



## Elaboration and characterization of a battered food, Frozen from earberry (*Solanum melongena*).

*Elaboración y caracterización de un alimento rebozado, congelado a partir de la berenjena (*Solanum melongena*).*

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### Abstract

The main drawback of the eggplant is the rapid oxidation caused by polyphenol oxidase (PPO), comes the need to raise awareness of the different properties that have this vegetable and benefits representing consume, its composition is 92% water, it contains minerals among them we can find abundant potassium, iodine and magnesium also has vitamin B1, vitamin C, thiamine, among others and phytonutrient as phytosterols and beta carotene. DPPH analysis of which showed a high content of flavonoids being most stands chlorogenic acid, which helps the removal of free radicals in the body was performed. The limiting factor for the development of this research was the production of this vegetable in Ecuador because they are small and sporadic crops near Canton Daule located in the province of Guayas.

### key words

eggplant, process, batter, characterization, antioxidant, frozen, oxidation

### Resumen

El inconveniente principal en la berenjena es la rápida oxidación causada por la Polifenol oxidasa (PPO), nace la necesidad de dar a conocer las diferentes propiedades que tiene esta hortaliza y los beneficios que representa al consumirla, su composición es un 92% acuosa, contiene minerales entre ellos podemos encontrar de forma abundante el potasio, además tiene yodo y magnesio, posee también la vitamina B1, vitamina C, tiamina, entre otras y fitonutriente como fitosteroles y beta caroteno. Se realizó análisis de DPPH el cual demostró el alto contenido de flavonoides siendo el que más destaca el ácido clorogénico que ayuda la eliminación de radicales libre en el organismo. El factor limitante para el desarrollo de este trabajo de investigación fue la producción de esta hortaliza en el Ecuador, debido a que hay pequeños y esporádicos cultivos cerca del cantón Daule, ubicado en la provincia del Guayas.

### Palabras clave

berenjena, procesos, rebozado, caracterización, antioxidante, congelado, oxidación.

### 1. Introduction

Battered and subsequently fried products have traditionally been widely consumed and constitute an essential element in the diet of many families.

The batter layer is primarily composed of cereal flour, which provides a significant amount of starch and, to a lesser extent, proteins. [1]

Currently, it has evolved, and what were once typically homemade products have transitioned into industrial agri-food production, mainly due to the ease of freezing storage and the speed with which they can be cooked for immediate consumption. Consumers expect increasingly higher quality products, and the market offers a range of new products, in this case, precooked eggplant. [2]

This vegetable contains nutrients, and it also has a significant number of antioxidants in both the skin and pulp, which are highly beneficial for health.

The *Solanum melongena* used for this study was the smooth purple variety, cultivated in small gardens in Canton Daule and Durán. One of the challenges is its rapid oxidation due to polyphenol oxidase activity, which is why a precooking process was chosen for this vegetable. [3]

#### 1.1 Eggplant description

Annual herb, sometimes perennial, spiny, pubescent, with stellate hairs. Stems 30-70(200) cm, erect, branched, spiny or unarmed, stellate-pubescent. Leaves 70-150(250) by 30-100(180) mm, ovate or oblong-ovate, obtuse or acute, subcordate, entire, sinuate, or with 5-6 lobes, densely stellate-pubescent, especially on the

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underside; petiole 2-8 mm, stellate-pubescent, sometimes with a few fine spines. Inflorescence in umbelliform cymes, isolated, paciflorous, generally reduced to a single flower, sessile, extra-axillary, rarely opposite the leaves. [4]

Actinomorphic, hermaphroditic, or functionally male flowers, without bracts, pedicellate; pedicels 15-40 mm during flowering, and 5-18 mm during fruiting, sometimes spiny, non-articulated. Calyx 13-20 mm, campanulate, with 5-9 lobes, very accrescent in hermaphroditic flowers, spiny; tube about 5 mm, shorter or equal to the lobes; lobes 8-15 mm, lanceolate, acuminate, sometimes unequal. Corolla (25)30-45(50) mm in diameter, twice the length of the calyx, rotate, with 5-8 lobes, blue, violet, or purple: ovate lobes. Stamens 5-7(8), equal, with filaments 0.6-2 mm, united at the base, with the distal part free, shorter than the anthers, glabrous; anthers 6-8 mm, ellipsoid, connivent, yellowish. Ovary stellate-pubescent with cylindrical style, widened at the apex, stellate-pubescent on the lower 3/4, exerted and stigma compressed, depressed in the center. Fruit 50-200(300) by 50-100(150) mm, exceeding the calyx by 2-5 times, sub globose, ellipsoid, ovoid, long pyriform, or more rarely spherical, fleshy, glossy, violet, purple, yellow, blackish, or variegated white-violet. Seeds 3-4 by 2-5 mm, discoid or sub reniform, compressed, pale yellow or light brown [5].

Its fruit is edible, a berry that ranges from 5 to 30 cm in length, mostly cylindrical, oblong, or elongated, with a smooth, shiny skin in various colors depending on the variety. The most common is purple or black when ripe, but there are also white, purple, black, yellow, and red or mixed colors, especially white, black, purple, and green [6].

The flesh is firm, with a spongy texture, white in color, has a slightly bitter taste, and contains small yellow seeds. It is available year-round as it is cultivated in greenhouses during cooler seasons.

Anthocyanins (flavonoids) have been identified in the skin of the fruit, pigments that give it its purple color. [7]

Eggplant (*Solanum melongena* L.) is a common vegetable consumed in various parts of the world. It is a member of the potato family and is known by several synonyms such as aubergine, brinjal, melanzana, garden egg, and patlicana, indicating that it is native to India. Eggplant contains high levels of phenolic compounds with antioxidant activity and also provides relevant amounts of certain minerals such as phosphorus, potassium, calcium, and magnesium. It has been observed that environmental conditions and growth techniques can influence the content of phenolic compounds and minerals in eggplant. [8]



Fig. 1. Eggplant

## 1.2 Eggplant production and consumption

Eggplant is considered the third most important crop within the Solanaceae family, following potatoes and tomatoes. According to FAO data, global eggplant production has significantly increased over the past 20 years, rising from 11.8 million tons in 1991 to 46.8 million tons in 2011, with a cultivated area of 1.8 million hectares. [9]

Eggplant production is currently highly concentrated, with over 90% represented by just five countries. China is the leading producer, accounting for 60% of the global total in 2011. It is followed by India (25%), and to a lesser extent by Iran (2.6%), Egypt (2.5%), Turkey (1.8%), Indonesia (1.1%), Japan (0.7%), Italy (0.5%), and Spain (0.4%).

In 2011, global exports reached 440,000 tons. Among the countries with the highest export volumes, Spain stands out (27.8%), followed by Jordan (14.7%), Mexico (11.1%), the Netherlands (10.8%), and Iran (5.2%). The main importing countries, in order of importance, which accounted for 70% of the total traded, were: the United States, France, Germany, Syria, Russia, Iraq, Italy, Canada, and the United Kingdom.

### 1.2.1 Production in Ecuador

In Ecuador, the cultivation of eggplant (*Solanum melongena*) is limited, as is its production or industrialization, due to a lack of awareness about the medicinal and culinary benefits of this vegetable. According to a report by the newspaper El Universo on July 30, 2010, eggplant is being cultivated in Canton Durán, Guayas Province, for commercialization in an Italian restaurant. [10]

### 1.3 Eggplant Variety

Although the greatest diversity of eggplant is found in the Indo-Burmese Center, considerable variation can also be found in China and the Mediterranean region, which are therefore considered Secondary Centers of variation.

While there are several botanical classifications of eggplant, the most common among cultivated types is Bailey's classification (1947), which distinguishes three botanical varieties: var. *esculentum*, which includes the common forms; var. *serpentinum*, which includes varietal types with very long fruits; and var. *depressum*, consisting of types with small and early fruits. [11]

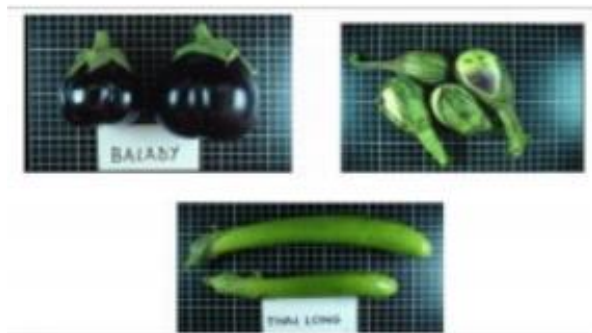


Fig. 2. Fruits of the botanical varieties *esculentum*

The most important characteristics in the varietal classification of eggplant fruits are: fruit shape and size, color, color uniformity, the presence of spines on the calyx, and the length of fruit covered by the calyx. In our country, it is common to classify types into the following categories based on shape: long, semi-long, oval, and round, and within each of these by color (black, purple, green, white) and distribution (uniform, striped, reticulated). [12]

#### 1.4 Characteristics

Eggplants are not particularly known for their energy, protein, or calorie content. On the contrary, they are composed of 92% water. The most abundant mineral in eggplants is potassium; they also contain iodine, sodium, and magnesium [13].

This vegetable contains a variety of vitamins, including vitamin B1. It is rich in folates, magnesium, copper, manganese, and has a high fiber content, which aids our digestive process and helps prevent coronary diseases. [14]

## 2. Materials and methods

Based on the information obtained from battered foods in meats, seafood, and vegetables, an experimental method is applied. Experimental method: This technique allows for an approach to obtaining the precooked product, for which the conditions and variables influencing this practice will be adjusted or modified, and the hypothesis will be demonstrated.

### 2.1 Equipment and Materials

#### Sanitization materials

- Latex gloves
- Mask

- Hairnet or cap
- Apron
- Absorbent towels
- **Materials for use**
- Tweezers
- Aluminum tray
- Thermometer
- Stopwatch
- **Equipment**
- Washing chamber
- Knife
- Blades
- Cooking chamber
- Cold chamber
- Sealing machine
- Analytical balance
- **Raw materials**
- Egg
- Eggplant
- Wheat flour
- Corn flour
- Salt
- Olive oil
- Monosodium glutamate

### 2.2 Process Description

#### 2.2.1 Reception of raw materials

1.7 kg of eggplant is received from Canton Daule, located in the province of Guayas.

#### 2.2.2 Classification

The eggplants are classified, and those with any handling damage are separated.

#### 2.2.3 Washing with chlorinated water

It is washed externally in chlorinated water (100 ppm) with a pH of 6.7, followed by a rinse with potable water to remove any chlorine residues.

#### 2.2.4 Peeling

The eggplants are manually peeled using a knife.

#### 2.2.5 Slicing

The eggplants are sliced into rounds with a thickness of 8-10 mm.

#### 2.2.6 Exudation

The slices are placed in a brine solution to remove the bitter taste of the eggplant (*Solanum melongena*).

#### 2.2.7 Washing and draining

The slices are washed and left to drain to remove excess water from the surface.

### 2.3 Preparation of the Battering Mixture

#### 2.3.1 Mixing

To prepare the batter, corn flour, eggs, salt, and wheat flour are mixed together with water.

#### 2.3.2 Immersion

The sliced eggplant (*Solanum melongena*) is immersed in the container holding the batter mixture.



### 2.3.3 Frying

The battered food is placed in the frying chamber for 30 seconds.

### 2.3.4 Cooling

The battered food is allowed to cool for 30 minutes.

### 2.3.5 Freezing

After cooling, the food is transferred to a freezing chamber with a theoretical temperature of (-30°C) and an actual temperature of (-18°C).

### 2.3.6 Vacuum Packing

The battered food is vacuum-packed using a sealing machine.

### 2.3.7 Storage

The vacuum-packed battered food is stored in a cold chamber at a temperature of (-18°C).

## 2.4 Parameters According to the Variable

### 2.4.1 Independent Variable

Table 1. Independent Variables

Definition	Measurement Level	Maximum Allowable
Frying time	Ratio 30 s	40 s
Renewal rate	Ratio 10 ml / h	10 hours
Food piece size	Interval 7 – 8 mm	8 mm
Oil absorption by food	Ratio minimum	Minimum
Freezing temperature	Interval -30 – 73.3 °c	- 128.9 °c
Coating index	Ratio as low as possible	As low as possible

### 2.5.2 Dependent Variable

Table 2. Dependent Variables

Definition	Measurement Level	Maximum Allowable
Frying temperature	Ratio 180 °c	185 °c
Type of oil	Olive oil	Olive
Type of heating	Continuous/ Discontinuous intervals	Continuous
Production level	Ratio g product/hour	As high as possible
Food state	Interval frozen/fresh	Medium state
Food water content	Ratio 70 – 80%	90 %
Batter preparation	Interval solid content 35 – 45%	50 %

## 3. Results

Table 3. Formula N° 1

Raw Material	g
Wheat flour	38
Salt	2
Water	60
Resulting mixture	100

Table 4. Formula N° 2

Raw Material	g
Corn flour	26,8
Salt	3,2
Water	70

Resulting mixture	100
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Table 5. Formula N° 3

Raw Material	g
Wheat flour	12
Corn flour	8
Water	74,5
Salt	5,5
Resulting mixture	100

Table 6. Formula N° 4

Raw Material	g
Wheat flour	175
Corn flour	20
Water	240
Salt	4
Monosodium Glutamate	1
Resulting mixture	440

Table 7. Formula N° 5

Raw Material	g
Wheat flour	175
Corn flour	20
Water	240
Salt	4
Monosodium Glutamate	1
Resulting mixture	440

Table 8. Formula N° 6

Raw Material	g
Wheat flour	193,12
Corn flour	22,72
Salt	8,38
Monosodium Glutamate	1,36
Milk	59,08
Water	218,176
Resulting mixture	500

### 3.1 Process for Obtaining Breaded Eggplant

To produce this breaded product, 100 kg of eggplant of the smooth purple variety was used. The eggplants underwent a washing and peeling process, resulting in 79.8 kg of pulp and 15.2 kg of peel. The eggplants were then sliced into rounds with a thickness of 2 cm, producing 3,527.85 slices. These slices were subjected to a salting process using 6.26 kg of salt evenly distributed across all the slices. After 30 minutes, a brine solution of 28.247 L and a residue of 2.68 kg were obtained, along with 77.19 kg of eggplant pulp with a moisture content ranging from 89.20% to 92.20%.

The slices were washed using 1,441.8 L of water, which increased the weight of the slices to 128.1 kg with a moisture content of 93.5%. The slices were immediately drained on metal racks for 45 minutes, resulting in 93.68 kg of washing water and partially dried slices weighing 83.27 kg with a moisture content of 90%.

For the preparation of the batter, we used 89.90 kg of wheat flour, 10.27 kg of corn flour, 2.05 kg of salt, and 1.1052 kg of monosodium glutamate, resulting in a total of 102.74 kg of solids. For the liquid part, 23.66 kg of



milk and 94.6 kg of water were used, resulting in a total of 118.3 kg of liquids. The mixing ratio was 1/1.2, meaning that for every 100 kg of solids, 120 kg of liquids were added, resulting in a batter mixture of 221.04 kg with 46.48% solids. The 3,527 slices were then mixed with the 221.04 kg of batter in a sufficiently large container, resulting in 189.106 kg of breaded product and 160.1 kg of residual batter, which can be reprocessed.

These breaded slices were fried in 117.6 L of olive oil at 175°C, the frying point of the oil. The slices were fried for approximately 30 seconds and then removed onto absorbent paper. After approximately 1 minute, the product was immediately transferred to a freezing chamber set to -30°C until it reached the freezing point. The product was then vacuum-packed and stored in a stabilization chamber at -20°C until final consumption.

### 3.2 DPPH Analysis

Table 9. Data Obtained from the Spectrophotometer of Eggplant Peel with 50 µL

Date:	21/11/2015
Sample:	Eggplant peel
Quantity:	50 µl
t/s	ABS
0,06	0,771
30,061	0,112
60,061	0,101
90,058	0,085
120,062	0,075
150,06	0,071
180,061	0,071
210,06	0,071
240,061	0,07
270,06	0,07
300,059	0,07
330,06	0,07
360,061	0,071
390,059	0,07
420,059	0,07
450,06	0,07
480,06	0,07
510,058	0,07
540,06	0,07
570,061	0,07
600,06	0,07
630,059	0,07
660,059	0,071
690,06	0,07
720,059	0,07
750,059	0,07
780,059	0,07
810,06	0,07
840,058	0,071
870,058	0,071

Using 50 µl of methanolic extract from the peel, a 90% inhibition was obtained, indicating a high content of flavonoids.

Table 10. Data Obtained from the Spectrophotometer of Eggplant Pulp with 50 µL

Date:	21/11/2015
Sample:	Eggplant pulp
Quantity:	50µl
t/s	ABS
0,061	0,762
30,061	0,437
60,06	0,353
90,06	0,299
120,059	0,274
150,061	0,515
180,059	0,524
210,061	0,487
240,059	0,451
270,061	0,435
300,059	0,424
330,061	0,413
360,06	0,406
390,06	0,399
420,062	0,393
450,059	0,388
480,059	0,383
510,061	0,378
540,063	0,374
570,059	0,369
600,059	0,365
630,06	0,361
660,059	0,357
690,06	0,353
720,06	0,349
750,061	0,346
780,06	0,342
810,059	0,339
840,06	0,336
870,059	0,333

Using 50 µl of methanolic extract from the pulp, a 64% inhibition was obtained, indicating a significant flavonoid content.

Table 11. Data Obtained from the Spectrophotometer of Eggplant Pulp with 100 µL

Date:	21/11/2015
Sample:	Eggplant pulp
Quantity:	100µl
t/s	ABS
0,061	0,6
30,059	0,172
60,062	0,123
90,06	0,11
120,06	0,105
150,059	0,124
180,059	0,108
210,061	0,121
240,061	0,143
270,06	0,125
300,059	0,112
330,062	0,106
360,061	0,103
390,059	0,102
420,059	0,102
450,059	0,102
480,061	0,102
510,06	0,101
540,061	0,101



570,06	0,101
600,062	0,101
630,059	0,101
660,061	0,101
690,06	0,101
720,06	0,101
750,063	0,101
780,06	0,101
810	0,1
840,06	0,1
870,059	0,1

Using 100 µl of the methanolic extract of the pulp was used, resulting in an inhibition percentage of 83%, indicating a high flavonoid content.

### 3.3 Microbial Analysis of the Final Product

Products intended for human consumption must not show any signs of contamination. Microorganisms such as fecal coliforms, Escherichia coli, and aerobes should not be present in the product, meaning the count should be <10 CFU/g. These analyses were conducted at the Technological Research Institute of the Faculty of Chemical Engineering.

Table 12. Microbiological Analysis

Microbiological Tests	Units	Values	Environmental Conditions	Methods
Total Coliforms	CFU/ml	0	35°C incubation temperature	Plate count
Escherichia coli	CFU/ml	0	35°C incubation temperature	Plate count
Aerobic Germs	CFU/ml	0	35°C incubation temperature	Plate count

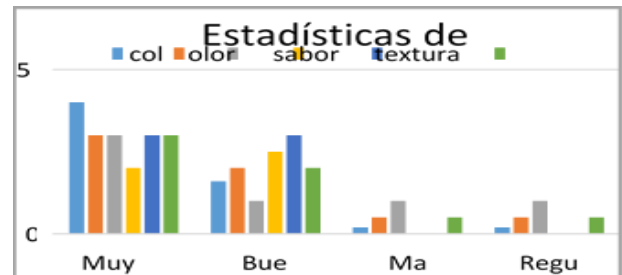
### 3.4 Sensory Analysis

The objective of this sensory analysis is to evaluate the organoleptic characteristics of the product (battered eggplant). A survey was conducted among a group of 60 tasters who responded to a series of questions, providing acceptance percentages from the participants.

The goal of this analysis is to evaluate the following factors:

- Color
- Smell
- Taste
- Texture
- Presentation
- Preference and appearance
- Quality

### 3.5 Results of the Product Acceptance Survey



The survey results indicate the acceptability of this product, as many of those who tried it expressed their approval, and the presentation was considered innovative.

### 4. Conclusions

Through this research topic, the nutritional composition of eggplant (nutrients, minerals, vitamins, and phytonutrients) was determined.

The product is considered innovative as it aims to introduce a new form of presentation and processing of Solanum melongena.

Using the DPPH method, it was found that eggplant has a high flavonoid content (chlorogenic acid), which is an antioxidant that helps eliminate free radicals.

The optimal temperature range for the pre-cooking phase is between 170–180°C, and the time range in the cooking chamber is 30 seconds.

Further research is recommended using flour mixtures with a high gluten content to improve the emulsion and thereby the texture of the final product.

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