (final weight) – Log (initial weight) / (Time period [days]) x 100%

Survival Rate (%) = (Initial number of fish stocked – Mortality)/ (Initial number of fish stocked) x 100%

Feed Conversion Ratio, FCR = (Total weight of dry feed given (g) / (Total weight gain (g))

Feed Intake, FI (g) = Total feed intake for 126 days

HSI (%) = (liver weight/fish weight) x 100

VSI (%) = (visceral weight/fish weight) x 100

Fish sample preparation

The feeding trial was terminated when the fish attained the common market weight which is approximately 250 g. Then a total of 5 fish from each tank and cage were randomly selected and killed in crushed ice for flesh quality attributes evaluation. Another 10 fish were selected and killed using overdose anaesthetic Transmore (NIKA Brand) for fillet proximate and fatty acid analysis. Final weight, final length, fish liver, viscera were measured and fish samples were stored at -80°C for final body proximate analysis and body indices calculation.

Table 1. Fatty acid composition of commercial tilapia feed

Type	Fatty acids	Concentration (%)
SFA	C16:0	19.66 ± 0.23
	C18:0	3.44 ± 0.04
	TOTAL SFA	24.78 ± 2.72
MUFA	C18:1 n9c	23.03 ± 0.19
	TOTAL MUFA	25.90 ± 3.74
	C18:2 n6c	32.22 ± 0.56
	C18:3 n3	3.78 ± 0.09
PUFA	C20:5 n3	1.86 ± 0.05
	C22:2	1.22 ± 0.02
	C22:6 n3	9.25 ± 0.04
	TOTAL PUFA	49.38 ± 3.87
	TOTAL UFA	75.28 ± 2.64
	TOTAL UFA/SFA	3.04 ± 0.04
	TOTAL n-3	14.89 ± 0.21
	TOTAL n-6	33.12 ± 0.59
	(n-3)/(n-6)	0.45 ± 0.10

Note: (Data expressed as % of total fatty acids, mean ± SE). Minor fatty acids (concentration < 1.0%) not listed here were C14:0, C15:0, C17:0, C20:0, C24:0, C16:1, C18:1 n9t, C20:1, C22:1, C24:1, C18:2 n9t, C20:3 n9t and C20:4 n6. SFA – (Saturated fatty acid), MUFA – (Monounsaturated fatty acid), PUFA – (Polyunsaturated fatty acid, UFA – (Unsaturated fatty acid).

Post-harvest quality attributes

A five-point hedonic scale were used in evaluating sensory of the GIFT tilapia fillets as described by Eyo (2001). Then 49 untrained panels were provided with questionnaires and evaluated the three parts of post-harvest quality evaluation process:

I. Physical appearance & freshness of raw GIFT tilapia (whole fish) after harvested which were evaluated based on the appearance, eyes & gills colour, scales, flesh and odor. Using acceptance test (5-point hedonic scale were used; 1- Extremely fresh-like, 2- Fresh-like, 3- Neither fresh nor off-odor detected, 4- Off-odor (rancid) and 5- Extremely off-odor/very rancid).

II. Eating quality of steam GIFT tilapia fillets evaluated based on fillets appearance, texture, odor & taste by using 5-point hedonic scale of acceptance test (1- Like extremely, 2- Like, 3- Neither like nor dislike 4- Dislike and 5- Dislike extremely).

III. Eating quality of steam GIFT tilapia fillets dipped with Asam Pedas gravy and evaluated by using pair-preference model test. Untrained panels chose sample of fillets that they like/most preferred and dislike/least preferred, and then state their comments.

Chemical analysis

Crude protein, crude lipid and moisture were determined with the following standard methods of Association of Official Analytical Chemistry (AOAC, 2005). Fatty acid analysis was conducted by analysing the fatty acid methyl ester from the crude extract in a gas chromatography (Shimadzu GC-2010, Shimadzu Corporation, Kyoto, Japan), equipped with flame ionization detector and an auto injector. Capillary column (60 m x 0.25 mm ID; BPX70 column, SGE, Australia) was used to separate the esters. Peaks were identified by comparing their retention times with commercially known mixtures of 37 components FAME MIX Standard (Supelco™ 37 Component FAME mix, Supelco Inc., Bellefonte, USA).

Statistical analysis

All the results were expressed as mean ± standard error (SE). Data were compared between the culture systems by Student's t-test at 5% significance level using the SPSS statistical package program (SPSS 17.0, SPSS Inc., Chicago, Illinois, USA). Mann-Whitney U test were subjected to hedonic scale test and Chi-square test on paired-preference test at 5% significance level.

RESULTS

Water quality and plankton composition

Overall, the water quality and nutrient content in both culture systems were considered to be in a suitable range and favourable for aquaculture practice. The temperature, dissolved oxygen and pH ranged from 28.04–31.45°C, 5.38–6.59 ppm and 5.45–7.05, respectively. Meanwhile, nitrate was not detected in both culture systems. Nitrite and ammonia ranged from 0.00–0.01 mg/L NO and 0.00–0.25 mg/L NH, respectively (Table 2). The plankton composition was dominated by several zooplankton and phytoplankton species i.e: river shrimp (*Caridae* sp.), water fleas (*Daphnia* sp.), *Scenedesmus* sp. and *Chlorella* sp..

Growth performance

GIFT cultured in cage had better MWT, DGR, SGR and FCR (360.06 g, 2.86 g $fish^{-1}$ day^{-1}, 3.35% day^{-1} and 1.06, respectively) than GIFT tilapia cultured in tank (288.37 g, 2.29 g $fish^{-1}$ day^{-1}, 3.31% day^{-1} and 1.41, respectively). In contrast, GIFT tilapia cultured in tank had significantly higher survival rate (100%) compared to those cultured in cage (94%). Significantly higher values ($P < 0.05$) of VSI and HSI of GIFT tilapia reared in cage than in tank were also observed (Table 3). Figure 1 shows the exponential increase of weight gain of tilapia GIFT cultured in both systems, with higher R^2 value in pond culture system.

Table 2. Water quality parameters recorded throughout the feeding trial

Water parameters	Range	
	Tank	Cage (Pond)
Temperature (°C)	28.04 ± 0.17[a]	31.45 ± 0.93[a]
Dissolved oxygen (ppm)	6.59 ± 0.18[a]	5.38 ± 0.13[a]
pH	5.45 ± 0.03[a]	7.05 ± 0.41[a]
Nitrate (mg/L)	Not detected	Not detected
Nitrite (mg/L)	0.00 ± 0.00[a]	0.01 ± 0.01[a]
Ammonium (mg/L)	0.25 ± 0.14[a]	0.00 ± 0.00[b]

Note: Means ± SE (standard error) in horizontal followed by the same letter are not significantly different (P > 0.05) from each other.

Table 3. Growth performance of GIFT tilapia in different culture systems

Parameters	Tank culture system	Cage culture system
Mean initial body weight (g)	4.53 ± 0.51[a]	5.40 ± 0.80[a]
Mean final body weight (g)	292.90 ± 16.32[a]	366.06 ± 6.94[b]
Mean initial total length (cm)	6.35 ± 0.10[a]	6.52 ± 0.03[a]
Mean final total length (cm)	21.78 ± 1.18[a]	22.45 ± 0.20[a]
Mean weight gain (MWT), (g)	288.37 ± 7.03[a]	360.06 ± 5.36[b]
Daily growth rate (DGR), (g $fish^{-1}day^{-1}$)	2.29 ± 0.13[a]	2.86 ± 0.06[b]
Specific growth rate (SGR), (% day^{-1})	3.31 ± 0.07[a]	3.35 ± 0.05[a]
Total feed intake (g) per culture system	100716.26 ± 88.75[a]	120705.48 ± 54.44[a]
Feed conversion ratio (FCR)	1.41 ± 1.59[a]	1.06 ± 0.20[a]
Survival (%)	100.00 ± 0.00[a]	94.00 ± 1.16[b]
VSI (%)	5.38 ± 1.72[a]	9.16 ± 0.20[b]
HSI (%)	1.26 ± 0.06[a]	2.50 ± 0.44[b]

Note: Means ± SE (standard error) in horizontal followed by the same letter are not significantly different (p > 0.05) from each other.

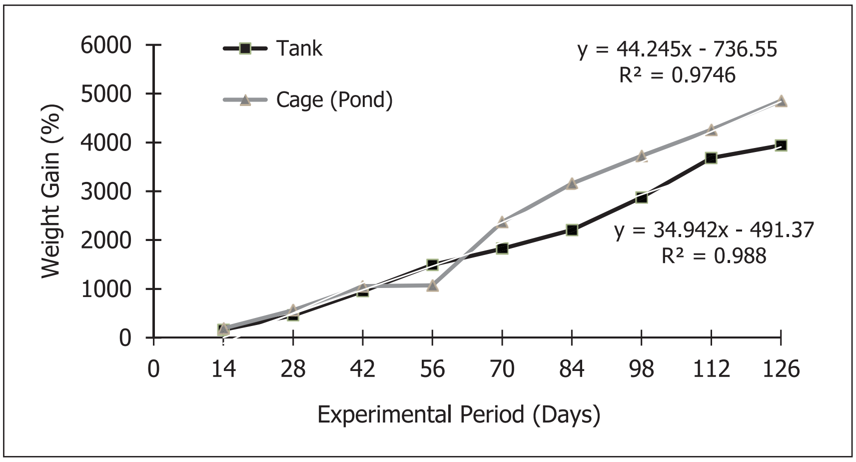

Fig. 1. Weight gain (%) over time of tilapia GIFT in both culture systems.

Sensory evaluation

The mean scores for physical evaluation of raw whole-fish and sensory evaluation of steamed fillet are presented in Table 4. Based on physical evaluation, appearance (3.06–4.71), odor (3.06–3.87) and overall acceptability (3.67–3.87) were significantly influenced by the culture system. However, freshness value (3.46) was better for whole-fish produced from tank culture than those from cage (odor, 3.46; overall acceptability, 3.67). Except

Table 4. Physical evaluation of raw whole-fish and steamed GIFT fillets by using hedonic 5 scale scores

Sensory attributesof raw whole-fish	Acceptance scores for each cultures	
	Tank	Cage (Pond)
Appearance	3.06 ± 1.06E	4.71 ± 0.24G
Odor	3.87 ± 0.55E	3.46 ± 1.03G
Freshness	3.46 ± 0.49E	3.06 ±0.19E
Overall Acceptability	3.87 ± 1.08E	3.67 ± 0.73G
Sensory attributes of steamed GIFT fillet		
Appearance	3.33 ± 0.13E	3.53 ± 0.27E
Odor	3.34 ± 0.43E	4.01 ± 0.14G
Texture	4.62 ± 0.36E	4.42 ± 0.72E
Taste	3.81 ± 0.11E	4.35 ± 0.24G
Overall acceptability	3.46 ± 0.09E	3.74 ± 0.01E

Note: Means were calculated from panellist responses (n = 49) for each attribute. Mean ± SE in horizontal followed by the same letter are not significantly different (p > 0.05) from each other.

Table 5. Proximate composition (% wet weight) of GIFT tilapia fillet cultured in two different systems

Means	Culture Systems		P-value
	Tank	Cage (Pond)	
Moisture	79.10 ± 0.34E	78.65 ± 0.45E	0.57
Crude Protein	15.90 ± 0.87E	15.35 ± 2.56E	0.12
Crude Lipid	1.54 ± 0.73E	3.35 ± 2.39E	0.83
Fibre	0.12 ± 0.08E	0.21 ± 0.39E	0.73
Ash	1.45 ± 0.66E	1.05 ± 0.56G	0.04

Note: Values ± SE in the same row with the same superscript are not significantly different (P > 0.05).

for odor (3.34, tank culture; 4.01, cage culture) and taste (3.81, tank culture; 4.35, cage culture); appearance (3.33, tank culture; 3.53, cage culture), texture (4.62, tank culture; 4.42, cage culture) and overall acceptability (3.46, tank culture; 3.74, cage culture) of GIFT tilapia fillet were not affected by the culture system. Nevertheless, numerically higher scores were obtained for appearance, odor, taste and overall acceptability for GIFT tilapia fillet from cage culture in the pond.

Proximate and fatty acid composition

Except for crude ash content, the proximate composition of GIFT tilapia fillet from the two culture systems was not significantly different from each other (Table 5). Moisture, crude protein, crude lipid, crude fibre and crude ash ranged from 78.65–79.10%, 15.35–15.90%, 1.54–3.35%, 0.12–0.21% and 1.05–1.45%, respectively.

Of the saturated fatty acids (SFA), palmitic acid (C16:0) had the highest proportion, while oleic acid (C18:1n-9) was the main monounsaturated fatty acid (MUFA) and polyunsaturated fatty acid (PUFA) was also detected in the form of docosahexaenoic acid (DHA). However, total of SFA, MUFA and PUFA were not significantly different between the culture systems. Interestingly, significantly higher concentration of 24:0, 22:1n-9, 22:6n-3 and (n-3)/(n-6) of FA in fillets of GIFT tilapia cultured in tank than in cage was observed. Contradictly, significantly higher concentration of linoleic acid 18:2n-6 (19.53 ± 0.05 %) of GIFT tilapia fillet cultured in cage than those in tank (16.57 ± 0.12) (Table 6).

DISCUSSION

Superior growth performance of GIFT tilapia in cage compared to tank culture system was yielded in the present study. Fish cultured in cages have the advantages of having excess to natural food in the pond such as shrimp, small fish and macroplanktons. Besides, large volume of water exchange was also occurred in cage culture system. The water in pond observed in this study was dominated by *Caridae* sp., *Daphnia* sp., *Scenedesmus* sp. and *Chlorella* sp. which were common aquatic organisms found in freshwater bodies (Beniga & Circa, 1997; Hussain *et al*., 2000; Mather & Nandlal, 2000). The lower

Table 6. Mean fatty acids composition of fillet GIFT tilapia reared in different culture systems

Type	Fatty acid	Concentration (%)	
		Tank culture system	Cage culture system
SFA	C14:0	1.42 ± 0.05E	1.72 ± 0.03E
	C16:0	19.11 ± 0.19E	21.07 ± 0.27E
	C18:0	4.43 ± 0.28E	4.25 ± 0.03E
	C24:0	1.49 ± 0.18E	0.74 ± 0.03G
	TOTAL SFA	27.39 ± 1.15E	28.86 ± 1.88E
MUFA	C16:1	3.18 ± 0.23E	3.59 ± 0.38E
	C18:1 n9c	21.52 ± 0.33E	26.25 ± 0.03E
	C20:1	0.85 ± 0.11E	1.01 ± 0.03E
	C22:1 n9	6.70 ± 0.13E	0.16 ± 0.08G
	TOTAL MUFA	32.78 ± 1.90E	31.36 ± 1.03E
PUFA	C18:2	20.31 ± 0.09E	22.79 ± 0.12G
	C18:3 n6	0.98 ± 0.05E	1.17 ± 0.20E
	C18:3 n3	0.61 ± 0.00E	1.36 ± 0.06E
	C20:3 n6	Nd	1.74 ± 0.03E
	C20:4 n6	6.70 ± 0.13E	4.12 ± 0.14E
	C20:5 n3	0.29 ± 0.09E	0.16 ± 0.16E
	C22:6 n3	14.59 ± 0.23E	7.88 ± 0.17G
	TOTAL PUFA	39.83 ± 2.15E	39.78 ± 2.05E
	´ UFA	72.61 ± 1.55E	71.14 ± 1.98E
	UFA/SFA	2.65 ± 0.07E	2.47 ± 0.02E
	´ n-3 PUFA	15.49 ± 1.39E	9.40 ± 0.75E
	´ n-6 PUFA	19.92 ± 0.19E	26.56 ± 0.35E
	(n-3)/(n-6)	0.78 ± 0.09E	0.35 ± 0.05G

Note: Percentage means in horizontal followed by the same letter are not significantly different ($p > 0.05$) from each other. Minor fatty acids (concentration < 1.0%) not listed here except for EPA were C15:0, C17:0, C21:0, c24:1 and C22:2. SFA – (Saturated fatty acid), MUFA – (Monounsaturated fatty acid), PUFA – (Polyunsaturated fatty acid, UFA – (Unsaturated fatty acid)).

growth performance of GIFT tilapia in tank culture system could have also been caused by several other factors such as behavioural interaction, competition for food and living space; and increased stress (Diana *et al*., 2004; Chakraborty & Banerjee, 2010).

Eventhough the survival rate of GIFT tilapia cultured in tank was significantly higher than in cage, the survival rate of GIFT tilapia in the present study was considered very high, indicating good health of the cultured fish in both culture systems. Factors such as quality such as water temperature, dissolved oxygen concentration, pH, and waste in the culture system might have some influence (DeLong *et al*., 2009). However, in the present study, the water quality parameters in both systems were no differed that much. The FCR value was better in GIFT tilapia cultured in pond than those in GIFT tilapia cultured in tank even though the feed intake was insignificant between both culture systems. The better FCR value of tilapia reared in the pond was also partly influenced by the consumption of natural food available in the pond. In the present study, the FCR of GIFT tilapia in tank was relatively better than FCR observed in previous studies; 1.76 (Luo *et al*., 2011), 1.57–1.74 (Luo *et al*., 2012) and 1.42–1.46 (Ridha, 2014). The HSI and VSI of GIFT tilapia in the present study increased with the increase of fish size and appeared to be in the normal range of reported HSI and VSI of other tilapia strain (Ochang, 2011; Ada & Ayotunde, 2013; Ighwela *et al*., 2014).

In general, higher positive scores were obtained for fillet of fish from both culture systems, indicating the acceptance of consumers toward GIFT tilapia. Other similar finding claimed that the sensory attributes of GIFT fell within the range of highly acceptable flesh (Ponzoni *et al*., 2008). Nevertheless, as expected, pond culture system produced raw whole fish with lower score of odor as compared to those from tank culture, which affected the overall acceptability of consumers. Researchers stated that tilapia can absorb the flavour from the water it was raised in which associated with blooms of blue-green algae and microbes presence in pond ecosystem (Bett & Dionigi, 1997; Josupeit, 2005; Che Rohani *et al*., 2009) and differences in chemical composition of fish could also influence postharvest processing and storage techniques (Musara *et al*., 2018). Moreover, algae blooms can produce geosmin and 2-methyl-isoborneol (MIB) which impart muddy, musty flavour to freshwater fish (Che Rohani *et al*., 2009), thus triggering the presence of muddy taste in fillets of tilapia raised in earthen pond. Fortunately, the odor can be eliminated by practicing "flush-period" such as washing in supernatant of banana (*Musa* sp.) (Mohsin *et al*., 1999), salt solution (Che Rohani *et al*., 1995) and 4% acetic acid (El-Sahn *et al*., 1990) of the fish prior to harvest. Interestingly, the score for overall acceptability of GIFT tilapia fillets from the pond was better than those raised in tank, indicating that cooking process can play a significant role in improving the sensory attributes of the farmed fish.

In the present study, the culture system appeared to have little influence on the proximate composition of GIFT tilapia fillet. The significantly higher ash content of GIFT tilapia cultured in tank (1.45 ± 0.66%) compared to the GIFT tilapia reared in pond (1.05 ± 0.56%) was also observed in the previous study where crude ash of fillet GIFT tilapia reared in tank (1.7–4.3%) was relatively higher than the cage-pond culture system (0.88–1.15%) (Zenebe *et al*., 1988; Ng & Hanim, 2007; De Silva *et al*., 2015).

In general, a better profile of fatty acid composition was observed in GIFT tilapia cultured in tank compared to pond culture systems. The individual fatty acid concentration varied between both culture systems, and as expected the levels of eicosapentaenoic acids (EPA, 20:5n-3) and docosahexaenoic acids (DHA, 22:6n-3) in GIFT fillets were lower than many marine fish species, but they were consistent with the results reported by Bahurmiz and Ng (2007), De Souza *et al*. (2007) and Ponzoni *et al*. (2008). Despite of the less type of fatty acids found in GIFT tilapia fillets cultured in tank compared to the GIFT tilapia cultured in pond, a higher content of total MUFA and total PUFA concentration was observed. The most common fatty acids in both culture systems were 16:0, 18:1n-9, 18:2n-6 and 22:6n-3. Similar studies performed on tropical (Clement & Lovell, 1994) and temperate (Ahlgren *et al*., 1994) freshwater fishes showed the dominance of these fatty acids in the tissue of fish. Overall, the results of fatty acid concentration were consistent with the results reported for tilapia in tank culture system (Karapanagiotidis *et al*., 2006; Molnar *et al*., 2012; Ma *et al*., 2015) and in pond culture systems (Ponzoni *et al*., 2008; Nguyen *et al*., 2010). Some of the GIFT tilapia reared in pond were observed to have spawned during the experimental period (GIFT tilapia fingerlings were noticed nearby the cage during feeding time). Tilapia raised in pond with good growth condition tend to reach sexual maturity at a smaller size of 150g to 200g and younger age than in an intensive or tank culture systems (Popma & Masser, 1999; Nandhal & Pickering, 2004). In the present study, there were about 68 % of the fish harvested at the end of the trial in the pond were weighed more than 300 g which means about half of stocked GIFT tilapia had reached their maturity. Therefore, the differences in UFAs of GIFT tilapia might be also influenced by the different size of fish at harvest. As the GIFT tilapia cultured in pond have higher growth rate, the fish tend to have larger (older) body size that caused them to have higher level of fat than smaller size fish (Toppe *et al*., 2006). These alteration might also cause variation in the state of development of gonad and spawning of fish (Caponio *et al*., 2004; Alemu *et al*., 2013). Spawning activity of the fish could trench their fat reserves, thereby contributing to the fatty acids variability and low tissue lipids (Osibona, 2011). The fats accumulation during spawning might altered the fatty acids content in GIFT tilapia fillets reared in pond culture systems.

Other than that, FA ratios (n-3)/ (n-6) and UFA/ SFA showed important information concerning the yielded food product. According to Simopoulos (2002), for food to be considered healthy, the ratios must be smaller than 4.0 and greater than 0.4, respectively. In the present study, the (n-3)/ (n-6) and UFA/SFA ratios in the tilapia fillets were within this range for both culture systems. However, an arduous comparison among studies is impossible as fatty acid composition also stated to be depending on other factors such as stock origin, species habitat, life stage, nutritional history of experiment fish, duration of experiment, gender of fish and reproductive cycle (Ackman, 1982; Ackman, 1989; Saito *et al*., 1999; Ng & Chong, 2004; Ponzoni *et al*., 2008).

CONCLUSION

In general, it can be concluded that the performance of GIFT tilapia reared in pond culture system was better than those in tank culture system with benefits of early harvest and faster growth rate. On the other hand, tank culture system also has its own advantages in producing promising marketable product which has higher survival rate and better fatty acids profile. Therefore, findings from the present study indicated that both culture sytems are feasible to be practiced in Malaysia depending on the farm's objective and availability of culture facility.

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