

Anguilla sp. Handling as Raw Material for Processed Products (a Review)

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ABSTRACT

There is a wide variety of *sidat* in Indonesia (a type of freshwater eel species). Since eels have the potential to be developed, many nations, including Japan and Northern European nations, have started to cultivate eels to suit domestic and global market demands. Japan produces the majority of its eel goods through farming, whereas Europe still relies on wild catches, though cultivated items still play a part. Food items derived from flesh, including as smoked meat, jelly, and steamed or grilled fillets, make up the majority of eel goods. Depending on the type, location of fishing or cultivation, season, environmental factors, age or sexual maturity, sex, feed, genetics, type of analysis, and other factors, the composition of *Anguilla* eels will vary in value. Fish typically has a water percentage between 68 and 83 percent, a fat level that varies widely depending on the species, a protein content between 8 and 20 percent, and an ash content between 1 and 2 percent. The skin of the eel can be used to make wallets and bags; in Japan, the head is sold as a snack; the offal is grilled in soy sauce or canned to be added to specific sorts of foods; and the spine is dried and seasoned to be eaten as a snack. While only the meat marketed frozen, fresh, tinned, or vacuum-packed is used in Europe. *Anguilla* eel can be grilled, baked, or smoked as the end product. This review's goal is to concisely and clearly describe *Anguilla* sp. eels, starting with their classification, content, properties, and treatment as raw materials for processed goods.

Keyword: *Anguilla* sp., freshwater eel, handling, product, properties

1. INTRODUCTION

Indonesia has a high diversity of *sidat* (a type of freshwater eel species), moreover the first type of eel is *Anguilla borneensis* and is in the first position on the molecular phylogenetic tree, which is an eel originating from Indonesia. *Sidat* eel has economic value, Japan imported 60,000 tons of eel in 2002, and 80,000 tons in 2007. While China and Taiwan exported 67,000 tons of canned eel and 5,700 tons in the same year. Korean consumption of eel reaches 10,000 – 13,000 tons/year. Indonesia itself has started exporting 30 tons of eel in 2007 to destination countries such as Taiwan, South Korea and Japan [1],[2]. Eel has the potential to be developed and therefore several countries such as Japan and Northern European countries have been cultivating eel to meet domestic and international market demands.

Food and other products made from eel (Family Anguillidae) are found in many countries, especially in Japan and northern European countries. Most of the eel products in Japan come from cultivation, while in European countries they still depend on catches from nature, although cultured products also play a role. The dominant products from eel are food products that come from meat such as smoked meat, jelly and steamed or grilled fillets. Almost all parts of the eel are used depending on the country that uses it [3]. The purpose of this review is to describe briefly and distinctly about *Anguilla* sp. eel starting from the classification, composition, characteristics, cultivation to handling as raw material for processed products.

2. FRESHWATER EEL (*Anguilla* sp.)

2.1 Species, Distribution and Habitat

Species of freshwater eel fish of the genus *Anguilla* occupy habitats in rivers, flowing waters, lakes and estuaries in most of the subtropical and temperate regions of the world. Eels are divided into 17 species although some species are still a question for taxonomists [3]. Based on their relationship in utilization as food products and other products, the species of eel that are widely used are of the following species:

- Japanese eels (*Anguilla japonica*) are found from Japan, China and northern waters of Indonesia.
- The European eel (*Anguilla anguilla*), is found in western Europe, northern Africa and Iceland.
- American eel (*Anguilla rostrata*), found along the east coast of North America and Greenland.
- Australian eel (*Anguilla bicolor*), found in east Africa, India, Indonesia and southwestern Australia. In addition, there are also species *Anguilla australis* found in eastern Australia and New Zealand.

In the southern part of the island of Java, many eels hide and nest on the lips of steep river cliffs or cave-shaped river pits. According to [4], the eel taxonomy includes:

Kingdom	: Animalia
Phylum	: Chordata
Subphylum	: Vertebrates
Superclass	: Osteichthyes
Class	: Actinopterygii
Subclass	: Neopterygii
Infraclass	: Teleostei
Superorder	: Elomorpha
Order	: Anguilliformes
Family	: Anguillidae
Genus	: <i>Anguilla</i>

Anguilla eel consists of many species, eels commonly found in Indonesian waters are *Anguilla bicolor*, *A. spengeli*, *A. australis*, *A. borneensis*, *A. celebensis*, *A. marmorata*, *A. nebulosa*, *A. elphinstona* and *A. mauritiana*.

2.2 Morphology

The genus *Anguilla* can be distinguished from other genera by the presence of the pectoral fins and the beginning of the dorsal fin which are some distance from the head and the gill covers are located close to the pectoral. The distinctive feature of the eel is that it has no pelvic fins and no legs, elongated body shape, anal and dorsal fins joined to the tail fin to form a single fin that is long and has cycloid scales. The complete morphology of the eel that will be described is represented by the eel of the species *A. japonica* where this eel is an eel that has been successfully cultivated and is known throughout the world.

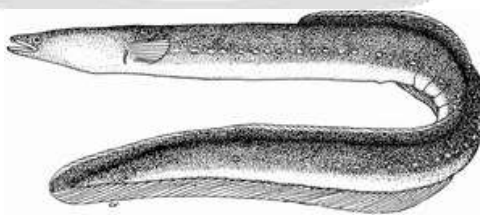


Figure 1. *Anguilla japonica*
Source: [1]

The body of the eel is elongated, the anterior is cylindrical and the posterior is smaller, the surface is smooth. The corner of the mouth extends to the posterior edge of the eye. The lower jaw is slightly longer than the upper jaw, has lip folds and is symmetrical. The distance between the dorsal fin and the opening varies from 9 to

13.5% of the total body length. The head length is about 11.2 – 11.9% of the total body length. Pectoral fin length 2.2 – 3.7 head length. Teeth are small, conical, dorsal and anal fins narrow with caudal fins. The distance between the dorsal and anal origins is shorter than the length of the head. The body is covered in scales that are embedded and form small clusters. The color is not conspicuous and lighter in color on the abdomen [1].

2.3 Life Cycle

All Anguillid fish have the same life cycle history, including catadromous fish. The life cycle in this species, spawning occurs in the sea and young eels migrate to estuaries and inland waters where they grow into adults, in the last stage they migrate back to spawning areas in the sea and the maturation process is complete. When the larvae move towards coastal waters, they metamorphose from an early larval form called leptocephalus to a glass eel stage where they begin to take the form of an eel but still lack pigment [3].

As glass eels move towards estuary waters and flowing waters, they undergo internal changes that allow them to live in low salinity and fresh water, they also become pigmented. At this stage they are referred to as elvers. These elvers continue to travel against the current and then live in places where they can eat and grow into yellow eels. Female eels have an average body size larger than male eels. Through a period of several years as juveniles or yellow eels they reach the appropriate size as a sign of entering adulthood. Simultaneously with this stage they migrate in the direction of the current to the estuary waters and then back to the sea. During re-migration the body changes to adapt to the conditions of the spawning area such as enlarged eyes, the color of the body becomes slightly dark red or bronze and the gonads have matured [3].

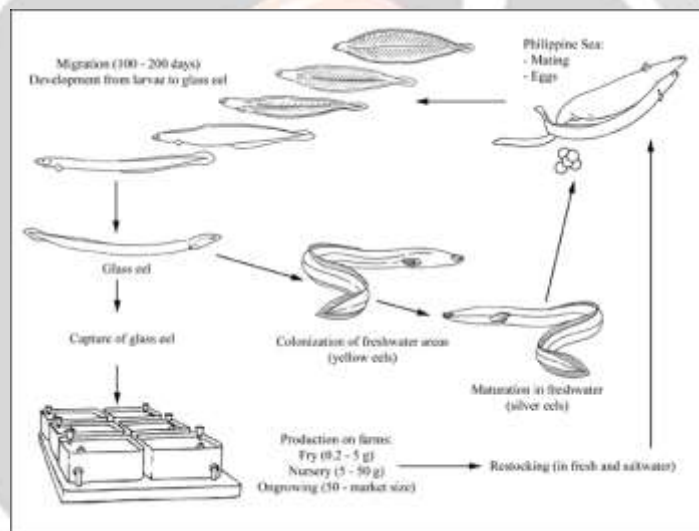


Figure 2. Life cycle of natural and cultured *A. japonica*
Source: [1]

2.4 Product of Wild-caught Anguilla Eel

Almost all eels in various stages of growth are caught by farmers. While the resulting product will describe or depend on tastes and ethnic preferences on how to use the eel. The youngest eels caught in the glass eel and elver phases were mainly intended for the implementation of the eel cultivation process. But in Spain and Portugal eels at this stage are also found in a variety of foods. Glass eel and *elver* are caught using a variety of small-mesh nets and usually fyke nets. In addition, eels are usually caught with traps, weir (forming sluice gates), and dip netting. All of these techniques utilize the habit patterns of young eels which tend to migrate in groups at night. When they move against the current, traps are set to intercept their movement. Active fishing gear such as trawls should not be used because these young eels are easily injured so that they are easily infected by bacteria [3].

Captured glass eels and *elver* are usually kept in large holding ponds equipped with running water, not fed or chemically treated until these eels reach the farm. Juvenile eels are caught by netting or trapping using bait. The eels of this phase are usually sold in live form to anglers to be used as bait for carnivorous fish such as sea bass. This eel can also be frozen and salted. Larger eels are caught using special tools or traps that can reach up to 3 feet in length, equipped with mesh nets, or stationary nets and weirs. Most large eels are caught at night when they are foraging or migrating with the current. Large eels are usually caught for sale to European destination countries [3].

Captured adult eels are usually stored in large holding ponds with running water for several days before being distributed to the market with the aim of cleaning the digestive tract and intestines of food debris so that the packaging at the time of distribution is not contaminated or if sent in frozen form the eel will not quickly experience quality deterioration caused by digestive enzyme activity. Eels can be distributed in live form in an aerated tank if the distance traveled is not too far and the costs are not too large. It can also be shipped by air in a polyethylene bag filled with a small amount of ice. When the ice melts, it not only cools the eels but provides moisture to their skin and gills thereby enabling them to obtain sufficient oxygen to survive during shipping [3].

2.5 Product of Cultured *Anguilla* Eel

Cultured eels are easy to obtain so they can be harvested when their size is optimal and according to market demand. The desired size in Japan is around 115 grams, in Europe the size that is considered optimal is between 150-230 grams. How to harvest farmed eels depends on the type in which they are raised. Eels that are cultured in ponds are usually netted, while eels in tanks are usually removed from the water.

The mode of transportation of cultured eels is the same as that of eels caught from nature, namely in the form of living in water with moist air or in a frozen state. Handling and preparation of the final product for smoking or other further processing occurs at the processor or consumer level if the eel is purchased directly for domestic use [3].

2.6 *Anguilla* Eel Composition

The composition of *Anguilla* eel will vary in value depending on the type, location of fishing/cultivation, season, environmental conditions, age or sexual maturity, sex, feed, genetics, type of analysis and so on. In general, fish contains water content ranging from 68 - 83%, fat content varies greatly depending on species, protein content ranges from 8 - 20% and ash content of 1 - 2% [5]. The proximate composition of eel (*Anguilla* sp.) based on the edible part is presented in Table 1.

Table 1. Proximate composition of eels (*Anguilla* spp.) per 100 g sample

Nutrients	Value (g)
Moisture	68.26
Crude Protein	18.44
Total Fat	11.66
Ash	1.41

Source: [5].

Farmed or cultured fish have a more predictable composition than naturally caught fish. The composition of the fish farmed is sourced from feed, season, number of stocks, sexual maturity, size, genetic and other environmental factors. It is known that cultured eel has a higher fat content, biological value of protein and essential amino acids than eel in nature. Meanwhile, cooling and freezing had minimal effect on the proximate content of fish. However, the fatty acid composition will still be affected by freezing due to the oxidation of saturated fatty acids. The addition of antioxidants to the feed or during storage had little effect on the fatty acid composition. It is best to separate this fat during processing. Processing with high temperatures in fish will affect the proximate composition including fat. Alkaline processing will reduce the fat content of fish [5].

2.7 *Anguilla* Eel Culture

A. japonica is a species that has been successfully cultured in Japan, this does not rule out the possibility for other types of eels, especially those in Indonesia, to be cultivated. As previously explained, the production of eel for cultivation is initially obtained from the catch of seeds in nature which are used for further growth, either in holding tanks or large ponds on the ground.

The source of glass eel for eel breeders in Japan comes from the waters around China to Malaysia or imported from other countries. Initially the glass eels (0.2 g each) were kept in small tanks (80-100 m³) for quarantine. The water temperature is stabilized at 25-29°C. These tiny eels are diagnosed with disease and fed with worms and then dry food. When the eels reach 5 g they are transferred to a juvenile production unit in a larger tank (300-600 m³) with a stock density of 0.8-1.0 kg/m² and fed dry pellets (1 mm) [1].

Places that can be used for enlargement are non-porous soil ponds, the water can be static or flowing, with a depth of 1-2 m. A good temperature ranges from 20-30°C. Every five weeks grading needs to be done so that maximum growth is achieved. In addition to the ground pool, a circular or square cement pool can also be used with

a size of 100-200 m². Eels are stocked in this pond at a size of 50 g, fed dry feed (1.5-3 mm) and graded every 6-7 weeks if necessary [1].

Eel feed contains high carbohydrates (about 22%) and uses fish meal as much as 65-70% with a crude protein content of up to 50%. In addition, yeast, wheat, soybean flour, starch, corn, dicalcium phosphate, animal or vegetable fats, minerals and vitamins are also added. The usual time to eat is 2-3 times a day.

The size of the harvested eel varies from 150 g to several kilograms depending on the target market. Feeding is stopped 1 to 2 days before harvesting. Harvesting can be done by draining the pond, using a seine net or scoop. The eels are then sorted according to different sizes and the eels that do not reach market size are returned to the rearing pond for further cultivation. Eel cultivation has expanded as a result of the strong demand for the fish. The availability of seeds, which have only depended on nature, is a major factor in eel cultivation [6],[7].

2.8 Handling after Harvest

After the eels are sorted by size, they are then placed in a holding tank for several days without feeding to clean their stomach. The eel is then cooled, packed into a thick plastic bag with sufficient amount of water to keep the eel skin moist. The bags are filled with oxygen and transported to the destination market. If it is to be used as a product, the eel is transported alive from the cultivation site to the processing site/industry. In order to gather mature eels and transport them alive to Europe, the Netherlands has deployed a ship with live wells to the United States and Canada [8].

2.9 Fresh Eel Processing and Marketing

Eels have historically been sold mostly in Japan, which receives supplies from farms in Taiwan and mainland China in addition to domestic production in Japan. However, Japanese customer behavior is thought to have changed as a result of repeated public attention to the presence of illegal substances in eel goods from mainland China and significant price hikes brought on by changes in the supply of glass eel [9].

The American freshwater eel market is not very developed, most of the eels caught in America are shipped to mainland Europe. Most of the consumption of eel in America comes from immigrants of European and Japanese descent who have eel processing recipes or are imported from eel processing countries. There are no eel processing plants in the United States and the eel smoking process occurs only according to consumer demand.

Nearly 91% of eel consumed in Japan as a finished product comes from aquaculture processes and a well-managed marketing system. After being transported from the breeding grounds, the congregation is kept alive and cool by the water that drips through the eels. Eel processing in Japan involves only one basic method but there are different processes based on geographic location. Broadly speaking, the preparation of eel includes:

- a. The eel is removed from the storage bin and placed on the cutting table where at this point the belly is split open and the innards are removed.
- b. To make the filet, the eel is clamped on the table with a special nailed handle, then the fish is straightened and then filleted using a knife starting from the back of the head and going towards the tail.
- c. The meat is then separated and removed from the attached bones/thorns.
- d. The filet is ready to be further processed into the final product.

Almost every part of the eel's body can be used as a product such as wallets and bags from the skin; the head is sold as a snack in Japan; the offal is grilled in soy sauce or canned to add to certain types of dishes; the spine is dried and seasoned to serve as a snack. While its use in Europe is only limited to the meat, sold frozen, fresh, canned or vacuum packed. The final product can be smoked, baked or grilled eel [3].

3. CONCLUSIONS

Since eels have the potential to be developed, many nations, including Japan and Northern European nations, have started to cultivate eels to suit domestic and global market demands. Depending on the country that employs it, almost every part of the eel is used. The existence of pectoral fins and the beginning of the dorsal fin, which are positioned some distance from the head and near to the pectoral, help to differentiate the genus *Anguilla* from other genera. In this species' life cycle, spawning takes place in the sea, after which juvenile eels travel to estuaries and interior waters to mature. Finally, they return to the sea to spawn, marking the end of the maturation phase. While cultured eels are simple to obtain and may be taken when their size is ideal and in accordance with market demand, captured adult eels are typically held in enormous holding ponds with running water for many days before being delivered to the market. Depending on the type, location of fishing or cultivation, season,

environmental factors, age or sexual maturity, sex, feed, genetics, and type of analysis, the composition of *Anguilla* eels will vary in value. Eels are first produced for culture by harvesting seeds from the wild, which are then employed for further growth, either in holding tanks or sizable ponds below earth. Almost all of an eel's body parts can be made into products.

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