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Use of the trumpet fish (Aulostomus strigosus) for the preparation of a substitute product for eel sauce and development of a culinary proposal in the city of Guayaquil

Aprovechamiento del pez trompeta (Aulostomus strigosus) para la elaboración de un producto sustituto de la salsa de anguila y desarrollo de una propuesta culinaria en la ciudad de Guayaquil

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Abstract
The present study has as main objective to elaborate a substitute product of the eel sauce with the use of the trumpet fish (Aulostomus strigosus), making three varieties of sauces with differentiated organoleptic characteristics; Roasted sesame seeds, sweet spices and orange, each providing a particular flavors such as: citrus, roasted and aromatic, taking into consideration that this titration proposal could become a product marketed in the city of Guayaquil at a very affordable cost for consumers of the eel sauce. In Ecuador, the consumption of trumpet fish (Aulostomus strigosus) has increased during the last decade, due to the low economic cost of this marine protein because it is a product of great reception in the gastronomic area. Through the surveys carried out, it was determined that the population of Guayaquil does know and consume trumpet fish (Aulostomus strigosus), however they do not know the nutritional properties that this food contributes to health. For the elaboration process, continuous experiments were carried out to measure the level of acids, viscosity and sweetness of the different varieties of elaborated sauces, getting to obtain a product with similar characteristics to the eel sauce. For the hedonic tests a preparation of oriental origin was made that has the name of "Yaki onigiri" a food with a neutral flavor, which in turn allowed to highlight the flavor of the three varieties of sauce presented, before the 70 unskilled judges.

key words
Eel, trumpet fish (Aulostomus strigosus), smoked, substitute, organoleptic.

Resumen
El presente estudio tiene como objetivo principal elaborar un producto sucedáneo de la salsa de anguila con el uso del pez trompeta (Aulostomus strigosus), realizando tres variedades de salsas con características organolépticas diferenciadas; ajonjolí tostado, especias dulces y naranja, cada una aportando un sabores particulares como: cítrico, tostado y aromático, tomando en consideración que esta propuesta de titulación podría llegar a ser un producto comercializado en la ciudad de Guayaquil a un costo muy accesible para los consumidores de la salsa de anguila. En el ecuador el consumo de pez trompeta (Aulostomus strigosus) se ha incrementado durante la última década, debido al bajo costo económico que tiene esta proteína marina por ser un producto de gran acogida en el área gastronómica. Mediante las encuestas realizadas se determinó que la población guayaquileña si conoce y consume pez trompeta (Aulostomus strigosus), sin embargo, desconocen las propiedades nutricionales que este alimento aporta a la salud. Para el proceso de elaboración se realizaron continuas experimentaciones para medir el nivel de acides, viscosidad y dulzor de las diferentes variedades de salsas elaboradas, llegando a obtener un producto con características similares a la salsa de anguila. Para las pruebas hedónicas se realizó una preparación de origen oriental que tiene el nombre de "Yaki onigiri" un alimento con un sabor neutral, que a su vez permitió resaltar el sabor de las tres variedades de salsa presentada, ante los 70 jueces no calificados

Palabras clave
Anguila, pez trompeta (Aulostomus strigosus), ahumado, sucedáneo, organolépticas.

1. Introduction

The purpose of this project is to investigate the culinary use of the trumpetfish (Aulostomus strigosus), which is currently a popular product in the markets due to its price, but limited to a few culinary preparations in the city of Guayaquil. This project aims to develop a smoked trumpetfish fillet product as a substitute for eel sauce, meeting the quality, texture, and flavor standards that this internationally recognized sauce possesses.

To achieve this goal, multiple experimental tests were conducted, starting with the smoking process, where different types of fruit tree woods such as laurel, oak, orange, and apple were used at various temperatures and times, which provided organoleptic characteristics similar to smoked eel. During the smoking process of the trumpetfish (Aulostomus strigosus), the correct international standards for this type of food were followed (Codex Alimentarius, FAO). Fruit tree wood was chosen due to the unique flavors it contributes to the sauce preparation.

Once the product was obtained, three preparations were made to measure the levels of sugar, soy sauce, and

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vinegar for a high-quality "unagi" (eel) sauce. Three varieties were made with ingredients added during cooking, such as toasted sesame, orange peel, and various spices. To draw conclusions, a hedonic test was performed, and interviews with experts in the field were conducted to understand their opinions and the acceptability level the sauce would have in the Guayaquil market.

1.1 The Origin of the Trumpetfish

In the fish collections of the Museum of La Plata, there had been, since 1918, an adult specimen of the curious "trumpetfish" or "trumpeter," so named because of the extraordinary length of its snout. Due to its color, fishermen also refer to it as the "canary." The trumpetfish is one of the most peculiar species found in the sea, not so much for its shape—since it seems like an evolution of seahorses, but with a more elongated body—as it has the same tubular shape and colors, with shades of green and yellow. This allows it to camouflage among the algae, preventing its prey from devouring it. It is a widely distributed species across the Indo-Pacific Ocean, from the African coast to Hawaii, Revillagigedo Island, and the Galapagos Islands. [1]

According to the article obtained from source [1] the trumpetfish is a blue fish that belongs to the seahorse family. This fish originated in Asia, and over time, its habitat changed, leading it to the Pacific Ocean's coasts, with Peru's coasts being the first where this marine species settled. It also began to populate the Galapagos Islands. The animal's main characteristic is its elongated body and its very peculiar trumpet-like snout, which is why it took the name "trumpetfish."

1.2 Characteristics

Like the entire genus of trumpetfish, it has an elongated body with an upward-facing, small mouth at the front of its long, tubular snout. The gills are pectinate, resembling the teeth of a comb. In front of the dorsal fin, it has 8 to 12 isolated and well-spaced spines. It has 24-27 soft dorsal rays and 26-29 soft anal rays.

This species can vary its color from the most common (brown) to the more uniform (green), to mottled brown or bright yellow. Its body has a pattern of pale vertical and/or horizontal lines. A black stripe, sometimes reduced to a dark spot, appears along the jaw. The dorsal and anal fins are clear with a similar appearance, with a dark basal stripe, located oppositely on the back of the body. It has a pair of black spots on the caudal fin and another on each base of the pelvic fins. Its size ranges from 60 cm to 80 cm in length. [1]

Fig. 1. Characteristics of the Trumpetfish Aulostomus strigosus

1.3 Habitat

This species is common in shallow waters of the Caribbean, extending from the coast of Florida, along the West Indies, the Gulf of Mexico coast, the Yucatán Peninsula, and the west of Central America, to southern Brazil. Isolated populations of trumpetfish are also found on the São Paulo rocks in the eastern Atlantic and scattered along the West African coast. The trumpetfish inhabits seagrass beds and coral reefs in shallow waters between 2 and 25 meters deep. It lives in both fore-reef areas and back-reef zones, where parrotfish also dwell. Ecuador has excellent specimens of trumpetfish in its reefs, particularly around areas abundant in vertical structures like sea whips. [2]

1.4 Diet

The trumpetfish is a carnivorous fish that feeds on very small animals such as zooplankton, phytoplankton, and tiny plants. However, there have been cases where it consumes slightly larger fish, such as surgeonfish. This fish has a straw-like or trumpet-shaped mouth, which opens wider than its body diameter to create a vacuum, allowing it to suck its prey into its mouth. One technique this marine animal uses to hunt its prey is camouflage, thanks to the chromatophores it has along its body. Another hunting method is swimming slowly alongside a larger fish, using it as camouflage, and then quickly wrapping its body around and launching itself at its prey. [3]

1.5 Nutritional Properties

The most well-known fatty fish are salmon, sardines, anchovies, mackerel, trumpetfish, herring, and tuna. The peculiarity of these fish lies in their fat content, which ranges between 5% and 12%, compared to the 1-4% found in lean fish like sole, hake, cod, or sea bass. Their

high content of omega-3 and fatty acids, as well as vitamins A, B, D, and E, along with potassium, magnesium, and calcium, makes them nutritionally valuable. Studies have shown that regular consumption of fatty fish reduces cardiovascular problems. Additionally, these fats play an important role in the development of brain function and vision. They also have beneficial effects on some depression-related problems and a positive impact on the immune system. [4]

According to [4] the trumpetfish has similar nutritional properties to the eel. This variety of fish contains vitamins A, B, D, E, and is rich in minerals, potassium, and fatty acids that are important for human body development. These fats are crucial for brain development and provide benefits that help counteract depression, immune system issues, and more.

1.6 Threats and Management

Trumpetfish are caught in large quantities for the traditional Chinese medicine industry, where they are considered as valuable as seahorses. Trumpetfish are said to be the best remedy for colds and flu. Generally, shrimp boats capture trumpetfish as bycatch using large trawling nets. However, instead of returning them to the sea like other marine animals caught in the same way, they keep them to sell to the traditional Chinese medicine industry. Divers searching for decorative shellfish also capture them.

As for the hunting and gathering of this fish variety, it is caught in abundance using boats. It is said that trumpetfish serve as a remedy to eliminate colds and other flu-related illnesses. For this reason, in the Chinese industry, this type of fish is commonly sold for medical use, not for culinary preparations.

In 1998 alone, India, the Philippines, Singapore, Australia, and Malaysia exported 12 metric tons (27,100 pounds) of dried trumpetfish to Hong Kong. In 1993 and 1994, Taiwan imported approximately 27 metric tons (59,500 pounds) of trumpetfish (equivalent to the weight of 11 sports utility vehicles).

It is also common to find trumpetfish in the pet trade. However, it is not advisable to purchase them because, like seahorses, they are difficult to maintain as they need live food every day. Researchers have reported a decrease in the number of trumpetfish in the seas of China and Australia. For collectors, it is becoming increasingly difficult to find them, and fishermen are finding fewer in bycatch. [5]

1.7 Origin of the Eel

Anguillidae are a family of teleost fish from the order Anguilliformes that use a single genus, Anguilla, commonly known as freshwater eels. They are euryhaline fish, spending part of their lives in the sea and another part in rivers, exhibiting catadromous behavior. They are distributed throughout most tropical and temperate waters, except in the eastern Pacific and southern Atlantic. Their name comes from the Latin "anguilla," meaning eel.

During Roman times and throughout the Middle Ages, eels were used to preserve stored water in cisterns and other reservoirs. This was because eels fed on algae and insects that grew in these waters, keeping them consumable, especially during sieges on fortresses. In the late 20th century, eel populations dropped to only 1% due to overfishing, water pollution, and obstacles like dams and hydroelectric plants that hinder their migration up rivers.

According to [6] the use of eels began during Roman times and the Middle Ages, when they were used to preserve water in cisterns. It is said that eels fed on algae and insects. However, in the past 50 years, eel populations have decreased to 1% due to factors such as water pollution, excessive overfishing, and many obstacles found in rivers. [6]

1.8 Nutritional Value of the Eel

Eel is the fattiest fish. It is a type of fatty fish, with a fat content of 18 grams per 100 g of edible portion. Unlike other fatty fish, the fat in eel contains a low percentage of omega-3 fatty acids. Nevertheless, it is rich in unsaturated fats (both monounsaturated and polyunsaturated), which makes its consumption suitable for heart conditions. However, it should be noted that its high-fat content results in a high-calorie intake, which increases when cooked with oils or other fatty condiments. Although its protein content is not very high, it is of high biological value. [7]

Eel also contains various vitamins and minerals. Among the vitamins, B vitamins like B1 and B2 stand out. Eels are one of the richest fish in vitamin B1, although when compared with foods high in this vitamin, like meats, legumes, or whole grains, the amount present in eel is not outstanding. Eel is the fish richest in vitamin B2, with a content similar to that found in foods considered sources of vitamin B2, such as eggs, liver, or dairy. As a fatty fish, eel also contains fat-soluble vitamins such as A, D, and E, which are stored in its liver and muscles. The presence of vitamins A and E is particularly notable, making eel the fish richest in these vitamins. [7]

According to [7] eel is a variety of fish that provides many important nutrients for human development. Unlike trumpetfish, this fish variety has a high amount of vitamin B2, which helps protect the liver and other vital organs. Its fat content is higher than other marine fish varieties and is rich in minerals and omega-3, which help tissue development.

Table 1.
Nutritional Properties of Eel

Nutritional value (per 100 grams)	
Calories	235 kcal
Proteins	14,5 g
Carbohydrates	0 g
Fats	14,8 g
Cholesterol	98,8 mg
Calcium	28,8 mg
Iron	1,2 mg
Zinc	2,4 mg
Potassium	2,83 mg

Vitamin A helps maintain, grow, and repair mucous membranes, skin, and other body tissues. It promotes resistance to infections and is necessary for the development of the nervous system and night vision. It also contributes to bone growth and is involved in the production of enzymes in the liver and sexual and adrenal hormones. Vitamin E has significant antioxidant effects. As for vitamin D, it is present in insignificant amounts compared to other fish. Regarding minerals, eel contains, among others, potassium, phosphorus, iron, iodine, and zinc. [7]

1.9 Food Preservation Techniques

Preserving food involves preventing the action of microorganisms that may contaminate and alter the original characteristics (smell, taste, appearance) of a food. Additionally, it reduces the oxidation of fats that cause rancidity. Food preservation can also include processes that inhibit visual deterioration, such as enzymatic browning in apples after they are cut during food preparation. However, many processes designed to preserve food involve more than one method of food preservation. [8]

1.10 Smoking Process

The fish smoking process is developed by using fire. Wood contains three main components that separate during combustion to produce smoke. The burning process is called pyrolysis, which is nothing more than chemical decomposition by heat. The main components of wood are cellulose, hemicellulose, and lignin. [9]

Smoking is one of the oldest preservation methods, combining the effects of salting, drying, heating, and smoking. Typical fish smoking is either cold (28–32 °C) or hot (70–80 °C). Cold smoking does not cook the meat, coagulate proteins, inactivate spoilage enzymes, or eliminate pathogens in the food; therefore, refrigerated storage is required to preserve the fish. [9]

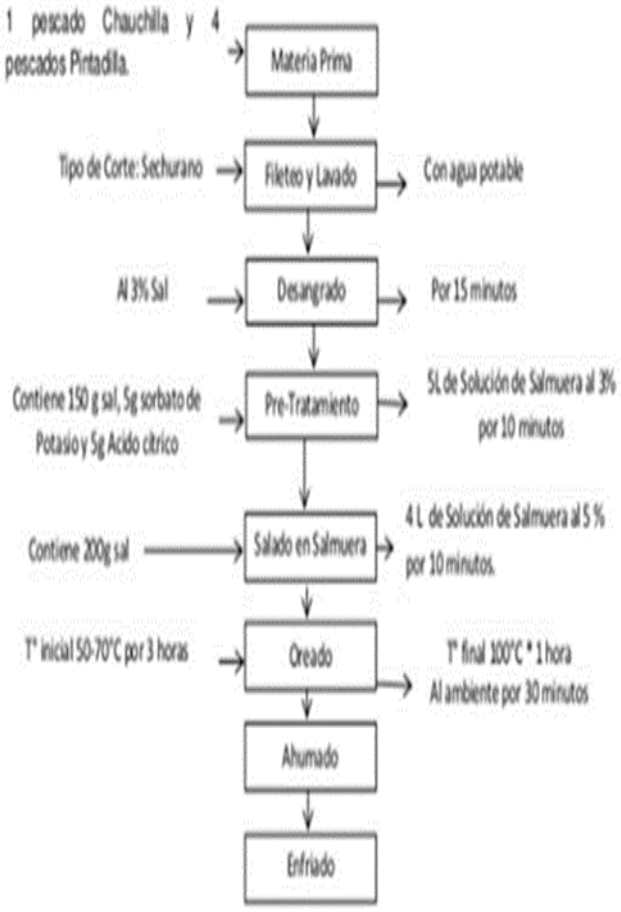

Fig. 2. Fish Smoking Process Flowchart

According to [9] the main characteristic of the smoking process is the type of wood used. The fish to be smoked must be properly cleaned, and proper GMP (Good Manufacturing Practices) must be applied since fish is a food that can easily acquire any type of bacteria. The cooking point to which the fish is subjected must be correct, fluctuating between 70 and 80 °C.

1.11 Types of Smoking

Cold Smoking: This process is used in most curing procedures. It is done without raising the smoke temperature above 30 °C, so the fish does not begin to cook. The operation lasts from several hours to several days, depending on the final product to be obtained. Typically, only one batch of cold-smoked fish can be produced every 24 hours. [10]

The equipment used in cold smoking consists of the traditional smokehouse or chimney, or a mechanical smokehouse. Here, the fish's temperature should never exceed 28–32 °C; otherwise, the surface would appear damaged, the fish would begin to soften, and fall off due to sagging in the fire (also called "droppers" in the trade). [11]

Hot Smoking: This type of process is used for most products. Here, the goal is to cook the fish while smoking it. The smoke reaches temperatures of 121 °C, and the center of the fish can reach 60 °C. Under these conditions, the operation is quick, lasting between 30 and 60 minutes, allowing several batches to be produced per day. [12]

Electrostatic Smoking: his is achieved by spraying electrically charged particles onto a surface with a small radius of curvature, particularly at the tips.

The method of using electrically charged particles has been applied to facilitate smoke deposition on the fish's surface. This dry method smokes and cooks the fish. The drying aims to prepare the product's surface to receive the smoke particles.

The smoking itself occurs as a result of the electrokinetic properties of the smoke in a high-voltage field of about 40,000 volts or more. The purpose of baking is to cook and dry the fish with a high temperature gradient, accelerating the rate at which water and smoke particles dissolve in it and diffuse into the muscle (thermal diffusion).

Electrostatic smoking is done very quickly, in less than 60 seconds, achieving products of equal quality to those obtained by traditional methods. [13]

Friction Smoking: Smoke obtained by friction is produced using a device with a horizontally placed ribbed metal plate, driven by an electric motor rotating at a specific speed. A piece of wood, preferably hardwood, is compressed against this plate to burn slowly due to the frictional heat generated, which can reach temperatures between 260 and 360 °C. Smoke begins to form in 3–5 seconds; the temperature should not rise high enough to create a flame, and additional devices allow automatic regulation of smoke density and volume. [14]

2. Materials and Methods

The experimentation of the eel sauce substitute using the trumpet fish was carried out for the production of three types of sauces. These products were made considering some variables, which are detailed below.

Smoking of trumpet fish: For the preparation of trumpet fish sauces, the raw material was obtained from the southern market of the city of Guayaquil, "La Caraguay." The trumpet fish was then cleaned and trimmed, followed by the smoking process, which lasted 30 minutes at a temperature of 65 °C. Fruitwood (apple) was used, adding a particular flavor to the smoked trumpet fish.

After obtaining the smoked trumpet fish, three varieties of sauces were prepared, using the same quantities of ingredients, time, and temperature for the preparation of the three sauces: sesame, sweet spices, and orange.

After conducting experimental tests to obtain the substitute product, sensory analysis was performed. A sample of trumpet fish sauce was then sent to the food laboratory at the University of Guayaquil, located at the Faculty of Chemical Engineering on the university campus (Ciudadela Universitaria, Avenida Kennedy and Francisco Boloña).

A sample of 150 ml of trumpet fish sauce was sent to the laboratory for microbiological tests to verify the protein content, pH, microbiological assays (aerobic germs, total coliforms, Escherichia coli), moisture, ash, carbohydrates, and energy. This ensures that the product complies with all quality standards and is suitable for human consumption.

3. Results

3.1 Trumpet Fish Sauce

In the preparation of the sauce, GMP and HACCP were followed, along with INEN Standard No. 82 for "sauces and dressings" in effect in Ecuador. To obtain the sanitary registration, the company must first be legally established, and certified laboratories must conduct tests confirming the quality and stability (shelf life of the Trumpet Fish Sauce). Technical reports on the process and packaging material are also required, as well as the plant's operating permit.

The application form for the sanitary registration, processed at the National Institute of Hygiene and

Tropical Medicine "Leopoldo Izquieta Pérez," must include the label and nutritional information for the Trumpet Fish Sauce, based on INEN 1334-1:2000 and INEN 1334-2:2000 standards for the labeling of food products for human consumption. Nutritional information was calculated based on pH and protein tests.

3.2 Labeling

According to INEN Standard 1334-1, the labeling of products within the food industry for human consumption must contain the nutritional information, highlighting the macronutrients. Below are the specific requirements that the tables with the nutritional properties for the prepared product, in this case, a sauce, must include: Name of the Food, Net Content, Ingredient List, Expiration Date, and Health Registry, Manufacturer Identification, Country of Origin. It is important to note that the sauces will be packaged in 250 ml glass bottles, which contain approximately 1.5 standard portions (250 ml).

Additionally, the selected label for the product is shown below; it is a vinyl label as it is unaffected by the moisture to which this product will be exposed, unlike a paper label that would deteriorate easily.

Fig. 3. Front label, design, content, and product name

4. Conclusions

- Since the 1990s, the trumpet fish, which had typically inhabited the coastal region of Peru, began migrating toward Ecuadorian coasts in search of warmer waters. Initially, it was treated as waste (animal feed or bait), but when a group of fishermen in Santa Rosa were trained in filleting and handling the trumpet fish, they prepared dishes that won over Ecuadorian palates. The price of the fish increased from $0.50 per pound to $2.50 currently. Nevertheless, it remains the cheapest filleted fish in the “La Caraguay” wholesale market. Nowadays, it is used in ceviche or breaded preparations.

- After conducting various smoking experiments at different temperatures, it was observed that the product cooked best at 75°C for 1 hour with applewood. Three sauce trials were also carried out, varying the percentages of the main ingredients, leading to a formula that emulates the taste and viscosity of the original unagi sauce. With the described formula, three sauces with different characteristics and uses were created: an orange sauce with citrus tones, a toasted sesame sauce to highlight the smoky flavor, and finally, a sweet spice sauce for aroma.

- A sensory test was conducted with 70 untrained judges to measure the level of acceptability of the three varieties of trumpet fish sauces prepared (sesame, sweet spices, orange). The results showed that the sesame sauce had the highest degree of acceptability among the three varieties, emphasizing the toasted sesame flavor that enhanced the trumpet fish sauce.

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5. Appendices

LA-IIT-UG
LABORATORIO DE ALIMENTOS
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INFORME DE ENSAYOS REALIZADOS

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Guayaquil, Ecuador

Nº IN20028 PÁGINA 1 DE 1

FECHA DE RECEPCIÓN: 07 de febrero de 2020

SOLICITANTE: Gustavo Lamota

DIRECCION DEL SOLICITANTE: Francisco de Marcos 330 y Chimborazo

CIUDAD: Guayaquil

MUESTRA: Salsa de pez trompeta

CÓDIGO: 20028E

FECHA DE INICIO/FINAL DEL ENSAYO: 21 - 26 de febrero de 2020

ENSAYOS FÍSICO QUÍMICOS	UNIDADES	VALORES	CONDICIONES AMBIENTALES	MÉTODO	OBSERVACIONES
PROTEÍNAS	g/100g	6,46	25°C	PEE/LA-IIT-UG/07	—
pH	Unidades pH	4,46	25°C	PEE/LA-IIT-UG/02	—
ENSAYOS MICROBIOLÓGICOS	**UNIDADES**	**VALORES**	**CONDICIONES AMBIENTALES**	**MÉTODOS**	**OBSERVACIONES**
AEROBIOS MESÓFILOS	ufc/g	Ausencia	35°Temperatura de Incubación	Recuento en placas PETRIFILM / AOAC 990.12	—
COLIFORMES TOTALES	ufc/g	Ausencia	35°Temperatura de Incubación	Recuento en placas PETRIFILM / AOAC 991.14	—
ESCHERICHIA COLI	ufc/g	Ausencia	35°Temperatura de Incubación	Recuento en placas PETRIFILM / AOAC 991.14	—

La muestra fue tomada por el cliente

Guayaquil, 26 de febrero de 2020

Ing. Radiun Avilés Chonillo
Jefe de Laboratorio LA-IIT-UG

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Este informe solo pude ser reproducido en su totalidad y con autorización del LA-IIT-UG

Appendix 1. Laboratory Results

NUTRITIONAL INFORMATION	
Serving size 250g	
Amount per serving	
Calories 235 kcal	
% Daily Value	
Total Fat 14,8 g	**3%**
Saturated Fat	6,5 g
Monounsaturated Fat	7,2 g
Polyunsaturated Fat	1,1 g
Cholesterol 98,8 mg	22%

Carbohydrates 0 g	0%
Protein 14,5 g	3%
Calcium 29,8 mg	7%
Iron: 1,2 mg	1%
Zinc: 2,4 mg	1%
Potassium: 283 m	63%

Appendix 2. Nutritional Table

Appendix 3. Interview with Experts or Professionals Knowledgeable in the Subject