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# Exploration and Processing of Pigment Source Feed Materials for Ornamental Fish Feed

Kiki Haetami[1*], Agung S. Meidito[1]

[1]Fisheries and Marine Science, Universitas Padjadjaran
Jalan Raya Bandung Sumedang KM.21, Hegarmanah, Kec. Jatinangor, Kabupaten Sumedang, Jawa Barat 45363

***Correspondence**:
kiki.haetami@gmail.com

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**ABSTRACT**

Ornamental fish farming is identical to attractive colors formed from the union of genetics and digested feed sources. Exploration and processing of feed ingredients are one of the important factors added to feed formulations to increase brightness in fish. Pigment sources are divided into 2, namely natural pigment sources (plant and animal), and synthetic pigment sources as commercial materials. The application of pigment source feed ingredients is used as feed additives (nutritive and non-nutritive) which are added or mixed in the formulation. The preparation technique for adding pigment sources is carried out by spray drying, and coating (coating) in feed. Feed additives in commercial ornamental fish feed formulations can be in the form of active substances astaxanthin ($C_{40}H_{52}O_4$) and beta-carotene ($C_{40}H_{56}$) which give red-orange color, or in the form of alternative feed ingredients from spirulina, carrots, and pumpkin which give yellow and orange colors. Astaxanthin and beta-carotene dyes have been proven effective in enhancing the brightness of color in ornamental fish at a dose of 1500 ppm. The aim of the review is to provide information and insight regarding pigment source feed ingredients as well as related processing of pigment source materials using several extraction methods. The method used in this review is based on the results of a literature study using articles that have been searched on Google Scholar for the period 2012-2024. Each journal used has the results of research on pigment source materials, processing of pigment sources and their application for pigments in fish.

## INTRODUCTION

The attractiveness of ornamental fish is mainly measured by its brilliant color, shape, physical features, behavior, and health condition or stamina (Lestari, 2019). An important factor that influences the brightness of fish color is the pigment in fish cells. Pigments are non-nutritional compounds that stimulate the appearance of colors such as yellow, orange and red in fish. The color of the fish's body is caused by the presence of pigment cells or chromatophores located in the dermis on the scales or under the skin. The cells that play a role in providing this color include chromatophores and iridocytes, with chromatophores containing pigment granules in the cytoplasm which are the source of color

The classification of pigment types based on the ingredients used to make the pigment is divided into two parts. Natural pigments or organic pigments are pigments made from natural materials such as animals, plants, soil, insects and shellfish. Meanwhile, pigments made from materials derived from chemically processed raw materials or mining materials are called synthetic pigments. The manufacture of synthetic pigments is carried out using chemical methods, namely by synthesizing commonly used carotenoid monomers (imitations) which are synthesized directly from raw materials or mineral mines. Administration is done by mixing it into the feed. The results of research (Phonna *et al*., 2022) show mixing synthetic pigments of 750 mg/1/2 kg feed (1500 ppm) for comet fish. Synthetic dyes must go through various testing procedures before they can be used as feed colorants. For its use, the dye must undergo a use procedure test called a certification process. So, many food processors for fish rarely use synthetic dyes because the manufacturing process is difficult and the use of synthetic dyes cannot guarantee the health of the fish.

The use of natural dyes is considered safer than synthetic dyes (Neliyanti, 2014). Various studies have been conducted to explore natural dyes as an alternative to synthetic dyes. Anthocyanins, chlorophyll, and carotenoids are examples of natural pigments that are commonly used as dyes. In addition to these three pigments, betacyanin is also a pigment found in plants and can be used as a natural dye. Betacyanin is water-soluble, and research by (Setiawan *et al*., 2016) shows that betacyanin extracted from opuntia fruit is stable at a maximum pH of 5 and a storage temperature of 4ºC, but is unstable at high temperatures..

Fish can only synthesize black and white pigments naturally, while red, orange and yellow colors depend on the amount of carotenoids obtained from feed (Wayan *et al.,* 2010). Therefore, the formation of color in ornamental fish is closely related to the presence of carotenoids in the feed. (NRC, 1998) explains that pigments such as carotenoids, xanthophylls and pterins play an important role in producing various colors in fish. The yellow color is produced by β-carotene, lutein, zeaxanthin, and taraxanthin, while the orange and red colors are produced by astaxanthin and canthaxanthin. Because fish are unable to synthesize their own pigments, they rely on pigment sources from natural feed or additional feed (feed additives) to maintain and increase the brightness and intensity of color.

Several main methods for preparing ornamental fish food include spray, drying and coating. The coating process is a method that is widely used to coat pellets with additional ingredients, including substances that increase immunity, accelerate maturation, and increase the brightness of the color of ornamental fish. This coating process is carried out by adding nutrients such as astaxanthin and beta-carotene to the pellets. The use of synthetic pigments, although popular in the feed industry, has limitations such as high cost and negative impact on the aquatic environment. As an alternative, natural pigments rich in carotenoids are a more environmentally friendly and sustainable option in the long term. Therefore, the development of feed technology that is able to integrate natural pigments in an efficient manner is one of the main focuses in the ornamental fish farming industry.

## METHODS

The method used in preparing this journal is the literature study method (systematic review). Literature study is an activity of collecting data from various library sources, reading and taking notes, and managing research materials (Zed, 2008). The data used in this journal comes from the results of various research that has been previously carried out in databases such as Science Direct, Web of Science, Elsevier, Google Scholar, and other database sources. In preparing this journal, ten journals were obtained to discuss the effect of adding pigments to feed for ornamental fish.

## RESULTS AND DISCUSSION

### Natural Dyes And Their Classification

Natural dyes derived from various types of plants have a wide variety, including red, yellow, blue, brown, and black. These variations depend on the plant species, the part of the plant used, and the extraction method applied. There are around 2000 types of pigments produced by plants, of which 150 have been utilized in various applications. In addition, dyes extracted from some plants can also be categorized as drugs, and some of them have been shown to have antimicrobial activity (Visalakshi & Jawaharlal, 2013)

Natural dye molecules are a combination of unsaturated organic substances, chromophores as color carriers such as azo, nitroso, nitro and carbonyl groups, and auxochromes as binders between color and fiber such as cations and anions (Witt in Suheryanto, 2013).

The process of color formation in the fish's body is caused by the presence of pigment cells located in the outer layer (Sally,1997) in (Bianco *et al*., 2022). The intensity of color brightness in fish can be influenced by the source of pigment in fish, especially from the carotenoid group (Indarti et al., 2012) Types of natural pigments can be classified into several parts as follows:

A. Karotenoid

Carotenoids are color-forming components that give red and yellow colors (Bianco *et al*., 2022). Natural chemical compounds which are yellow-orange-red pigments are carotenoids (Rymbai *et al*., 2011). Important carotenoid groups include: karotene-karoten ($C_{40}H_{56}$) dan lycopene($C_{40}H_{56}$); xanthophyl canthaxanthin ($C_{40}H_{52}O_2$), zeaxanthin ($C_{40}H_{56}O_2$), lutein ($C_{40}H_{56}O_2$), and capsanthin ($C_{40}H_{56}O_3$)-karoten is an orange-yellow pigment, while lycopene is a pigment that can provide a red color.

(1) Astaxantin
The most effective type of carotenoid pigment found for coloring is Astaxanthin (Meiyana and Minjoyo, 2011) in (Bianco *et al*., 2022). Astaxanthin added to fish feed is one of the dominant and effective carotenoids for increasing fish brightness, because fish will absorb it from the feed and use it directly as red pigment cells. Fish absorb astaxanthin from feed, then use it directly as red pigment cells which can inhibit the aging process in all types of living creatures.

(2) Xanthophyl, namely a type of oxygen carotene, which can give an orange-yellow color.

(3) Betacyanin (betalains) is a red pigment, obtained from red beet extract (*Beta vulgaris*), its main use is as a food coloring.

(4) he main component of betacyanin (betalains) is betanin pigment (95%) and has good taste. Beet root extract contains red, yellow and also bluish-red pigments depending on the betanin content, stable in the high pH range. Used to color foods such as drinks, confectionery and dairy products. Bixin can be obtained from Sinduri seed extract (*Bixa orellana* Linn.), which can provide an orange-yellow color to the product. Curcumin is

a bright yellow dye, obtained from the powdered extract of turmeric rhizomes (*Curcuma longa* Linn.).

(5) Lutein, is a very common carotenoid, more green-yellow in color.

(6) Combined Carotenoids. The yellow-orange color of annatto comes from the outer layer of *Bixa orellana* seeds, this color is a combination of caratenoids, bixin and nor-bixin (Aberoumand, 2011) in (Rymbai *et al*., 2011).

B. Flavonoid

(1) Antosianin

Anthocyanins are classified as pigments called flavonoids. Flavonoid compounds are polar compounds and can be extracted with polar solvents. Anthocyanin is a pigment that can be extracted from the skin of the *Hylocereus polyrhizus* dragon fruit. Anthocyanins are a group of red to blue pigments that are widely distributed in plants.

(2) Quercetin is one of the most significant flavonoids, with the molecular formula $C_{15}H_{10}O_7$. Luteolin, which is also included in the flavonoid group, is a yellow compound and has the molecular formula $C_{15}H_{10}O_6$ (Rymbai *et al*., 2011). Anthocyanidins are part of the flavonoids that are very colorful. Anthocyanins, which are glycosides of anthocyanidins, belong to the class of phenolic compounds that provide blue, red, orange, and purple colors. To date, more than 540 types of anthocyanin pigments have been identified, most of which are structural variations of glycosidic substitutions at positions 3 and 5, as well as the possibility of acylation of sugar residues with organic acids (Rymbai *et al*., 2011).

(3) Tannins can be divided into hydrolyzable tannins (pyrogallol tannins) and condensed tannins (cathecol tannins). Condensed tannins, also known as proanthocyanidins, are polymers consisting of 2 to 50 or more flavonoid units, which are connected through carbon bonds, so they are not easily hydrolyzed (Ismarani, 2012). Both hydrolyzable tannins (pyrogallol) and condensed tannins (cathecol) are included in the flavonol group and can be used as tanning agents. Both provide yellow-brown and reddish brown colors (Kasmudjiastuti, 2014) .

C. Plant Chlorophyll

Plants as a source of natural pigments have many benefits for increasing color in ornamental fish. As the results of research by (Syahrizal *et al*., 2017) show that the addition of carotenoids from water hyacinth flour (*Eichhornia crassipes*) to artificial feed has an effect on color changes in koi carp. Apart from that, other carotenoids contain basil leaf flour (*Clitoria ternatea* L.) as a source of natural pigment and its effect on the color quality of fish tails (Andriani *et al*., 2021).

Tetrapyrolle is chlorophyll which is a green pigment used by all plants for photosynthesis. Use as a dye is limited, due to the lability of magnesium and the associated color changes that occur. Anthracenes contain several well-known dyes. The largest group most known for its use is the anthraquinones (quinones), because they give a sharp color. Anthraquinone dyes require a mordant (complex metal ion) for the fabric dyeing process (Rymbai *et al*., 2011).

Blue indigo is obtained from dry leaf extract of *Indigofera* spp, which contains indican glucoside or isatan B or Indigotin. Heating tea leaves in a wet and acidic environment can cause the change in chlorophyll compounds to pheophytin, and the color changes to brownish green.

**Coating Pigment Source For Ornamental Fish Coloring**

In the ornamental fish sector of the fishing industry, the coloration of fish plays a crucial role, significantly influencing both aesthetic appeal and commercial viability. Elbe *et al*. (1996) in Jiwintarum *et al*. (2016) define dyes as chemical substances, which can be either natural or synthetic, that impart color. According to Winarno (1992) in Jiwintarum *et al*. (2016), these coloring agents can be categorized into two main types: natural and synthetic. Natural dyes are derived from various sources, including animals such as the pink hues found in flamingos, salmon, and plants, which provide colors like caramel, chocolate, and those from suji leaves. Conversely, synthetic dyes, often referred to as artificial dyes, are produced through chemical processes involving sulfuric or nitric acid, which may be tainted with toxic substances such as arsenic or other heavy metals.

One way to increase the natural color of fish is to provide feed containing pigments, such as astaxanthin, beta-carotene, or canthaxanthin, which is coated using a coating technique.

The purpose of Coating Pigments in Ornamental Fish Food is

1. Pigment Stability: Pigments like astaxanthin are susceptible to oxidation, light, and heat. Coating protects pigments from degradation during storage and feed manufacturing.
2. Release Control: Coating ensures the pigment is released gradually in the fish's digestive tract thereby improving absorption.
3. Increased Effectiveness: Coating the pigment can increase the bioavailability of the pigment so that more of it is absorbed by the fish's body.
4. Increases Feed Durability: Coating prevents pigments from dissolving in water before being eaten by fish, thereby reducing waste and maintaining aquarium water quality.
5. Extends Shelf Life: Coating agents such as polymers, fats, or proteins can slow pigment deterioration during storage.

Coating materials that can be applied to feed can be in the form of solid powder or liquid extract. The material that is the source of the pigment is extracted which includes: solid extract and liquid extract. Some pigment sources can be easily obtained, both synthetic and natural pigments. Processing of natural pigments can be done by extraction using simple processing technology.

Extraction of natural ingredients from carrots: Prepare raw carrot ingredients, clean them, then weigh 20 grams and then grate them. Assemble the extraction tool, put 20 grams of grated product and 200 ml of water into a three-neck flask. Then heated to produce, the dye solution from the extraction process is concentrated by heating until ¼ of the volume remains. Then put it in a porcelain cup, then put it in an oven where the temperature has been set at around 60˚C until most of the solvent has evaporated.

Extraction of purple sweet potatoes begins with reducing the size of the ingredients (for example 25 grams of sweet potato flesh) using a crusher or grater. Then put it in a tube and extracted with a neutral (water) or polar (ethanol) solvent and the extract obtained is filtered with filter paper.

**Application of Natural Pigment Sources in Fish**

Coating technology in feed processing is a significant solution for ornamental fish farmers to increase the aesthetic appeal of fish and increase their selling value. Several examples of pigment source coating applications in feed are presented in Table 1.

Based on Table 1, the pigments commonly used in fish are from the carotenoid group (yellow-orange pigments from fruits), Anthocyanins (water-soluble orange, red, blue), and Curcumin (yellow, red, orange from turmeric plants). In addition, there are also pigments from animal materials, namely squid, shrimp that can be applied as a source of astaxanthin. These substances have proven effective in strengthening color pigments in fish, providing a significant increase in red, orange, and yellow colors that cannot be produced naturally by fish. The use of these materials is generally applied through the coating technique with a dose generally ranging from 3% in feed.

Table 1. Application Coating Materials Originating as a Source of Carotenoid Pigments as Feed Additives

| Pigment resource | Coating Method | Contents | Color pigments | Best results/dosage | Reference |
|---|---|---|---|---|---|
| Tomato extract | Cutting, milling, filtrat fluid. Sprayer | Astaxantin 113.05 mg/kg | Red | Solvent extract ratio 75%/10 ml + commercial feed | Sukmawati *et al*. (2023) |
| *Spirullina Fusiformis* powder | Milling in powder form (satin cloth sieve/sieve) | astaxantin, beta-karoten, cryptoxanthin | Red, yellow, orange | 3% in total feed | Phonna *et al*. (2022) |
| Synthetics Pigment | Coating | Axtaxantin | Red | 1500 ppm on fish. | Prariska *et al.* (2023) |
| Carrot (*Daucus carrota* L), | Cold method extraction with neutral solvent (water) | B-caroten | orange | Self Pre-Mixing 5% carrot extract (5 ml/ kg feed) | Isnaini *et al.* (2022) |
| Purple sweet potato (*Ipomoea batatas L*) | Destilate (T 80°C) | antosianin dan antioksidan | purple, red, blue | 300 mg extract sweet potato / kg (300 ppm) | Lestari *et al*. (2019) |
| Pumpkin flour | Milling | Beta-Karoten | orange yellow | 3 % in feed | Haerawati (2024) |
| Red dragon fruit skin | maceration extraction ethanol solvent | antosianin (62,68%) | purple red | 3% extract bv/bb feed | Usman *et al.* (2022) |
| Squid ink extract (*Loligo sp.)* | maceration | Melanoprotein, 90% melanine, 5% protein, 0.8% carbohydrates | black | 15% squid ink extract per weight of feed | Dahlia *et al*. (2023) |
| Moringa Leaves (*Moringa oleifera*) | Powder | karotenoid 520 ppm | Green | 3 % in feed | Hutapea *et al*. (2014) |

Another benefit of feed additives as a source of pigment is beneficial in terms of health. In addition to increasing the expression of body pigments, carotene is also known to naturally function as a basic ingredient of vitamin A, supports thermoregulation or the process of regulating body temperature, helps the formation of egg yolks in the reproductive process, and affects fish health (Bachtiar, 2002). Natural pigments obtained by fish from plant extracts containing carotenoids act as antioxidants that are good for fish health. This antioxidant has a value ten times greater than astaxanthin. Astaxanthin as an antioxidant can inhibit lipid peroxidation and protect cell membranes from oxidative damage in aquatic organisms

(Higuera-Ciapara *et al*., 2006).

**Pigment Source Extraction Technology**

The initial step in the acquisition of natural dyes typically involves the extraction process. A variety of techniques are available for extracting plant materials, with traditional methods like Soxhlet extraction being commonly employed. Nevertheless, there has been a recent shift towards the adoption of alternative extraction methods, including supercritical fluid extraction (SFE), pressurized fluid extraction (PLE), microwave-assisted extraction (MAE), ultrasonic-assisted extraction (UAE), pulsed electric field (PEF), and enzyme-assisted extraction (EAE). Each of these innovative techniques offers distinct advantages and outcomes (Saini & Keum, 2018).

A critical aspect of investigating the production of novel pigments from plant sources involves understanding the stability of these pigments and selecting the appropriate extraction method. Various extraction techniques, including enzymatic processes, solvent extraction, ultrasound, and microwave-assisted methods, each offer distinct advantages and outcomes (Saini & Keum, 2018). The stability of pigments poses a significant challenge for industrial applications, as numerous variables influence their quality. External factors such as light exposure, temperature, oxygen levels, and acidity can adversely affect this stability (Ebrahimi & Parvinzadeh Gashti, 2016).

(1) Anthocyanin Pigment Extraction

Table 2. Results of Extraction of Pigment Anthocianins from Fruit Peel Waste as an Exploration

| Type of Material | Extraction Method | | | | | | Reference |
|---|---|---|---|---|---|---|---|
| | Tech. | solvent | Power | Temp. (°C) | Time | Rende ment (g/kg) | |
| Dragon Fruit rind | UAE | Aquades, citric acid 10% | 65% | - | 45’ | 0,59 | Widyasanti *et al*. (2018) |
| Grape rind | MAE | Citric Acid | 600 W | - | 40” | 1,73 | Li *et al*. (2012) |
| Grape rind | MAE | Methanol 40% | 500 W | 1000 | 5’ | 1,86 | Liazid *et al*. (2011) |
| Sour cherry (*Prunus cerasus* L.) | MAE | Ethanol 80% | 500 W | - | 90” | 12,47 | Kurtulbas *et al*. (2021) |
| Mangosteen skin | Mase-ration | Ethanol 95%, hydrochloric acid | - | 300 | 24 h | 0,001 | Basito (2011) |
| Purple passion fruit peel | Mase-ration | Ethanol 96%, hydrochloric acid | - | 52,03 | 180’ | 5,78 | Herrera-Ramirez *et al*. (2020) |
| Markissa purple peel | UCGE | water | 780 W | - | 50’ | 0,83 | Liu *et al*. (2018) |
| Jabuticaba peel | HAE | Ethanol 9,1% | - | 47,10C | 21,8’ | 81 ± 2 | Albuquerque *et al*. (2020) |
| Jabuticaba peel | PLE | Ethanol 99,5% | Pressure 5 MPa | 800 C | 9’ | 2,14 | Santos *et al*.,(2012) |

MAE: Microwave Assisted Extraction UAE: Ultrasound assisted Extraction UCGE: Ultrasonic cell grinder extraction DW: Dry Weight, PLE: Pressurized liquid extraction, HAE: Heat-assisted extraction

Based on Table 2, based on various studies that have been conducted, anthocyanin pigments have been successfully extracted from various types of fruit skins. Jabuticaba fruit skin showed the highest anthocyanin content, which was 81 ± 2 g/kg, which was obtained through the heat-assisted extraction (HAE) method and optimized using Response Surface Methodology (RSM). This result is two times higher than the ultrasonic extraction method (Ultrasonic Extraction, UEA). Jabuticaba (*Myrciaria jaboticaba* (Vell.) Berg.) is a berry originating from Brazil, with dark purple skin that is rich in anthocyanins. The high yield of HAE extract can be explained by the stirring system applied in each method. In the HAE method, a continuous magnetic stirring system is used, while in UEA, stirring is carried out only with the power of the ultrasonic probe. As a result, the lower power in UEA results in less than optimal mixing motion (Albuquerque *et al*., 2020).

Conventional methods such as HAE have advantages in terms of ease of application and low investment costs when compared to non-conventional methods such as UAE. The extraction duration significantly affects the anthocyanin recovery rate. Therefore, the longer the extraction time, the lower the anthocyanin recovery rate obtained, due to the damage to the structure of sensitive compounds due to longer processing times. Optimal conditions for HAE are determined by short extraction times, moderate temperatures, and the use of lower ethanol concentrations. Ethanol is chosen as a solvent in the extraction process because it has a low level of toxicity and efficiency in recovering phenolic compounds, including anthocyanins (Albuquerque *et al., 2020*). HAE is a solid-liquid extraction method commonly used to extract pigments and other bioactive compounds. This process involves mixing a solid sample with a solvent for a certain period of time and temperature (Manzoor *et al*., 2021)

(2) Betalain Pigment Extraction

Numerous studies have demonstrated the successful extraction of betalain pigments from various fruit skins. Among these, the skin of Prickly Pear (*Opuntia engelmannii*) exhibits the highest concentration of betalains, quantified at 201.6 g/kg, when employing the Ultrasound Assisted Extraction (UAE) technique. This elevated yield can be attributed to the UAE method's capacity to operate at lower temperatures and with reduced solvent usage, while also shortening the extraction duration compared to traditional methods (Manzoor *et al*., 2021). Variations in extraction conditions arise from factors such as the solvent employed, extraction duration, temperature, and the solute/solvent ratio (Lestari *et al*. 2019). The UAE technique is categorized as a non-thermal extraction process, allowing for the extraction of betalains at lower temperatures, which is particularly advantageous for heat-sensitive compounds, as it minimizes thermal degradation (Saini & Keum, 2018).

The solid-to-liquid (S/L) ratio of 5 g/L (1:200) and a methanol concentration of 34.6% are critical parameters; an increase in the S/L ratio enhances extraction efficiency. A higher ratio not only increases the solvent volume but also amplifies the surface area of acoustic waves, facilitating the formation of cavitation bubbles that enhance mass transfer between the solvent and the sample. Consequently, a greater solvent volume leads to increased pressure and surface area, thereby promoting osmosis and the release of more cell fluid or bioactive compounds . Furthermore, the use of lower concentrations of methanol is influenced by the polarity of water in relation to betalain extraction. Since water-soluble pigments are typically sequestered within cell vacuoles, ultrasonic disruption of the cell wall allows these molecules to preferentially dissolve in more polar solvents, such as water. The application of methanol as a solvent in the extraction of compounds from prickly pear skin proves effective, as the extraction process is enhanced by the polarity compatibility between the solvent and the target compounds. Additionally, methanol's status as a universal solvent enables it to effectively solubilize a wide range of polar substances.

(3) Carotenoid Pigment Extraction

Numerous studies have demonstrated the successful extraction of carotenoid pigments from various fruit peels. Among these, orange peel exhibits the highest carotenoid concentration, quantified at 86.85 g/kg, when employing the Automatic Solvent Extraction (ASE) technique. The use of heptane as a solvent yielded particularly favorable results, attributed to the relationship between the polarities of the solute and solvent; lower polarity enhances the extraction efficiency of β-carotene. Notably, heptane 34 outperformed hexane, a difference that can be explained by the higher density of heptane compared to hexane. Furthermore, the more hydrophobic nature of heptane contributes to its selectivity for carotenoid compounds (Toprakçi *et al.*, 2021). The ASE method is recognized as an environmentally sustainable approach for carotenoid extraction from orange peel, offering a viable alternative that utilizes various solvents. This technique significantly reduces both extraction time and solvent consumption relative to traditional solvent extraction methods (Manzoor *et al*, 2021). Additionally, the automated nature of the ASE system simplifies the extraction process and minimizes solvent requirements. Recent research indicates that ASE is superior to Ultrasound-Assisted Extraction (UAE) and conventional extraction methods, influenced by factors such as sample preparation techniques, the particle size of raw materials, the origin of the fruit, climatic conditions, and the timing of harvest (Toprakçi *et al.*, 2021). The particle size is critical to the extraction process, as smaller material sizes facilitate quicker extraction by increasing the contact area between the material and the solvent.

## CONCLUSION

1. Exploration of pigment source feed ingredients is still extensive, so this provides an opportunity for research related to pigment extraction that can be used for fish feed additives. The types of pigments that are extracted and valorized to increase added value are anthocyanin pigments, betalains, carotenoids (betacaroten and astaxanthin)
2. Pigment source extraction techniques are divided into HAE: Heat-assisted extraction PLE: Pressurized liquid extraction ASE: Automatic solvent extraction MAE: Microwave Assisted Extraction UAE: Ultrasound assisted Extraction UCGE: Ultrasonic cell grinder extraction and maceration, with good techniques to maintain pigments and easy to apply, namely HAE (Heat assisted extraction)
3. The addition of feed additives using pigment sources improves the color of ornamental fish as a whole, depending on the pigment extract used. Solid extract of carrot flour at 5%, spirulina flour at 3%, dragon fruit skin at 3%.
4. Pigment substances in feed additives become a source of antioxidants for the fish's body so that the fish have better immunity and health.

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