**REVIEW OF LITERATURE**

Bangladesh is a land of rivers and has a variety of fisheries resources. Our water body includes 260 species of freshwater, 475 species of marine water, 24 species of freshwater prawns, 36 species of marine shrimp and crabs, snails, mussels, turtles, etc. (DoF, 2010). Freshwater aquaculture, coastal shrimp, fresh water prawn culture and marketing, crab marketing, etc. are the major subsectors of fisheries in Bangladesh The demand of aquarium fishes or ornamental fishes is becoming very popular in our country day by day. Ornamental fish lovers usually keep aquarium fishes in their houses and offices for aesthetic purpose. In Bangladesh there are only a few native fish species that are considered ornamental fish species e.g. Rani fish (*Botia* sp.). Most of the available ornamental fishes are exotic species.

There is a long tradition in Bangladesh of introductio of ornamental fish species. Unfortunately, during the import of this species, no concern and no quarantine steps were taken and, as a consequence, they were introduced into the country without proper documentation. Information such as the lists of useful and harmful effects published; published science data on the ecological and economic impacts of such species are not available. Despite the absence of research, the exact time of the introduction of ornamental fish is difficult to identify.

History reveals that, in 1952, the Siamese Gourami (*Trichogaster pectoralis*) was first introduced from Singapore into Bangladesh. Then, in 1953, the goldfish (*Carassius auratus*) was introduced from Pakistan to Bangladesh. It was originally used in aquariums and concrete ponds for recreational purposes (DoF, 2001).

In Bangladesh the professional culture of aquarium fish was started in 1980. At first, the aquariums were set up in the restaurant to attract people for aesthetic pleasure. In shopping centers, the rearing of aquariums was then practiced. Generally, elite individuals keep aquariums for their aesthetic pleasure in their home or workplace. The tradition of ornamental fish culture has been growing day by day. In the mid-1980s, aquarium fish culture was focused at Kataban in Dhaka due to rising demand (Mostafizur et al., 2009).

The increasing interest in aquarium fish has contributed to a steady rise in the worldwide trade in aquarium fish. Today, ornamental fish processing is an important business activity as well as one of the most common hobbies in the world, with a turnover of US$ 9 billion a year and an annual growth of 8 percent. This sector is believed to contribute to economic development in underdeveloped countries, especially those in the tropics (Yanar et al., 2008).

Ornamental fish are characterized by a wide diversity of colours and colour patterns and success in the ornamental fish trade is very much dependent on the vibrant colour of the fish. The commercial value of these fish reflects this requirement; hence, ornamental fish growers are constantly exploring methods of enhancing skin colouration. This color is derived from the accumulation of carotenoids in the tissue of fish (Simpson , 1981).

The carotenoids are also vital nutrient for healthy growth, metabolism, and reproduction as well as colour (Miki, 1991).

Since fish are unable to synthesize these pigments, the ingested carotenoids are responsible for the pigmentation of the fish. The fish diet contains multiple sources of carotenoid pigments, such as pure carotenoid pigments, animal sources and plant sources. A double benefit is the use of plant sources in fish feed: besides being rich in carotenoid pigments, they are a direct source of nutrients such as protein, lipids and vitamins. Many studies have emphasized the interest in utilization of plant sources of carotenoid pigments such as paprika (*Capsicum annum*) (Tsushima et al., 1998), yeast (*Rhodotorula sanneii*) (Savolainen and Gyllenberg, 1970), chesnut flowers (Neamtu et al., 1976), dried flowers (Torrissen et al., 1989) and hippophae oil (Hippophaerhamnoides) (Kamata et al., 1977).

Chapman (2000) has concluded that to enhance colouration in ornamental fish, a combination of synthetic and natural carotenoid pigments should be added at a level of 0.04- 2% of the diet. Marigold (*Tagetes erecta*), contains various carotenoids of which lutein is the principal (Navarrete-Bolaños et al., 2005).

One of the reasons that make ornamental fish in the public's interest is colour. The presence of pigment cells or chromatophores in the dermis on the scales, outside and below the scales causes the appearance of colour in fish (Wayan et al. 2010).

The red, orange and yellow colours cannot be synthesized by the fish's body, so the amount of carotenoids present in the feed greatly affects the colour formation in ornamental fish (Wayan et al., 2010).

Feed have great effects on the growth and health of fish. Not only that, the feed can also function to increase the colour value, so that it is better to feed it with the addition of certain ingredients to increase the colour value of ornamental fish.

Feed that contains pigments or certain dyes such as carotene, if given together with artificial feed will be able to increase the amount of pigment in the chef, so that the colour of the chef will be clearer or brighter (Bachtiar, 2002).

The colour of ornamental fish can be maintained by providing food containing colour pigments. The source of colour pigments can come from synthetic or natural substances. One source of natural pigments can be obtained from carrot flour can be one of the sorce of naturally occurring pigments (Lesmana, 2002).

Carrots are a source of natural pigments that produce beta carotene which can increase the colour value of ornamental fish. Carrots are rich in beta carotene so that they can increase the value of red as well as the use of Spirulina added to the feed (Sunarno 2012). The high carotenoid content makes carrots can be used as a natural food colouring material for fish. In addition, beta carotene in carrots also acts as a vitamin A precursor (Ikawati 2005)

Globally, the ornamental fish trade is a multi-billion dollar industry valued to the tune of approximately US$15 billion (Rhyne et al., 2017). Even though considerable developments occurred over the years, several issues such as brood stock management, spawning induction, embryo development, hatching and the development of efficient grow out diets still exist in this sector (Olivotto et al., 2017; Randazzo et al., 2018 ).

In fish, skin coloration is an important attribute that increases attractiveness, value and demand, especially in the ornamental fish market Fish are only fed on compound feed supplemented with carotenoids in captive rearing conditions to maintain their pigmentation and in captive rearing conditions fish are solely fed on compound feeds supplemented with carotenoids in order to retain their pigmentation (Chatzifotis et al., 2005).

Due to captive stress, most of the brightly colored ornamental fish gradually fade when placed in the clear water of aquariums and if dietary carotenoids are lacking (Saxena, 1994). Several factors such as fish species and its physiological status, water quality and dietary level, quality or feed consumption affect the level of carotenoids in fish tissues (Gupta et al., 2007).

Several sources of carotenoids in fish species have been found to be successful in increasing skin pigmentation. The influence of synthetic carotenoids, like astaxanthin, canthaxanthin, lycopene, β carotene, carophyll pink on skin colouration has been studied by several researchers (Meyers, 1994)

It was reported that pigments from the natural sources is quite effective such as Spirulina (Kiriratnikom et al., 2005), red yeast, *Xanthophyllomyces dendrorhous*, Alfalfa, *Medicago sativa* (Yanar et al., 2008) and marigold, *Tagetes erecta* (y Juan et al., 2013).

The international aquarium fish trade has strongly increased in the past century, particularly since the early 1980s, to become one of the most popular hobbies globally (Andrews, 1990; Dufour, 1998; Wabnitz et al., 2003; Strecker et al., 2011).

Today, it is estimated that million households possess at least one aquarium, particularly in the United States of America, European countries (Germany, France, Belgium, and Italy), Japan, China, Australia and South Africa (Andrews, 1990; Wabnitz et al., 2003)

The entire industry inclusive of retail sales, associated materials and wages is valued at approximately US$ 15 to 30 billion per year (Andrews, 1990) and the international market probably includes more than 100 countries (Whittington and Chong, 2007).

It is estimated that over 6,000 aquarium fish species are now traded internationally each year, among which three quarters (ca. 4,000) live in freshwaters and one quarter (ca. 1,500-1,800) in marine waters (Whittington and Chong, 2007). The global market has probably reached a billion fish annually, which would be a multiplication by six of the total number of fish sold globally in the late 1980s (Andrews, 1990; Whittington and Chong, 2007).

Fish feeds are usually consist of relatively expensive carotenoids, i.e. astaxanthin or canthaxanthin carotenoids. Therefore, there is a growing need to find cheaper carotenoid substitutes. Carotenoids extracted from paprika (*Oleoresin paprika*) contain mainly capsanthin and may be a cheaper substitute for the currently used feed additions. The present research examined the effects of carotenoids from paprika (*Oleoresin paprika*) added to (*M. ramirezi* ) fish feeds on growth rate, survival, carotenoid accumulation level, and colour intensity of the fish ( Harpaz & Padowicz 2007). Carotenoid deposition can vary according to fish size (Halten et al., 1995).

Therefore, carotenoid supplementation is needed to enhance colour performance. An abundance of studies on the addition of carotenoids to fish diets have been conducted on salmonids and involved the use of different carotenoid sources and inclusion levels (Halten et al., 1995 , Yanar et al., 2008).

In contrast, a limited number of studies have been conducted on carotenoid addition to diets of ornamental fish, e.g., goldfish and koi carp (Hancz et al., 2003), neon serpae tetra (Wang et al., 2006), and guppies (Grether et al., 1999).

Carotenoids are an important group of natural lipid soluble pigments that are found in all families of the plant and animal kingdoms. There are about 600 different natural carotenoids that have been identified (Lorenz 1998; Latscha, 1991). Carotenoids derive their names from the fact that they constitute the major pigment in the carrot according to a trivial name system and an IUPAC system (Kiaui & Bauernfeind 1981). Carotenoids represent the most widespread and structurally diverse pigmenting agents. Carotenoids and their derivatives are important in animals as the basis of the visual pigments responsible for light detection and colour discrimination (Britton, 1983). Carotenoids are responsible for many of the brilliant yellow to red colours in 5 plants and animals, as well as the variety of bluish, greenish, purplish, brownish and blackish colours seen in many fish and crustaceans (Latscha, 1990).

Carotenoids are structurally related to retinol and β-carotene, the main sources of vitamin A for animals (Latscha, 1989). β-carotene can be converted to two identical molecules of retinol and vitamin A (Lee et al., 1999). The beautiful yellow, orange and red colours found in the skin of ornamental fish are the result of a group of carotenoid pigments, although colourless pteridines may also be present (Latscha, 1991). Fish, in the same way as other animals, must ingest carotenoids as precursors for vitamin A, as well as depositing pigments. Aquatic animals are unable to perform a de novo synthesis of carotenoids in their body and therefore they must acquire these pigments from their diet (Bagnara & Hadley, 1973; Latscha, 1991). In nature, fish gain their colour through their natural diets such as algae because only plants and protists are able to synthesize carotenoids.

Dietary carotenoids are widely used to provide pigmentation of fish in cases where the fish can no longer obtain it from natural feeds. Although the usage of carotenoids in improving pigmentation is commonly adopted, the proper type of carotenoids, the correct amounts and the feeding period are still an issue of research for different fish species in their growing stages. In intensive modern aquaculture systems, dietary carotenoids must be included as part of the diets formulation, especially in diets for ornamental fishes.( Katayama et al. 1973) proposed that aquatic animals can be divided into three classes based on their biosynthetic capabilities.

Some of the commercial aquafeed producer is currently adding Carophyll Pink into their dry-pelleted diets (Torrissen et al. 1989). A group of scientific researchers did several studies on Atlantic salmon and rainbow trout using Carophyll Pink and Carophyll Red to improve flesh pigmentation (Bjerkeng & Berge, 2000). Based on the results of studies on salmonids, astaxanthin seems to be absorbed and deposited better than canthaxanthin. (Torrissen, 1986). Hatlen et al. (1995) also tested the pigmentation on Arctic charr using Carophyll Pink in different concentrations.

Scientific studies of Haematococcus microalgae by research institutions and international feed companies have concluded that this microalgae is a safe and effective natural alternative for pigmenting aquatic animals (Lorenz and cysewski 2000). Miki (1991) found that the more stable esterified form of astaxanthin is believed to be an adaptive feature to be able to store astaxanthin in tissues without excessive oxidation. Esterified astaxanthin is the main form found in *H. pluvialis*. Naturose has been successfully used as a source of pigments in aquaculture in such species as shrimp, rainbow trout, coho and Atlantic salmon.

Other than pigmentation, studies indicate that carotenoids also have a biological function involved in growth and reproduction. Several researchers have reported positive effects on growth for different fishes fed diets supplemented with carotenoids, especially astaxanthin (Christiansen et al., 1994). The mobilization of carotenoids from the flesh to the skin and ovaries during maturation also shows that carotenoids may have a function in reproduction. Torrissen (1985) detected a decrease in the carotenoids content of the flesh of Atlantic salmon about six months prior to spawning and proved the mobilization of carotenoids from the flesh to the skin and ovaries during maturation. Torrissen (1984) showed the presence of astaxanthin and canthaxanthin in the plasma of feeding rainbow trout, indicating that serum is the transport medium.

Studies have shown that there are many sources of dietary carotenoids that can be used for the colouration of cultured fish. Carrot and hibiscus, astaxanthin and canthaxanthin (Torrissen, 1986; Ito et al., 1986; Storbakken et al., 1987; Choubert & Storbakken, 1989; Choubert & Heinrich, 1993) and microalgae (Harpaz et al., 1998) can be used in fish diets to enhance the colours of fishes.

Synthetic astaxanthin has long been used in aquaculture to enhance the flesh colour of cultured rainbow trout and salmon (Torrissen, 1984, 1986 and 1989; Choubert & Storbakken, 1989; Choubert & Heinrich, 1993;). Torrissen et al., (1989) had shown evidence pointing to the vital role of carotenoids in the physiology and health of plants and animals. This study observed higher growth rates in Atlantic salmon. Astaxanthin has also been incorporated into feeds for ornamental fishes.

The findings of Smith et al. (1992) on coho salmon indicated that feeding low astaxanthin concentrations resulted in the most effective use of pigment and uniform pigmentation during the grow-out cycle from fry to market size. In addition, an increased dietary dose has been shown to have no significant effect on the variation in pigmentation in Atlantic salmon (Torrissen & Christiansen, 1995), while an increase in the duration of feeding carotenoids has been reported to reduce inter-fish variation in pigmentation in Atlantic salmon (Torrissen & Christiansen, 1995), rainbow trout and Chinook salmon (March and MacMillan, 1996).

Storebakken et al. (1987) also showed similar results in the study on pigmentation of Atlantic salmon. The retention coefficients decreased as the pigment dose in the diet increase and this phenomenon showed that there is an optimal level of dietary carotenoids which maximised deposit accumulation of carotenoid in the fish. The excess carotenoid given would be a waste and it will increase the cost of production.

Czeczuga (1979) reported that fishes with higher level of carotenoids were more resistant to bacterial and fungal diseases than fishes with low carotenoid levels. Torrissen (1984) showed that carotenoids supplied in the diet increased the growth rate in Atlantic salmon. This strongly indicated that carotenoids have a biological function. Segner et al. (1989) found an improved liver histology and performance in fish fed high astaxanthin levels in the diet and other carotenoids functions include.

Torrissen et al. (1989) assumed that pink to red pigmentation in flesh could be achieved by pigmentation of astaxanthin and canthaxanthin. The study of Choubert and Storebakken (1989) on dose response to astaxanthin and canthaxanthin pigmentation of rainbow trout fed various dietary carotenoids showed that astaxanthin is more efficiently utilized and the flesh pigmentation increased by increasing the dietary carotenoids concentration in different ratio of different pigment.

Tan et al. (2006) added hibiscus flower and carrot into goldfish practical diet to test the skin colour enhancement and the result indicated that carotenoids accumulated in the body of goldfish especially in the head region. The study on the effect of Carophyll Pink on the skin colouration of Angelfish (*Pterophyllum scalare*), Japanese carp (*Cyprinus carpio*) and goldfish (*Carassius auratus*) also showed the same result.