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Review: The nutritional value and health benefits of *kawakawa* (*Euthynnus affinis*)

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Abstract. *Rahma HS, Ayuningtyas HR, Nabila I, Annafi DN, Nurwulandari M, Indrawan M, Dadiono MS, MD Naim D, Setyawan AD. 2024. Review: The nutritional value and health benefits of* kawakawa (Euthynnus affinis). *Indo Pac J Ocean Life 8: 72-83. Kawakawa* (*Tuna*), or *Euthynnus affinis* (Cantor, 1849), is a species of pelagic fish of the Scombridae family with a vast habitat and distribution in tropical and subtropical waters in the Indo-Pacific region. This literature review aims to provide an understanding of the habitat, morphological characteristics, nutritional content, and benefits of *kawakawa* for health. *Kawakawa* prefers warm waters with a temperature of 20-30°C. As a pelagic fish, *kawakawa* spends most of its life in the open water column and away from the seabed. *Kawakawa* morphologically has unique characteristics, namely oblique and curved black stripes on the ribs and the presence of a pattern of black stripes between the abdomen and fins. This fish can grow to a maximum weight of 14 kg and a maximum fork length (FL) of 100 cm. The nutritional content of *kawakawa* is diverse, and it includes protein, omega-3, omega-6, selenium, vitamin D, and DHA. The protein content of *kawakawa* ranges from 20 to 25%, with 0.87% fat, which is lower than that of other fish species. With its high protein, low fat, and strong omega-3 fatty acid profile, *kawakawa* has a high overall nutritional value, making it a nutrient-dense food choice. The nutritional content in *kawakawa* has significant health benefits, providing reassurance of its value in preventing stunting, reducing heart risk, preventing cancer, maintaining eye health, increasing body immunity, preventing anemia, and maintaining bone health.

Keywords: Benefits, health, *kawakawa*, nutrition

INTRODUCTION

Tuna or *kawakawa* (*Euthynnus affinis* Cantor, 1849) are large pelagic fast swimmers that live in groups (Hawkins et al. 2014; Bar et al. 2015; Harahap et al. 2022). *Kawakawa* live in tropical and subtropical waters, such as the Indian, Pacific, Mediterranean, and Black Oceans. Among the *neritic tuna* that live in the coastal waters of India, *kawakawa* is the most widely found species (Mehanna 2024). *Kawakawa* is a promising aquaculture due to its rapid development and increasing demand (Yazawa et al. 2016). *Kawakawa* belong to the neritic species, live in water temperatures ranging from 18 to 29°C, and form a multispecies group based on size (Syamsuddin et al. 2018). *Kawakawa* tend to form multispecies groups depending on their size, ranging from 100 to more than 5,000 individuals (Syahliani et al. 2021; Widiastuti et al. 2023). Living at a depth of 200 meters, these fish are epipelagic marine species (Sivadas et al. 2020). However, according to Agustina and Sulistyaningsih (2022), this species appears in groups that reach a depth of 400 meters. Large pelagic fish have no definite fishing ground; the catchment area constantly changes and moves in response to changing environmental conditions, causing the fish to automatically choose a more suitable habitat (Safruddin and Hidayat 2023). *Kawakawa* has varied diets, so it can absorb more elements from its food sources, increasing its nutritional value, which enhances its nutritional value, making it an intriguing species for further study.

Kawakawa has long been recognized as an important source of nutrients for human health (Djunaidah 2017). Among the various types of marine fish, the *kawakawa* has nutritional value and health benefits (Khoa et al. 2021). As a pelagic species widespread in tropical and subtropical waters around the world (Sutton et al. 2017), this fish has been the subject of exciting nutrition and public health studies because of its nutritional content. Although *kawakawa* has long been consumed, in-depth research on its nutritional content is still developing. Numerous studies reported various essential nutritional components in *kawakawa* (Danitasari and Rahmawaty 2024). The protein content in this fish plays a vital role in forming and maintaining body tissues because it contains all the essential amino acids needed by the body. In addition, the fat content found in *kawakawa* is relatively low (Abou-Taleb et al. 2019). However, there are beneficial omega-3 fatty acids such as EPA and DHA in the fat of *kawakawa* that have been shown to benefit the heart, brain, and nervous system.

Sea fish contains essential vitamins, such as vitamins A, D, B12, and E, also found in *kawakawa* (Rifat et al. 2023). With various complete and balanced nutritional components, consuming *kawakawa* is a healthy diet to support human health (Murti et al. 2022). In addition, *kawakawa* is also known as a source of nutrients that are low in cholesterol and high in protein (Munubi et al. 2022). Therefore, it is a popular dietary choice for individuals concerned about heart health and striving to maintain a healthy weight. The balanced fat content, especially omega-3 fatty acids, makes it an attractive option for maintaining optimal brain function and reducing the risk of health problems such as heart disease and neurodegenerative diseases; it also provides reassurance about its health benefits. *Kawakawa,* known as *ikan tongkol* (Sayuti et al. 2022), is quite popular in various communities. People like that this fish can provide a lot of nutrients at an affordable price (Musafira and Sikanna 2023). Absah and Hasanah (2022), due to its nutritional content and taste, it is widely processed into various types of food. However, not many people know that *kawakawa* has a lot of benefits for consumers. There are limited studies on the benefits of *kawakawa*, which has high nutrients and health benefits. This review can clearly understand its nutritional profile and reveal the potential health benefits of consuming *kawakawa*. This literature review aims to provide an understanding of the habitat and morphological characteristics of *kawakawa* and their nutritional content and health benefits.

HABITAT AND DISTRIBUTIONS OF *KAWAKAWA* (*Euthynnus affinis*)

Kawakawa is a species of pelagic fish of the family Scombridae with an expansive habitat and distribution (Jesila et al. 2023). The habitat and distribution of *kawakawa* are important factors affecting their survival and population dynamics. *Kawakawa* is widely distributed in tropical and subtropical waters of the Indo-Pacific region (Binashikhbubkr et al. 2023). In the Indian Ocean and the Pacific Ocean, this fish is widely found in the coastal waters of India, Sri Lanka, and Maldives, along the coast of East Africa, including the Persian Gulf and the Red Sea. Their presence in these areas indicates a high adaptability to various conditions of coastal waters. In the coastal waters of India, *kawakawa* can be found around the western and eastern coasts, with significant populations in the Bay of Bengal and the Arabian Sea. Sri Lanka is also an important habitat, especially in coastal areas rich in coral reefs and seagrass beds. With its distinctive atoll ecosystem, the Maldives provides an ideal *kawakawa* environment. The clear, warm waters support an abundance of plankton and small fish, the primary food source for *kawakawa*. Along the East African coast, from Somalia to Mozambique, nutrient-rich waters are home to large populations of *kawakawa*. The Persian Gulf and the Red Sea are important habitats, with relatively warm and nutrient-rich water conditions supporting *kawakawa* life. Its presence in these areas indicates a high adaptability to various conditions of coastal waters.

In the Pacific Ocean, *kawakawa* is distributed from Southeast Asian waters such as Indonesia, Malaysia, and the Philippines (Husain et al. 2021). This fish is often found in Java, Sulawesi, and Banda Sea. The Java Sea, with its shallow waters and rich in nutrients from river courses, is one of the main locations for the *kawakawa*ery. The Sulawesi and Banda seas also provide a supportive habitat for these fish with their greater depths and abundant coral reef ecosystems (Reuter et al. 2022). Meanwhile, in Malaysia and the Philippines, the waters around the Malay Peninsula and the Philippine Islands are a suitable habitat for *kawakawa*. Their distribution extends to Japan and Australia. In Japan, *kawakawa* is found around Ryukyu and Kyushu because warmer water and nutrient-rich oceans create an ideal environment (Ohshimo et al. 2024). In Australia, this fish is distributed along the eastern and northern coasts. On the east coast, from Queensland to New South Wales, *kawakawa* are found in coastal waters rich in coral reefs and seagrass beds, while on the north coast, they inhabit shallow, warm waters abundant in nutrients. *Kawakawa* are also found in Pacific Islands such as Papua New Guinea, Fiji, and Polynesia. With its long coastline and rich marine ecosystem, Papua New Guinea supports a significant population of *kawakawa*. Fiji and Polynesia have rich marine ecosystems, providing a life-supporting environment for these fish. Extensive coral reefs and atoll ecosystems in Fiji, Polynesia, are ideal water conditions for *kawakawa*, with abundant feed sources and stable water conditions (Harding et al. 2022).

The distribution of *kawakawa* in various regions shows they are adaptable to various tropical and subtropical water conditions. These adaptations include adapting to variations in temperature, salinity, and food availability. *Kawakawa* can be found in waters with strong currents and diverse environmental conditions (Jumsar et al. 2023), ranging from shallow waters near the coast to deep waters around coral reefs. Habitats with complex structures, such as coral reefs and seagrass beds, provide protection and enlargement areas for *kawakawa*. Coral reefs offer a place to forage and protect from predators (Rogers et al. 2018). In regions such as Indonesia, the Philippines, and Malaysia, abundant coral reefs create an ideal environment for *kawakawa* to survive and breed. In addition, strong currents in the ocean help spread larvae and juveniles of *kawakawa*. These strong currents carry nutrients that are essential for the production of plankton, as well as helping in the distribution of fish populations (Ardyna and Arrigo 2020). In the Indian and Pacific Oceans, the North and South Equatorial currents play an important role in determining the geographical distribution of *kawakawa*. This adaptation also allows *kawakawa* to utilize various food sources, including plankton, small fish, and crustaceans. The ability of fish to migrate and explore different water areas enables them to find and utilize available resources, thus supporting their survival and population growth in various habitats (Tamario et al. 2019). GBIF has 1,473 point occurrences of *kawakawa* with a distribution as shown in Figure 1 (GBIF 2024).

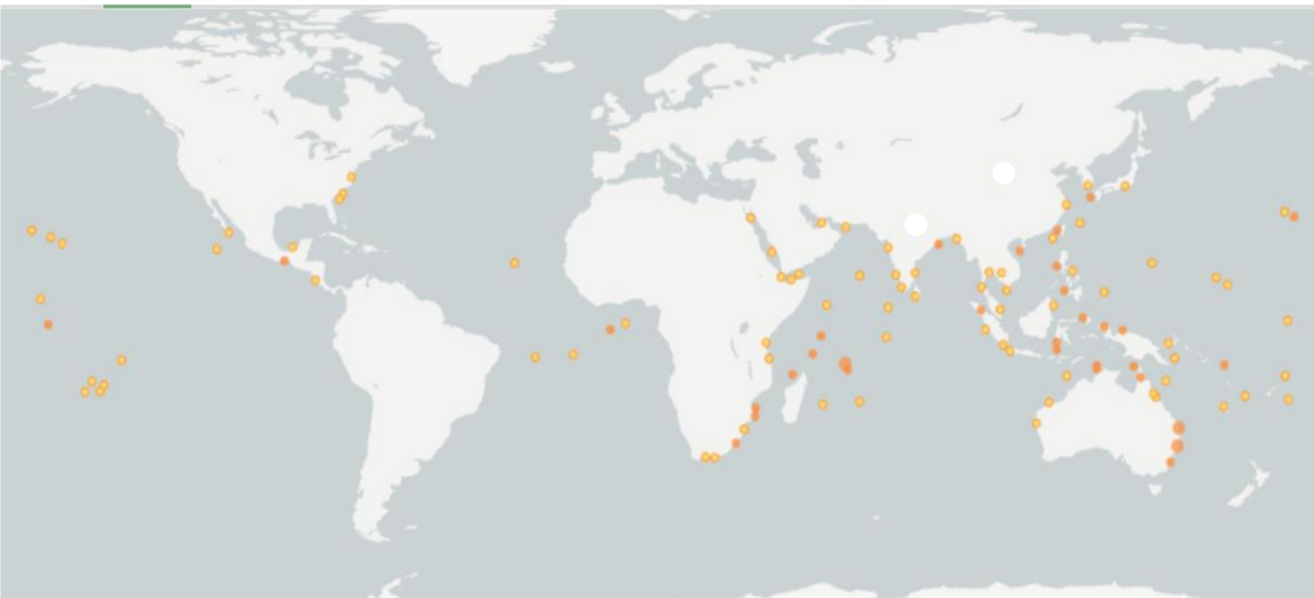

Figure 1. The world distribution of *kawakawa* (*Euthynnus affinis* Cantor, 1849) (GBIF 2024)

As a pelagic fish, *kawakawa* spends most of its life in the open water column and away from the seabed (Sianturi et al. 2023). These fish generally inhabit waters near the coast (Patmiarsih et al. 2023). In addition, they swim up to the open sea, especially in deeper waters around coral reefs and waters rich in nutrients (Wiratmini and Wijana 2024). They are active inhabitants of vast, open waters, moving freely without being tied to the seabed. It allows *kawakawa* to navigate and search for food at various depths and regions. In addition to avoiding predators, this pelagic pattern of life also enables them to explore broader areas in search of food sources. *Kawakawa* often swims near the surface to a depth of about 200 meters (Hamjan and Mallawa 2020). This adaptation allows them to exploit the abundant food resources at various ocean depths. Fish habitats are strongly influenced by marine environmental conditions, such as water temperature, food availability, and habitat structure (Husain et al. 2021). *Kawakawa* thrive in warm waters with temperatures ranging from 20-30°C, typically found in tropical and subtropical regions with strong currents and nutrient-rich waters that support abundant plankton and small fish as their primary food sources (Koropitan et al. 2021). Coral reefs and seagrass beds are crucial habitats, providing protection and ideal rearing areas for these fish (Whitfield 2017).

Ecologically, *kawakawa* plays an important role in the marine food chain. This fish is an active predator that feeds on various types of small fish, crustaceans, and plankton (Renjith et al. 2023). Its role as a predator ensures that its prey population remains controlled, thus helping to maintain the balance of the marine ecosystem. *Kawakawa* have a varied diet and do not depend on one type of prey. It shows their flexibility in finding food and adjusting to the resources in their habitat. As a predator, *kawakawa* interacts with various species of small fish and crustaceans that become its prey. These interactions are important in maintaining the structure of marine communities. In addition, *kawakawa* also interacts with other predators, such as sharks and giant tuna. Competition for food resources and living space with other species also affects the distribution and abundance of *kawakawa* in various habitats. The existence and distribution of fish in the sea are dynamic, constantly changing or moving following the movement and changes in environmental conditions (Nagi et al. 2023). This phenomenon reflects the high adaptability of *kawakawa* to aquatic conditions. They can survive in various aquatic conditions as long as the temperature and availability of food meet their needs. This adaptation includes tolerance to temperature variations and the ability to find and utilize available food sources in various environmental conditions of its habitat. Pelagic fish are fast swimmers (Laksono et al. 2024). High swimming speed gives *kawakawa* an advantage in chasing prey and avoiding predators. This capability also allows them to migrate long-distance efficiently.

The ability of *kawakawa* to migrate and adapt quickly to environmental changes helps them maintain stable populations in various water areas (Tamario et al. 2019). Seasonal migration is an important adaptation for *kawakawa*. The fish move to deeper waters or closer to the shore depending on water temperature and food availability (Erzad et al. 2018). In the summer, they will migrate to the waters with lower temperatures and deeper altitudes, searching for food and more comfortable conditions. Conversely, in the winter, they approach the coast with warmer water. Fish migration helps avoid unfavorable environmental conditions and maximizes the chances of getting more food (Xu et al. 2020). These fish often follow migratory patterns related to the movement pattern of ocean currents and seasonal water temperature changes.

Global climate change that causes an increase in sea temperature and changes in ocean current patterns affect the distribution of *kawakawa*. Rising water temperatures force *kawakawa* to migrate to colder regions, while ocean currents change the distribution of plankton and other prey. *Kawakawa*'s adaptation to these environmental changes determines their ability to survive in the long term. The behavior and ecological responses of *kawakawa* species to environmental changes are crucial to understanding their habitat and distribution in different water areas (Bernal et al. 2017). This adaptive migratory behavior also allows *kawakawa* to avoid areas with high predator pressure or less favorable environmental conditions, such as waters with very low or very high temperatures. In addition, migration allows them to exploit regions with plentiful seasonal food supplies (Kubelka et al. 2022). *Kawakawa* migration patterns that follow water temperature and food availability reflect complex ecological adaptations. This seasonal migration allows them to take advantage of optimal environmental conditions throughout the year. Migration to deeper waters or closer to the coast depends on the season and water temperature changes, ensuring they remain in the most suitable habitat for growth and reproduction.

Nutrient-rich aquatic conditions are often the ideal habitat for *kawakawa* (Sartimbul et al. 2017). The abundance of nutrients in these waters is usually caused by upwelling, where nutrient-rich water from the seabed rises to the surface (Waas et al. 2023). These conditions favor the abundant growth of plankton, which then becomes the primary food source for many small fish, including *kawakawa*. Thus, the presence of *kawakawa* is often an indicator of the health of marine ecosystems. These fish also avoid polluted waters or have poor water quality, so their populations decline dramatically in heavy pollution areas. Overall, the adaptation and lifestyle of the *kawakawa* as pelagic fish gives them a competitive advantage in finding food and survival. With the ability to explore various depths and areas of the ocean, *kawakawa* can make optimal use of marine resources and ensure its population's survival and growth (Hawkins and Popper 2017). The ability to navigate various environmental conditions allows *kawakawa* to maintain a stable population despite the changing environmental pressures on its habitat.

MORPHOLOGY OF *KAWAKAWA* (*Euthynnus affinis*)

Morphology is a branch of science that studies the body's shape, size, and structure. Fish morphology is used to distinguish fish species and even closely related species, and the shape and size of the fish body are important instruments in morphology (Binashikhbubkr et al. 2024). *Kawakawa* is one of the marine biological resources with relatively high economic potential; hence, fishermen target it as a fishery product (Hasibuan et al. 2023).

Kawakawa is a pelagic from the Scombridae family that lives in groups (Tangke et al. 2021). The body shape of the *kawakawa* is elongated like a torpedo, slender, streamlined, and included in the fast-swimming fish (Sayuti et al. 2022). The *kawakawa*'s body shape helps the fish swim more efficiently, nimbly, and quickly in seawater. *Kawakawa* is a carnivorous fish (Pebiloka et al. 2023). Morphologically, *kawakawa* have unique characteristics: oblique and curved black stripes above the ribs. Dark spots are as many as 2 to 5 above the ventral fin (Mardlijah et al. 2022), and black stripes between the abdomen and fins (Pulungan et al. 2022).

Kawakawa has one pair of pectoral fins, one pair of ventral fins, one anal fin, one caudal fin, and two dorsal fins. *Kawakawa* has two dorsal fins spaced apart (Isti'anah and Maulana 2020). Spines support the spaced first dorsal fin, and soft fingers only support the second dorsal fin (Ahmed et al. 2015). The anal fin has 14 weak fingers, and there are 6 to 9 additional fingers; 8 to 10 pieces of small fins located behind the second dorsal fin (Nuraisyah et al. 2019). Weak fingers in fish have internodes, are generally branched, and bend easily to move (Kahby 2023). *Kawakawa* has 10 to 14 anal fins to help the fish to swim backward by pushing the anal fin down so that they can push the water in the opposite direction and moves backward. In the abdomen, *kawakawa* has two lobes (interpelvic process) (Hidayat et al. 2018).

Kawakawa has a tapered, slender, elongated head shape. The head shape of the *kawakawa* helps the *kawakawa* to cut through the water while swimming at a reasonably high speed. *Kawakawa* have a broad mouth type and tilt down; their scales are tiny and belong to the ctenoid type. Ctenoid scales have small serrations on their posterior parts; these scales are thinner, smaller, lighter, and transparent (Valen et al. 2022). On the tail, there are three "keels" or serrations with a sharp central peak; the keel in the middle is elongated and higher than the keel that squeezes it. The swimming mechanism of *kawakawa* is like that of tuna, but *kawakawa* do not have swim bladders and are different from tuna, which have red muscle distribution (Havelka et al. 2021). The swim bubble is a bag that contains air or oxygen and is in the body cavity of some fish (Fikri et al. 2023).

Kawakawa has a black, turquoise, or metallic gray color on the back with smooth color gradations. The color helps *kawakawa* camouflage in seawater. *Kawakawa* has a silvery white color on the abdomen, and the silver color is brighter and shiny than the greenish-blue color on the back of the *kawakawa* (Hamed et al. 2016). The forehead of the *kawakawa* is dark blue or dark green, with tiny black dots. The dorsal fin also has a dark blue or dark green color, and the tip of the dorsal fin is black. The silver color on the belly of the *kawakawa* helps the fish to reflect light and avoid predators from below. The body color of the dark dorsal and bright ventral parts is called countershading, as the effort to camouflage in the open seas (Kaidi et al. 2021).

The eyes of *kawakawa* have a diameter ranging from 5-7 mm and a dark blue iris and black pupils. *Kawakawa* have a dorso temporal direction of vision or upper forward vision, which benefits fish; they quickly see prey on the water and see predators from above and below to help escape predators. The dorso-temporal direction of the eyes also serves to navigate their environment. *Kawakawa* has receptor cells composed of single-cone and double-cone cells that spread evenly throughout the retina. Single-cone and double-cone cells make *kawakawa* vision highly sensitive to differences in color and light intensity received (Fiolita et al. 2017). The presence of double-cone cells allows fish to perceive better colors and be more diverse.

The skeleton is a structure that helps the body stand upright, serves as a lifeguard, and supports the body's organs. Based on X-ray photography, the bone morphology of *kawakawa* consists of 20 segments of the trunk and 18 segments of the tail (Shengjie et al. 2022). *Kawakawa* have a light and strong bone skeleton that allows them to swim quickly and nimbly in the water. *Kawakawa* has gill bones on the head's sides and supports large pectoral fins. *Kawakawa* has 29 to 33 gills in the first hollow and 28 or 29 Gill teeth, while vomerine teeth are absent.

Fish morphometrics are characteristics related to body size or body parts of fish (Figure 2), such as total length and length of fish body poles (Radona et al. 2017). *Kawakawa* has the characteristics of a medium-sized body. The growth in terms of body length significantly affects weight, most likely caused by two factors: the availability of food sources and the body shape of fish (Lelono and Bintoro 2019). *Kawakawa* can grow up to a maximum weight of 14 kg and a maximum Fork Length (FL) of 100 cm (Ohshimo et al. 2024). Generally, the caught *kawakawa* weigh less than half that size in most of their distribution area. Male and female *kawakawa* have different lengths and weights; males are generally larger than females (Lestari and Suparno 2023). The difference in size between males and females occurs due to differences in behavior, mortality, and growth rates (Setiawati and Suparno 2023). FL is measured starting from the mouth to the tail pole of the fish (Horton et al. 2018). Fork length measurements can identify species, estimate age, and monitor population health and growth patterns.

The fish caught in the Java Sea have a fork length of 27-58 cm (Masuswo and Widodo 2016), while those in western Sumatra have a fork length of 30-60 cm (Fathurriadi 2020). The fork length of *kawakawa* caught in Pati waters ranged from 33-52 cm (Prasetyo et al. 2019), in the Sunda Strait was 40.7 cm (Ardelia et al. 2016), and in the Malacca Strait was 43 cm (Jamon et al. 2016). The difference in the fork length of *kawakawa* in various waters can be caused by differences in aquatic environmental conditions (Ekawaty and Jatmiko 2018). The differences in the fork length of *kawakawa* could be caused by differences in fishing gear during fishing, ecological conditions, and variations in fishing intensity (Chodrijah et al. 2016). Analyzing the length and weight of *kawakawa* is critical to determining the biological condition of fish and fish stocks, making it easier to manage the sustainability of fish biodiversity. In fisheries biology, the relationship between the length and weight of fish is needed for complementary information data (Arnenda et al. 2020). Research on the relationship between the length and weight of fish helps to understand their habitat, reproductive behavior, history, life cycle, and fish health (Mudumala et al. 2018).

NUTRITIONAL VALUE OF *KAWAKAWA* (*Euthynnus affinis*)

Fishery resources are vital for human due to their commercial value and high nutritional content (Cahyono et al. 2023). *Kawakawa* is a species of mackerel tuna found in the western and Indian Pacific Oceans. It is widely distributed and abundant. This fish is usually caught as a bycatch in commercial fishing. The fish is traded in various forms worldwide (Ahmed and Bat 2015), and canned tuna is one of the most consumed seafood worldwide (Garofalo et al. 2023). *Kawakawa* is included in the fish that are sold freely or commercialized. Due to the increasing demand for canned tuna, the fishing industry is concentrated in Asia, particularly Japan, Taiwan, China, Indonesia, and South Korea (Abinaya and Sajeevan 2023). Nonetheless, *kawakawa* viscera can be used as a source of protease enzymes (Taheri and Bakhshizadeh 2020).

At zero hour, *kawakawa* chips had the moisture 70.95±0.42%, protein 1.920±0.21%, lipids 0.45±0.22, and ash contents 2.61±0.07 on wet weight respectively (Abou-Taleb et al. 2019). The tiny tuna, *kawakawa*, and carp fish chips had pH, TVBN (Total Volatile Basic Nitrogen), TMA (Trimethylamine), and TBA (Thiobarbutic Acid) values of (6.07±0.04, 0.008, 0.009, 0.005 mg MDA/kg), (6.44±0.09, 0.008, 6.44, 6.07), and (6.16±0.09, 11.38, 39.04, 43.94 mg/100g), respectively, at zero time (Abou-Taleb et al. 2019).

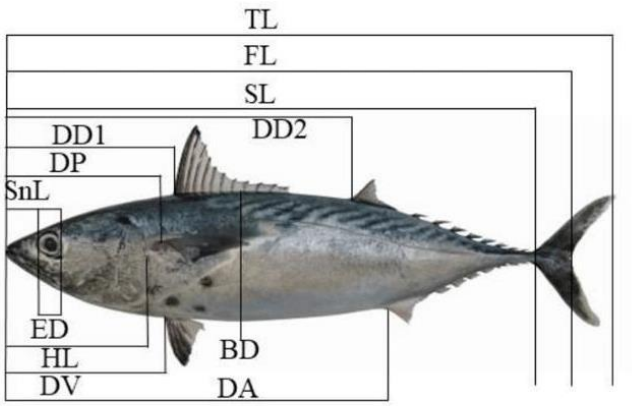

Figure 2. Morphometric measurements of *Euthynnus affinis* (*Kawakawa*). TL: Total Length, FL: Fork Length, SL: Standard Length, HL: Head Length, BD: Body Depth, ED: Eye Diameter, SnL: Snout Length, DP: Distance of pectoral fin, DD1: Distance of the first dorsal fin, DD2: Distance of the second dorsal fin, DV: Distance of ventral fin, DA: Distance of anal fin. Source: Binashikhbubkr et al. (2024).

The nutritional value of protein is determined by its amino acid composition (score), the level of essential amino acids, and digestibility (FAO 2013; Bandyopadhyay et al. 2022). Fish protein is superior to red meat due to its lower collagen content and better digestion (>90%) (Vijaykrishnaraj and Prabhasankar 2015). Fish consumption has several health benefits due to its high content of omega-3 polyunsaturated fatty acids (PUFAs) (Tilami et al. 2018). *Kawakawa* is an excellent source of nutrients due to its high and low fat and protein content. Ahmed and Bat (2015) stated that *kawakawa* contains high iron and low lead in the liver and muscle. Fish liver has substantially higher iron levels than muscle tissue since it plays a physiological role in the production of blood. Previous findings showed the health benefits of food-derived bioactive peptides and proteins. These dietary proteins break down easily to release more potent soluble peptides against heat, stomach acid, and proteolytic enzymes. Protein hydrolysates have excellent biological activities, including antihypertensive, antioxidant, antibacterial, immunomodulatory, and anticancer (Vijaykrishnaraj and Prabhasankar 2015). Since they are higher in the food chain than other fish, top predators like *kawakawa* collect heavy metals. In polluted and contaminated water, they are continuously exposed to contaminants. According to Ahmed and Bat (2015), muscle fibers of the *kawakawa* contained Fe (46.9644±12.54456 µg/g) and Mn (10.4089±3.19444 µg/g). The liver contained Ni (2.7983±0.0.81944 µg/g), Fe (660.2367±141.23909 µg/g), and Mn (47.3711±12.29087 µg/g). However, this fish contained hazardous metals such as Pb and Ni. Hazardous or heavy metals should not be found or detected in food intended for human consumption. Based on the European Union Regulation, Pb is a hazardous metal. Pb concentration in the muscle and liver of *kawakawa* was 0.4958±0.13641 µg/g and 1.5950±0.3045 µg/g, respectively (Ahmed and Bat 2015). These values were much higher than the maximum level (0.30 mg/kg wet weight) established by the Turkish Food Codex and the EC (Commission Regulation). It should be noted that Pb levels in *kawakawa* were expressed in µg metal g-ı dry weight in the present study. It makes it very difficult to compare the two (Ahmed and Bat 2015). However, Ahmed and Bat (2015) also stated that *kawakawa* from the area is generally safe for human consumption, and several metals were found in *kawakawa* samples at varying levels but within the maximum residual levels allowed by the EU and FAO/WHO. The metal concentrations were higher in the liver than in the muscle, but *kawakawa* livers are not eaten.

The kawakawa condition variable, which assesses the physical ability to survive and reproduce, shows that the fish thrives in a healthy habitat and contains important nutrients. Water quality, environmental stressors, and food availability are just a few of the variables that impact various aspects of fish health. It's fascinating to see that fish with a high condition factor are not just healthy but also remarkably adaptable to their environment, thriving in even the most challenging conditions.

The fat content of *kawakawa* is 0.87%, which is lower than that of other fish species, such as big-head hairtail fish. Because of its low-fat content, it is a good choice for those who wish to eat less fat without compromising nutrients. In contrast, tuna, including *kawakawa*, has a protein content ranging from 20 to 25%, making it an excellent protein source. *Kawakawa* is also an ingredient in the fish oil production process. Many impurities, including free fatty acids, pigments, phosphates, and particulate debris, are contained in the extracted crude fish oil (Hetta et al. 2020). White-muscle and dark-muscle tuna have excellent nutritional content, texture, and quality, making them ideal for culinary purposes (Kannaiyan et al. 2019). It is an excellent choice for anyone to increase protein consumption due to its high protein content, especially for athletes or people who exercise frequently.

Fish proteins, peptides, and amino acids have recently attracted attention because they exhibit characteristics comparable to PUFAs (Mohanty et al. 2019). In addition, omega-3 fatty acids, essential for the proper functioning of many organs in the body and have many health benefits, are abundant in *kawakawa*. Fish is also a good source of essential minerals, such as copper (Cu), manganese (Mn), zinc (Zn), and selenium (Se), which play a vital role in many biological processes (Khalili and Sampels 2018). Tuna oil has a long chain of unsaturated fatty acids, omega-3 and omega-6, especially DHA, which can lower the risk of various diseases (Ferdosh et al. 2015). The *kawakawa* diet consists of different types of fish, crabs, and mollusks, which impacts the nutritional value of fish. This diversified diet increases the nutritional value of fish because it enables them to absorb a wide range of elements from their dietary sources. Due to its high protein, low fat, and high omega-3 content, *kawakawa* has good nutritional value overall. The excellent nutritional value of *kawakawa* is also due to its varied diet and ideal environmental conditions.

BENEFITS OF *KAWAKAWA* (*Euthynnus affinis*) FOR HUMAN HEALTH

As explained, *kawakawa* has a high nutritional value that supports human health. The nutritional content of *kawakawa* can prevent various diseases, including heart disease and cancer (Fadzilla 2018). Although *kawakawa* has not been processed into pills or medical drugs, many of its ingredients support human health (Taheri and Bakhshizadeh 2020). These fish are often used for a healthy diet to support the health of the heart, brain, and immune system; with a high protein content, it reaches about 26.6%, making it an excellent source of protein (Abou-Taleb et al. 2022). Protein is an essential component in the diet because it plays a role in building and repairing body tissues and supporting various biological functions. The high protein content in *kawakawa* makes it very beneficial for muscle growth and maintenance and supports a healthy immune system.

In addition, many processed foods currently use *kawakawa* as a primary ingredient, ranging from canned food, nuggets, and various other products, so that the consumption of *kawakawa* becomes more manageable for children to adults (Kartikaningsih et al. 2021) and enjoyable different levels of society, so it increased health benefits. Some health benefits of consuming *kawakawa* include improving heart health through omega-3 content that can lower harmful cholesterol levels and the risk of cardiovascular disease. In addition, this fish's selenium content is an antioxidant that protects the body's cells from oxidative damage and supports healthy thyroid function. With its wide range of health benefits, *kawakawa* is an excellent food choice to support overall health and improve quality of life. As for some of the health benefits of *kawakawa* consumption, among others:

Prevent stunting

Stunting is one of the health problems that must be eradicated today (Sriwijayanti and Devi 2020). Various efforts are made to prevent stunting, including fulfilling nutrition when the fetus is still in the womb and newborn. Stunting is a growth and development failure in infants due to insufficient macronutrients such as protein and microelements such as vitamin D (Widanti 2016). Stunting can also be said to be a condition in which a person's height is shorter than other people's height in general (Simamora et al. 2019). According to Putri (2023), *kawakawa*, which is rich in omega-3 fatty acids, is undoubtedly well consumed by children in the growth phase. Omega 3 can help improve cognition, concentration, and memory. Omega-3 is excellent for brain cell development during the growth and development phase (Nurasmi 2021). *Kawakawa* contains omega-6, which is necessary in addition to omega-3 to avoid stunting and malnutrition (Ningsih et al. 2024). In a study by Nurfaidah et al. (2024), omega-3 was added to the solid food of breast milk substitute for nutritional fulfillment to prevent stunting. According to Wardhana (2024), omega-3 and omega-6 help to increase brain intelligence and avoid blood clots. Being deficient in omega-3 and omega-6 can increase the potential for stunting in children.

Prevent cancer

Consuming *kawakawa* can prevent cancer (Kannaiyan et al. 2019) due to its selenium content (Sa'adah 2022). Consumption of high-selenium foods can prevent the growth of cancer cells (Razaghi et al. 2021). Selenium is an antidote to free radicals that cause cancer. According to research in the 2000s by the American Institute for Cancer Research (AICR), selenium can aid in the prevention of lung and skin cancer. *Kawakawa* also has sufficient vitamin D, which regulates cell growth and reduces cancer risk by controlling cell differentiation and proliferation (Andhikawati et al. 2021). According to Paelongan et al. (2022), vitamin D induces apoptosis of cancer cells and plays an important and promising role in cancer therapy. The nutrients of *kawakawa*, such as selenium and vitamin D, significantly affect cancer prevention. Thus, consuming *kawakawa* can be an important part of a healthy diet to prevent various types of cancer.

Reduces heart risk

Heart disease is one of the diseases with a high mortality rate (Utomo and Mesran 2020). Omega-3 reduces the risk of heart attack (Bahurmiz 2019), and omega-3 is easily found in marine fish (Shen et al 2022). Omega-3s can prevent heart attacks. The omega-3 is the polyunsaturated fatty acids DHA and EPA (Djuricic and Calder 2021). The DHA also helps reduce the risk of developing heart disease (Yamagata 2020). Laidlaw and Tanya (2019) reported that consuming omega-3 can reduce cholesterol, ultimately reducing the risk of heart disease. Fish is the best source of DHA. In addition, DHA can also reduce the level of triglycerides in the blood, where triglycerides are a significant factor in the occurrence of heart disease (Setiawan and Halim 2022). In addition to DHA, EPA can also prevent degenerative diseases in the fetus and adults, and the fetus needs EPA to form the heart (Sari 2022). According to Danitasari and Rahmawaty (2024), *kawakawa* has the highest DHA and EPA content compared to some fish in Indonesia, such as red snapper (*Lutjanus campechanus*), white pomfret (*Pampus argenteus*), selar fish (*Selaroides leptolepis*), and mackerel (*Scomberomorus* sp.).

Maintain eye health

kawakawa has a relatively high DHA (decosahexaenoic acid) (Andhikawati 2020). DHA is one type of omega-3 that is essential for the body, especially for brain and eye health (Sugasini et al. 2020). DHA can help prevent macular degeneration and dry eye syndrome. In addition, the content of DHA can also help reduce inflammation in the eyes, which can cause damage to the lens and eye tissue. DHA can help maintain the function of the sense of sight. In addition, adequate DHA intake during pregnancy will be perfect for children's vision development (Kasmara et al. 2023). According to Qardhawijayanti (2022), DHA is one of the important constituent components of the eye's retina. The retina is one of the eye layers that captures light and sends visual signals to the brain. In the eye, DHA accumulates in the photoreceptor cells. High DHA content in photoreceptor cells influences how sharp the eye's visual is.

Improve immunity

According to Nalawati et al. (2024), *kawakawa* has various nutritional contents that are very beneficial for health, such as magnesium, iron, omega-3, omega-6, and selenium. These ingredients play an essential role in improving immunity. Its high nutritional and protein content makes it a highly recommended food. The omega-3 can increase the body's immunity. Omega-3s can help reduce inflammation and improve the immune response so that the body becomes better against infection and disease. According to Nolitriani et al. (2020), selenium is a vital selenocysteine component in cell function and biochemistry. Therefore, selenium can affect the body's specific and non-specific immune systems. Selenium could be an antiviral, antioxidant, and thyroid hormone regulator.

Prevent anemia

Kawakawa contains a natural iron. Iron is one of the essential minerals for various vital functions. Iron can help prevent anemia. Anemia is a lack of red blood cell formation and can be overcome by consuming iron. Gardiarini et al. (2021) state that adequately processed iron-rich foods can help prevent anemia. Consumption of foods high in iron, such as *kawakawa*, helps increase iron levels, supporting the production of red blood cells. Iron content in *kawakawa* helps the body produce blood cells. Fish consumption can prevent various diseases, including anemia. It suggests that *kawakawa*, with high iron content, prevents anemia.

Maintaining bone health

Oviana et al. (2019) stated that *kawakawa* has a reasonably high vitamin D. Vitamin D is an essential nutrient even in fetal development. Vitamin D is vital in forming and strengthening fetal bones (Shita and Sulistyawati 2015). Vitamin D is an essential micronutrient that helps maintain bone health. According to Fazalina et al. (2021), vitamin D deficiency results in vulnerable bones that break easily. Vitamin D deficiency causes the body not to absorb calcium efficiently, resulting in brittle and weak bones. Consuming *kawakawa*, which is rich in vitamin D, will be an effective solution to meet daily vitamin D requirements.

Secondary metabolites

The efficacy of *kawakawa* is related to its secondary metabolites. According to Hanifa et al. (2019), secondary metabolites are compounds only owned by specific organisms that are very valuable for pharmaceuticals, such as raw materials for drugs or other health. Marine animals generally do not have a perfect secretion system like mammals. It causes marine organisms to have very diverse chemical compounds, especially secondary metabolites. There are several types of secondary metabolites contained in *kawakawa*, including:

Carotenoids

Carotenoids are secondary metabolites produced by organisms living under extreme biotic and abiotic conditions (Ayala-Meza et al. 2022). According to Putra et al. (2023), carotenoids are natural pigments that can be found in animals. Carotenoids are pigments that provide color in fish. In *kawakawa*, the primary type of carotenoid is the astaxanthin type, which gives a red color to fish meat. The health benefits of carotenoids include protecting cells from oxidative damage, improving immune system function, and helping the body fight infection and disease. They may help reduce the risk of age-related macular degeneration.

Steroids

Steroids are bioactive compounds classified as non-polar (Prayitno et al. 2021). In tuna, steroids play an important role in various biological and physiological functions. Steroids have several bioactivities, such as anti-cancer drugs.

Alkaloids

Kawakawa positively contains alkaloids in its flesh (Hafiludin 2011). Alkaloids are the most secondary metabolite compounds that have nitrogen atoms. Alkaloids are derivatives of amino acids that have a bitter taste. Alkaloids play an important role in an organism's natural defenses, helping to protect against pathogens such as bacteria, viruses, and fungi. Alkaloids are known for their significant range of biological activities, including antimicrobial, anticancer, and antioxidant activities (Adamski et al. 2020).

Kawakawa will have good health benefits in natural conditions and not be contaminated (Kusumaningsih 2020). The excellent nutritional content of *kawakawa* provides various health benefits. It is necessary to ensure that this fish comes from a safe place to ensure its quality. Proper processing can also maintain nutrient content (Robert et al. 2022). In this case, environmental aspects and the management or cultivation of *kawakawa* are important in keeping nutrients excellent and ensuring that the fish does not contain toxic metals. Aquaculture conducted in a controlled environment could reduce the risk of contamination from chemicals. The balanced consumption and good quality of *kawakawa* could benefit consumers significantly. Therefore, understanding the selection and processing is needed for good consumption to obtain the maximum benefits of consuming *kawakawa*. With its rich nutritional content, including protein, omega-3 fatty acids, vitamins, and minerals, tuna can improve heart health, support brain function, strengthen the immune system, and reduce the risk of various chronic diseases. *Kawakawa* in the daily diet provides several nutritional benefits and supports a healthy and balanced lifestyle. Researchers and health practitioners should encourage people to increase tuna consumption to maintain health and prevent diseases. In this way, we can maximize the nutritional potential of tuna fish for long-term well-being and health.

CONCLUDING REMARKS

The review on *kawakawa* (*E. affinis*) aims to provide an understanding of the habitat, morphological characteristics, nutritional content, and benefits of *kawakawa* for health. *Kawakawa* is a species of pelagic fish of the Scombridae family that has a vast habitat and distribution in tropical and subtropical waters in the Indo-Pacific region. *Kawakawa* has unique morphological characteristics: oblique and curved black stripes on the ribs, dark spots as much as 2 to 5 above the ventral fins, and black stripes between the abdomen and fins. The body shape of the *kawakawa* is elongated and slender, like a torpedo. As a pelagic fish, the *kawakawa* has a line shape on its body that allows it to move in the waters without experiencing any obstacles. *Kawakawa* has 20-25% protein, low fat, and high omega-3. The nutritional content in *kawakawa* can be beneficial for health, preventing stunting, improving brain intelligence, preventing blood clots, and increasing immunity. Omega-3 content in *kawakawa* can also lower cholesterol if consumed regularly. The selenium and vitamin D content in *kawakawa* is very influential in cancer prevention and maintaining bone health. *Kawakawa* contains DHA, which can help lower the risk of heart attack, improve the eye's health, and reduce inflammation in the eye that can cause damage to the lens and eye tissue. The iron content in *kawakawa* can prevent anemia. *Kawakawa* has a high nutritional value, making it an excellent food choice. The habitat or place of cultivation of *kawakawa* can affect its nutritional content. Therefore, it is necessary to ensure that this fish comes from a safe place to ensure its quality.

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