CHAPTER 2

LITERATURE REVIEW

2.1 Worldwide aquaculture and African Catfish farmed in Malaysia.

In Peninsular Malaysia, these species namely *Clarias*, *Hemibagrus*, *Pseudomystus* and *Pangasius* may be found in aquatic bodies (Table 2.1) (Mohsin et al., 1983). Despite increased demand, wild fish levels have remained constant over the previous three decades, even though fish is a vital source of food ((FAO), 2016). As a result, aquaculture promises a potentially sustainable option to addressing rising demand for fish and fish product (Dauda et al., 2013). The number of species apparently cultivated or previously farmed globally is 580, with finfishes accounting for 362 of the totals ((FAO), 2016). Carps, tilapia, salmon, and catfish are the most cultivated finfish in the world (FAO, 2014). Amur catfish (*Silurus asotus*), Channel catfish (*Ictalurus puncuatus*), Striped catfish (*Pangasius hypophthalmus*), and African catfish (*Clarias gariepinus*) are the greatest cultured catfishes, with respective percentage contributions to total aquaculture production of 0.62 %, 0.53 %, 0.52 %, and 0.33 % at the end of 2014 (FAO, 2014).

Table 2.1: Freshwater Fish Species in Peninsula of Malaysia Aquatic Bodies

Species	Location	Total length (cm) range	Weight (g) range
Asian Redtail Catfish (*Hemibagrus nemurus*)	Perak	20.5 – 45.0	70.0 – 760.0
Asian Bumblebee Catfish (*Pseudomystus siamensis*)	Negeri Sembilan	70.2 – 14.8	4.0 – 32.0
Pangas Catfish (*Pangasius pangasius*)	Perak	81.0 – 38.0	280.0 – 585.0
Shark catfish (*Pangasius nasutus*)	Selangor	37.0 – 52.0	540.0 – 1500.0
Walking Catfish (*Clarias batrachus*)	Pahang	16.8 – 24.9	46.3 – 94.9
Broadhead Catfish (*Clarias macrocephalus*)	Pahang	19.8 – 33.6	60.0 – 260.0
African Catfish (*Clarias gariepinus*)	Selangor	19.6 – 35.4	50.0 – 270.0

Source: Mohsin et al., 1983

Malaysia's aquaculture industry is quite varied, including both in land and marine fishes, diadromous fishes, crustaceans, mollusks, and aquatic plants (FAO,2017). Malaysian aquaculture dates to the 1920s, when Chinese carps were intensively farmed in mining pools (Liong et al., 1988). However, by the 1950s, semi-intensive cockle and freshwater fish raising were cultured in ponds. This industry has grown steadily, with a total production of 506,465.25 tonnes in 2015, priced at a wholesale level of 3,296,463 Malaysia ringgit ($US 756,937). Aquatic plants (seaweeds) have historically dominated aquaculture productivity in Malaysia, contributing for 51.5 % of overall aquaculture production in 2015. However, more than 30 finfish species are farmed, with African catfish making for the majority and red (hybrid) tilapia, sea bass, river catfish (*Pangasius sp.*), and red snapper providing for the remainder (DOF, 2016).

Catfish output tremendously increased from 0.83 % in 2008 to 17.73 % (83,727 tonnes) in 2009, causing Malaysia to be the most productive finfish species producer.

However, the trend in catfish production showed a decrease between the year 2009 till 2013. Overall production fell significantly from 83,727 tonnes in 2009 to 63,206 tonnes in 2010, with the trend extending until 2013, when it slightly increased and then declined again, until rising marginally in 2015 to 50,683.12 tonnes. The ups and downs in African catfish production during this time had an impact on the overall aquaculture business in the nation, and one of the reasons might be the rise of infectious diseases (Dauda et al., 2018).

C. gariepinus, commonly known as African Catfish, is a non-native fish species in Malaysia that was imported from Thailand through aquaculture between 1986 and 1989 (Csavas I, 1995). The earliest record of *C. gariepinus* cultivation in Malaysia dates to 1987, with a yearly yield of 6.46 metric tonnes, and production has steadily increased since then. However, overall output fell significantly from 83,727 tonnes in 2009 to 63,206 tonnes in 2010, with the trend continuing until 2013, when it slightly recovered and then sank again, until rising marginally in 2015 to 50,683.12 tonnes.

Figure 2.1: African Catfish Diagram

2.2 Nutritional Content of African Catfish

The study characterizes the biochemical composition (proximate chemical composition, energy, amino acids, fatty acids, cholesterol, and mineral contents) of

African catfish's fillets to collect the nutritional data this species (Rosa et al., 2007). A study of cultured and wild *C. gariepinus* samples showed that the cultured tissues had greater levels of crude protein and carbohydrate content, whereas the wild samples had higher levels of moisture, ash, and fat. The moisture content of fish is the most important component (up to 80%) of the edible sections of seafood. Typically, the oil and water concentration combined is around 80%. Fresh fish has greater water retention. Moisture content is often inversely related to lipid content of wild sample (75.06 ± 0.04) than the cultured sample (73.22 ±1.62) (Rosa et al., 2007). The moisture content value was obtained by (Osibona et al., 2009), (Ayinla, 1993), (Adeniyi et al., 2012), and (Ayeloja et al., 2013), were 76.7%, 72.2%, 75.7%, 54.5%, and 75.1% respectively as in Table 2.2.

Table 2.2: Moisture Content Results of Wild and Cultured Catfish

Parameter	Wild sample (%)	Cultured sample (%)	Reference
Moisture	75.1	73.2	(Isangedigh et al., 2017)
	76.7	-	(Osibona et al., 2006)
	73.9	-	(Ayinla, 1993)
	54.5	-	(Adeniyi et al., 2012)
	75.1	-	(Ayeloja et al., 2013)
	-	33.9	(Emmanuel B. E et al., 2011)

The appropriate proportion of dietary protein to include in the diet of farmed catfish depends on a variety of circumstances but employing high-quality feed material containing at least 24 % protein for rapid development and good food efficiency is critical (Robinson & Li, 2012). Isangedigh and co-researchers (2017) reported the crude protein concentration in cultivated *C. gariepinus* was greater (57.19 ± 2.80) than in the wild (42.68 ± 1.03). The protein concentration of cultivated samples in this investigation is greater than that reported by (Emmanuel B. E et al., 2011) and (Ayeloja et al., 2013). Furthermore, the protein content of the wild sample measured in this study is larger than that reported by Ayinla (1993) and Adeniyi et al (2012). This is in addition to the fact that the cultivated samples were fed a commercial diet containing more than 38% crude protein throughout the experiment. The findings of this investigation confirm the findings of (Onyia et al., 2013), who found a significant difference in crude protein content ($P<0.05$) between the wild-caught and farm-raised of *C. gariepinus*.

Table 2.3: Crude Protein Results of Wild and Cultured Catfish

Parameter	Wild sample (%)	Cultured sample (%)	Reference
Crude protein	42.7	57.2	(Isangedigh et al., 2017)
	68.9	67.5	(Michael & Adedayo, 2019)
	61.0	60.0	(Ukagwu et al., 2017)
	50.2	48.9	(Onyia et al., 2013)
	19.6	-	(Osibona et al., 2006)
	16.4	-	(Ayeloja et al., 2013)
	20.8	-	(Adeniyi et al., 2012)
	-	25.4	(Emmanuel B. E et al., 2011)

However, Murray and Burt reported that the fat content of fish including catfish significantly more than moisture, protein, and mineral content. While the highest to lowest protein or water content recorded is less than 3:1, the highest to lowest fat values observed is more than 300:1 (Ho & Paul, 2009). The wild samples contained the most lipid (19.44 ± 0.71) while the cultivated samples had the least (18.01±1.0). This finding contradicts the data obtained from (Michael and Adedayo, 2019) and (Onyia et al., 2013), who found increased lipid content in cultivated samples. The current lipid study results contradict those reported by (Ayinla, 1993), (Michael and Adedayo, 2019), (Ayeloja et al., 2013), and others (Onyia et al., 2013). Onyia et al. (2013), on the other hand, found a significant difference ($p<0.05$) in the lipid content of wild and cultivated *C. gariepinus*. This is comparable to the current study. The increased lipid levels detected in wild samples reflect the availability of a range of fat and oil- rich dietary items in their immediate surroundings, which they successfully exploited (Table 2.4).

Table 2.4: Fat Content Results of Wild and Cultured Catfish

Parameter	Wild sample (%)	Cultured sample (%)	Reference
Fat	19.4	18.0	(Isangedigh et al., 2017)
	15.9	18.7	(Michael & Adedayo, 2019)
	1.18	-	(Ayinla, 1993)
	2.1	-	(Ayeloja et al., 2013)
	5.08	5.63	(Onyia et al., 2013)
	13.9	-	(Adeniyi et al., 2012)
	1.15	-	(Osibona et al., 2006)

Ash is the inorganic chemical residue that remains when a sample is burned, and it is primarily made of mental oxides. Ash is mostly constituted of salt and inorganic chemicals and is used in the proximate study of biological materials. It includes metal salts, which are required for ion-requiring activities such as sodium, potassium, and calcium. These trace minerals can be found in catfish fillet. The ash content of farmed samples was found to be greater (17.34 ± 0.85) than that of wild samples (9.12 ± 1.21). (Isangedigh et. al., 2017) found significant differences ($P<0.05$) between wild and cultivated samples, which is consistent with the findings of (Onyia et. al., 2013). An increase in ash content for cultivated *C. gariepinus* may be linked to the feed quality provided to them during production, which is rich in nutrients such as calcium, potassium, and phosphorus.

Table 2.5: Ash Content Results of Wild and Cultured Catfish

Parameter	Wild sample (%)	Cultured sample (%)	Reference
Ash	9.12	17.3	(Isangedigh et al., 2017)
	9.23	8.50	(Michael & Adedayo, 2019)
	2.03	-	(Ayeloja et al., 2013)
	2.30	2.09	(Onyia et al., 2013)
	1.23	-	(Osibona et al., 2006)

Carbohydrates are a type of molecule that includes sugars, starches, cellulose, and other chemicals that are closely related. They are one of the most common organic substances in nature (Robinson & Li, 2012). Carbohydrates may be roughly separated into an indigestible fraction (fibre) and a digestible portion sugars and starch as an energy source for catfish and other simple-stomached animals (Robinson and Li, 2012). Cultured samples had a greater carbohydrate content (9.09 ± 2.85) than wild samples (7.35 ± 2.53). This differs from the report of Emmanuel et. al. (2011). A higher Carbon, Hydrogen and Oxygen value in cultured samples indicates that the metabolic energy in the feed is being used efficiently.

The two groups differ considerably in terms of fibre content and metabolic energy. In the wild, feeding is not controlled. This may have an impact on the quantity of nutrition accessible to fish in their natural environment. Thus, quality feeds fed to cultured specimens might make a difference (Suttle N, 2010).

2.3 Fatty Acid Composition of Between Wild and Farm-Raised Catfish

Fatty acids are chemical molecules made up mostly of carbon, hydrogen, and oxygen. Fatty acids are categorised into three types based on the amount of double bonds: saturated fatty acids (SFA); monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA). PUFA contain two to six double bonds, MUFA have one double bond, and SFA have none. Some of the PUFA found in diet are vital to humans, such as alpha-linolenic acid (commonly known as ALA, 18:3 n-3) and linoleic acid (18:2 n-6). Essential denotes that the fatty acid must be obtained by humans through diet. Most animals and humans have enzyme systems capable of converting alpha-linolenic acid and linoleic acid by lengthening the carbon chain and adding extra double bonds. As an example, alpha-linolenic acid can be converted to eicosapentaenoic acid (also called EPA, 20:5 n-3). Despite some biosynthetic generation of n-3 PUFA in mammals (including humans) and marine fish, the majority of PUFA in these individuals comes from their food.

Foods containing EPA also include different levels of the derivative's Docosahexaenoic acid (DHA, 22:6 n-3) and Docosapentaenoic acid (DPA, 22:5 n-3) (Whelan & Rust, 2006). DPA is a rare fatty acid that can be found in trace quantities in animal lipids (Nhu, 2003).

Fish and fish oils are rich in EPA and DHA (fish and fish oil are the highest origins of EPA and DHA). DHA is the more prevalent of the two fatty acids EPA and DHA in fish, with levels two to five times higher than EPA (Whelan & Rust, 2006). Linoleic and alpha-linolenic acid (C18 PUFA) can be desaturated and prolonged to generate long chain PUFA in the form of Arachidonic Acid (20:4 n-6), DHA, EPA, or DPA in a low proportion in almost all fishes. Because of this low proportion, it is perfect for increasing the amount of n-3 long chain PUFA in the fish's body composition (Pan et al., 2013). As a result, the fish need consume n-3 long chain PUFA.

The fatty acid composition of *Clarias gariepinus* in fresh fillet differs significantly between wild and cage culture (Abiodun-Solanke et al., 2016). 14 fatty acids were identified in the wild species, while 17 fatty acids were identified in the cage cultured species after measuring them against a 37- congener fatty acid methyl esters standard using gas chromatography.

The fatty acid profiles revealed that stearic acid (C18:0) was the major saturated fatty acid in *C. gariepinus*, which was consistent with the findings of Ackman (1989), who discovered that stearic acid (C18:0) was a critical metabolite in fish whose level was unaffected by food (Abiodun-Solanke et al., 2016). Cis-10-Heptadecanoic acid (C15:1), the primary monounsaturated fatty acid in this species, was thought to be exogenous and a reflection of the fish diet (Ackman, 1989).

Palmitic acid (C16:0) and oleic acid (C18:1) were the most abundant saturated and monounsaturated fatty acids in wild C. gariepinus profiles, with a percentage composition of 27 different fatty acids (Osibona et al., 2006) (Table 2.6). Furthermore, (Ho & Paul, 2009) found that, it was notable that the Tra catfish fillets in the current research contained considerable quantities of EPA and DHA, the fatty acid that had not been detected in prior findings on this species. According to the current study, the level of DHA in Tra catfish oil 4.74 % was about eightfold higher than in Basa catfish (*Pangasius bocourti*) oil 0.59 % (Nhu, 2003). The low levels of DHA and EPA in freshwater Tra catfish were not surprising, as levels of these two fatty acids are generally lower in freshwater fish than in seawater fish (Haard, 1992). This is because seawater fish get these omega-3 fatty acids from oceanic plankton (Steffens, 1997) or are fed fishmeal containing these fatty acids (Balaban et al., 1994).

Table 2.6: Fatty Acid Composition Results of Wild and Cultured Catfish

No of carbon atoms	Fatty acids	% Composition		Reference
		Wild	Farmed	
C16:0	Palmitic acid	22.0	-	(Osibona et al., 2006)
C18:1	Oleic acid	26.0	-	(Osibona et al., 2006)
C18:2	Linoleic acid	12.3		(Osibona et al., 2006)
C20:5	Eicosapentaenoic (EPA)	1.0		(Osibona et al., 2006)
C22:6	Docosahexaenoic acid (DHA)	3.0		(Osibona et al., 2006)
C15:1	cis-10-Heptadecanoic acid	57.9	35.3	(Abiodun-Solanke et al., 2016)
C18:0	Stearic acid	17.1	28.8	(Abiodun-Solanke et al., 2016)
C20:5	Eicosapentaenoic acids (EPA)	-	4.76	(Abiodun-Solanke et al., 2016)
C22:6	Docosahexaenoic acid (DHA)	-	2.36	(Abiodun-Solanke et al., 2016)
C18:3	Linolenic acid	-	1.63	(Abiodun-Solanke et al., 2016)
C18:1n-9	Elaidic acid		30.93	(Ho & Paul, 2009)
C16:0	Palmitic acid		29.33	(Ho & Paul, 2009)
C20:5	Eicosapentaenoic (EPA)		0.31	(Ho & Paul, 2009)
C22:6	Docosahexaenoic acid (DHA)		4.74	(Ho & Paul, 2009)