



**DESIGN OF AN INDUSTRIAL PROCESS FOR THE  
PRODUCTION OF CANDIED FLAKES BASED ON BARLEY (*HORDEUM  
VULGARE*) AND (*LUPINUS MUTABILIS*) CHOCOLATE FLAVORED  
(*THEOBROMA CACAO*)**

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**Abstract**

The objective of this work was to design an industrial process for the production of candied flakes of barley (*Hordeum vulgare*) and (*Lupinus mutabilis*), being a new food with high nutritional value that takes care of the health of Ecuadorians. Therefore, to start with the process, the raw material that meets the quality requirements to be processed was selected; then, the grains were dehydrated in a dryer at 50°C for 24 hours, while the barley grains were roasted at 80°C until golden brown; then, they were crushed in a mill and sieved until a fine flour of each product was obtained. For

the elaboration of the candied flakes, and barley flour were added, performing 3 treatments with different percentages of both flours, 25, 50 and 75%, respectively; In addition, sugar, cocoa, vanilla and water were added, being mixed until a homogeneous dough was obtained, which was kneaded to form a thin sheet cut into small squares that was placed in a stove at 145 ° C for 90 minutes and the product was packed in a ziploc container. Finally, to determine which product was the most suitable to be marketed, different physicochemical, bromatological and sensory analyses were carried out based on the INEN 2561: 2010 Standard. Likewise, a comparison of the nutritional table with a competition pattern (Chocapic) was made, concluding that the candied flakes of the second treatment (50% both flours), was the product that met all the requirements, being ready to be consumed, since it provides benefits to human health, and avoids disease, so it is recommended to use as the main raw material in the elaboration of products derived from it, since it provides a high content of nutrients that would improve the quality of life of people.

Keywords: <INDUSTRIAL DESIGN>, <CANDIED FLAKES>, <(Lupinus mutabilis)>, <BARLEY (Hordeum vulgare)>, <DEHYDRATION>, <FOOD DRYING>, <GRAIN CRUSHING>.

## 1. Introduction

With the passage of time and in conjunction with the advancement of technology, the human being has become a being that has many benefits and facilities in their daily lives, including their diet. Thus, there are currently several foods that are easy to obtain and quickly consume, which satisfy, but do not comply with the daily diet necessary for a better quality of life. One of them are the candied flakes commonly known as box cereals, being consumed specifically at breakfast by humans of all ages, the same who believe that being a product made from cereals, has many health benefits, however, the same product can cause serious problems in the medium and long term, since, during its production, it is constituted by artificial substances and additives, which cause it to lose its natural properties and therefore, its nutritional value. For this reason, it is intended to develop a new product with natural raw material and typical of Ecuador, which has several benefits to human health and that meets the quality requirements according to the Ecuadorian Technical Regulations to be marketed and consumable.

### 1.1 Identification of the problem

Traditional candied flakes are generally produced with the use of cereals, such as: oats, corn, wheat and rice, which, through certain chemical processes in large-scale industrial equipment, transform this raw material into the desired product. Thus, currently, they have become a staple and quick to eat, than another, at breakfast. However, according to the Alliance for Food Health, of 371 box cereals (candied flakes), 69% are harmful to human health, since they are subjected to a refining process, losing their nutrients and adding artificial flavors, colors and sweeteners (Monroy, 2019, para. 2). However, there are other raw materials that can be used in the preparation of these candied flakes and that can be suitable for human consumption, due to their high nutritional value, barley and.

The demand for is unsatisfied, so, today, a large number of families have dedicated themselves to this product, specifically in the province of Chimborazo with about 800 hectares, followed by Cotopaxi and Tungurahua, adding between them 350 hectares of crops, with the aim of covering local demand in the short term and being able to export their production in the long term (Marquéz, 2020, para. 5). The is a legume cultivated in the Andean regions since pre-Columbian times, it is known as the "Andean soybean" due to its high content of calcium and proteins, regulates blood glucose levels, as it contains fiber and minerals such as phosphorus and iron, collaborating in the production of energy necessary for the proper functioning of the human body. In addition, it has antioxidant properties that decrease cellular aging and the appearance of neurodegenerative diseases, diabetes and certain types of cancer (Güipi, 2019, para. 7).

On the other hand, barley is one of the most important crops in the Ecuadorian highlands, with Chimborazo being the province that registers 18,000 of the 48,000 hectares dedicated to this crop nationwide. This cereal is rich in protein and contains a lot of fiber, being one of the main foods with omega 3, 6 and 9, also highlights its contribution of vitamins B and E and minerals such as calcium, phosphorus, potassium and magnesium, becoming a necessary food for nutrient deficiency states and for the growth process (Rosemary, 2018, para. 10).

Thus, both and barley are an ideal raw material to make a new product in the province of Chimborazo, making it an ideal food to combine at breakfast, given its nutritional benefits, contributing to a balanced diet and a healthy lifestyle.

At present Ecuadorian, the is mainly cultivated by farmers of low economic resources and is very desirable in the gastronomic industry in the mountains, either as a ceviche (cevichocho) or as a snack with toasted and tanned corn (tomato, onion, salt and lemon), likewise, barley is one of the most used cereals in the beverage industry in Ecuador, being the main ingredient in brewing. However, there are certain obstacles to the use of and barley as raw materials in the manufacture of other products derived from them. These obstacles refer to the lack of knowledge of the benefits that both have and their application in other industries, on the part of producers or the absence of wanting to taste something new, on the part of consumers.

## 1.2 Justification

The Republic of Ecuador is one of the countries located in the northeast of South America, bordered to the north by Colombia, to the south and east by Peru and to the west by the Pacific Ocean. Due to its latitudinal zone that crosses the equinoctial or equatorial line, from which it acquires its name, Ecuador has a great diversity of climates that are based on the tropical, obtaining as a primary advantage the obtaining of a wide range of agricultural products.

In consideration of the problem raised, the purpose of this work is to elaborate candied flakes, cereal type, from agricultural products native to Ecuador, barley (*Hordeum vulgare*) and (*Lupinus mutabilis*). Likewise, the importance of this work lies in demonstrating an innovative idea, creating a product with new raw material different from the one already known, through the use of products that are available in the national market, of different flavors, smells and colors characteristic of each product, which provides health benefits and satisfies the palate of its consumers. In addition,

it must comply with the quality requirements established in the INEN 2561:2010 standard, through physicochemical, bromatological and sensory analysis, so that it can be considered as a new substitute for traditional cereals.

In this way, through the development of this research work, it is intended to increase the demand for planting barley and cocoa (raw material for obtaining chocolate) and mainly in Ecuador, since the latter can be adaptable for other types of processes and industries, due to its high nutritional content and medicinal values it has, Thus, it is intended to replace the typical corn or wheat flours, used in the preparation of candied flakes, with and barley flours, the main ingredients to make a product that is suitable for consumption, obtaining benefits that improve the health and lifestyle of human beings.

## 2. Objectives

### 2.1 General objective

Design an industrial process for the production of candied flakes based on Barley (*Hordeum Vulgare*) and (*Lupinus Mutabilis*) with Chocolate flavor (*Theobroma Cacao*).

### 2.2 Specific objectives

- Identify the variables, parameters and operations necessary to carry out the design calculations in the process of obtaining candied flakes, cereal type, based on barley and, maintaining the flavor of Chocolate.
- Evaluate the quality of the flakes produced by physical, chemical, bromatological and sensory analysis based on the INEN 2561:2010 Standard.
- Determine the technical and economic feasibility of the production of candied flakes in Ecuador.

## 3. Methodology

### 3.1 Project location

This project will be developed in the Unit Operations laboratory and Analytical laboratory of the Faculty of Sciences of the Polytechnic School of Chimborazo, located in Riobamba, province of Chimborazo, at km 1 1/2 via Guayaquil.

Parameters	Description
Province	Chimborazo
Canton	Riobamba
Latitude	1° 39' 32.3" on
Coordinates	78° 40' 20"
Climate	17 °C

Table 1: Location and coordinates of the ESPOCH

Fuente: (Google maps, 2022).

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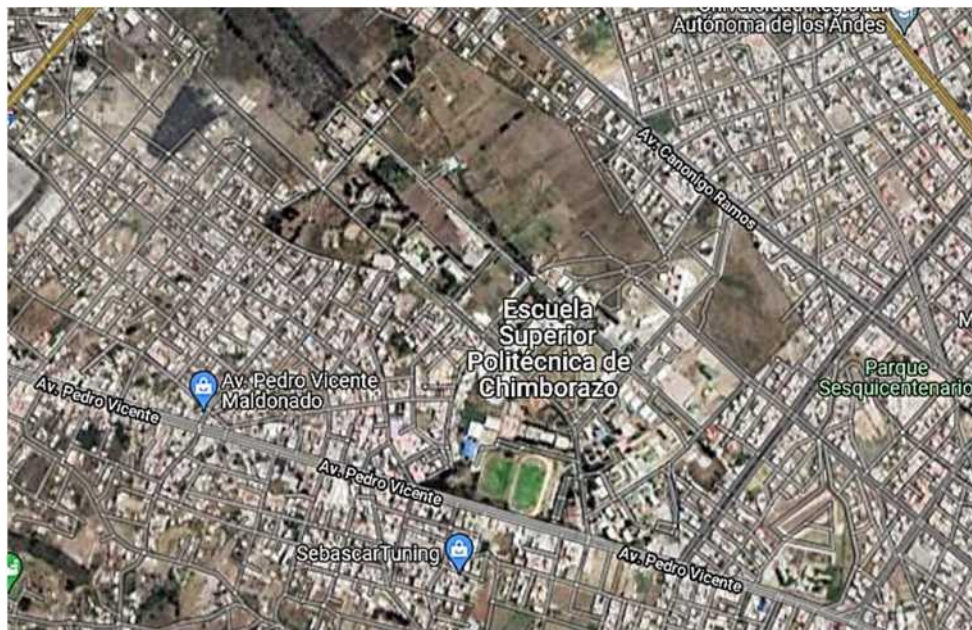


Figure 1: ESPOCH location

Fuente: (Google maps, 2022).

## 3.2 Project engineering

### 3.2.1 Type of study

The project to make candied flakes from barley and chocolate flavored pork, which may be suitable for human consumption, healthy and natural, is a technical project, which will be carried out through the compilation of different bibliographic sources related to the main topic, likewise, with the application of unit operations and different research methods: inductive, deductive and experimental that will allow to design the most optimal process for its elaboration, obtaining a product with the best quality and that complies with the requirements established in the Ecuadorian Technical Regulations.

### 3.2.2 Methodology

To achieve the objectives of the technical project, it will be executed according to three research methods: deductive, inductive and experimental, with which it is intended to determine three main parameters within the process: analysis of the raw material and the product obtained, engineering calculations and the validation of the process designed for the elaboration of candied flakes, allowing to be developed in an organized and systematic way.

### 3.2.2.1 Methods

#### Deductive method

The deductive method allows to achieve specific conclusions from general data, so through the use of this method, information, theoretical foundations, operations and industrial processes related to the subject of this project will be obtained from different bibliographic sources and at the same time, the knowledge acquired for the experimental development of the project will be applied, in this way it will be possible to know the desired characteristics of the raw material (barley and ) and the processed product (candied flakes).

#### Inductive method

The inductive method consists of starting from particular data to obtain general conclusions, so that the quality of the raw material (barley and) will be determined by carrying out its corresponding physicochemical analyzes to obtain the required calculations, the design alternatives and variables of the process in the elaboration of candied flakes of good quality.

#### Experimental method

The experimental method allows to verify the veracity of the hypothesis with the help of the experiment (observation, manipulation and control of variables), therefore, different laboratory techniques will be used for the determination of the quality of both the raw material and the elaborated product and instruments and equipment for obtaining the candied flakes in the laboratories of Analytical and Industrial Processes, respectively.

### 3.2.3 Techniques

The development of this curricular integration work will be supported by the Ecuadorian Technical Regulations (INEN) corresponding to the elaboration of candied flakes and the application of various laboratory techniques to perform physicochemical, bromatological and sensory analysis of both the raw material and the finished product, which will ensure that they are of quality and suitable for consumption.

## 4. Results

### 4.1 Characterization of the raw material

By carrying out the respective physicochemical analysis of the raw material (barley grains and) and the physicochemical, bromatological and microbiological analyses of the flours obtained (barley and) carried out in the Analytical Laboratory of the Faculty of Sciences of the ESPOCH and the food analysis laboratory "SAQMIC" obtaining the results presented in the following tables:

#### 4.1.1 Physical analysis of the raw material

Parameter	Barley	Chocho
Humidity (%)	7,48	71,7
Ash (%)	2,04	3,15

**Table 2.** Results of physicochemical analysis of the raw material  
Source: (Álvarez, 2022, p. 1).  
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#### 4.2 Characterization of the flours obtained

##### 4.2.1 Physical analysis of flours

Parameter	Barley flour	flour
Aspect	Homogeneous	Homogeneous
Smell	Characteristic	Characteristic
Color	Characteristic coffee	Characteristic light coffee

**Table 3.** Results of physical analysis of flours  
Source: (Álvarez, 2022, p. 1).  
Made by: Azaña, Anael, 2022.

##### 4.2.2 Chemical analysis of flours

Parameter	Barley flour	flour
Humidity (%)	2,74	5,28
Ash (%)	0,78	1,89
Protein (%)	10,1	41,0
Fat (%)	1,8	1,51
Wet gluten (%)	<0,1	<0,1
Acidity (% H2SO4)	0,1	0,1

Granulometry No. sieve	95	95
212 um (%)		

Table 4. Results of chemical analysis of flours

Source: (Álvarez, 2022, p. 1).

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## 4.2.3 Microbiological analysis of flour

Parameter	Barley flour	flour
Molds and yeasts (CFU/g)	Absence	Absence
Escherichia Coli (UFC/g)	Absence	Absence

Table 5. Results of microbiological analysis of flours

Source: (Álvarez, 2022, p. 1).

Made by: Azaña, Anael, 2022.

With the results obtained it was determined that both the raw material (barley grains and) and the flours obtained meet the quality requirements established in the Ecuadorian Technical Regulations, INEN, being suitable for subsequent use in the preparation of candied flakes and for human consumption.

## 4.3 Characterization of candied leaflets

Once the specific quantities of the three treatments for the preparation of candied flakes were used, the respective physicochemical, bromatological and sensory analyses were carried out to determine if they comply with the requirements established in the INEN 2561: 2010 Standard, referring to snacks of vegetable origin, analyzed in the "SAQMIC" laboratory. In this way, based on the results obtained, the best treatment for its elaboration can be established, in this way, the product obtained will be suitable for commercialization and for human consumption. The results can be seen in the following tables depending on the treatment (T1, T2 and T3) performed:

## 4.3.1 Physicochemical analysis

Parameters	T1	T2	T3
Humidity (%)	2,18	0,75	0,89
Ash (%)	1,99	1,96	2,05



Table 6. Results of physicochemical analysis of treatments

Source: (Álvarez, 2022, p. 3).

Made by: Azaña, Anael, 2022.

#### 4.3.2 Bromatological analysis

Parameters	T1	T2	T3
Protein (%)	14,89	32,0	23,2
Fiber (%)	2,7	3,5	2,1
Fat (%)	2,3	1,99	2,01
Carbohydrates (%)	78,05	61,6	72,10

Table 7. Results of bromatological analysis of treatments

Source: (Álvarez, 2022, p. 3).

Made by: Azaña, Anael, 2022.

#### 4.3.3 Microbiological analysis

Parameters	T1	T2	T3
Molds and yeasts (CFU/g)	Absence	Absence	Absence
Escherichia Coli (UFC/g)	Absence	Absence	Absence

Table 8. Results of microbiological analysis of treatments

Source: (Álvarez, 2022, p. 3).

Made by: Azaña, Anael, 2022.

#### 4.3.4 Comparison table

Finally, based on the analysis of the surveys carried out with direct judges (administrative staff, teachers and students of the ESPOCH) and the results of the bromatological analysis of the candied flakes, treatment 2 was selected as the ideal product to be produced, marketed and consumed; therefore, below are the values of the parameters that will validate the quality of the product obtained, making a comparison with a standard, Chocopic Cereal of the Nestlé brand, considered as the main competence of this.

Parameters	T2	Chocopeak (Pattern)
Protein (%)	32,0	2,0
Fiber (%)	3,5	0,5
Fat (%)	1,99	0,5
Carbohydrates (%)	61,6	25,0

Table 9. Results of microbiological analysis of treatments

Source: (Kellogg's, 2022, para. 3).

Made by: Azaña, Anael, 2022.

#### 4.3.5 Discussion of results

In the table presented you can see the values of the main parameters to take into account when consuming a box cereal type food (candied flakes), since they help maintain a better quality and healthy lifestyle. Therefore, there are great differences between the two products: in terms of protein content, T2 contains a higher percentage (32.0%) compared to the traditional product (2.0%); However, proteins are important for the proper functioning of the body, strengthening muscles, acting on the immune system and as an energy source. In reference to the percentage of fiber, T2 (3.5%) exceeds the traditional product (0.5%), this may be due to the fact that in the elaboration of the flour it was made with all its shell, that is, a whole wheat flour was obtained, this parameter (fiber) reduces the risk of suffering from diseases of the digestive system, diabetes, heart disease or suffering from some type of cancer, with which its consumption is highly recommended. However, in terms of fat content, the standard product contains less (0.5%) than T2 (1.99%), also the processed product, T2, contains a higher percentage of carbohydrates (61.6%) than Chocopic (25.0%), this may be due to the ingredients added in the preparation of the flakes in a significant proportion, such as sugar and cocoa powder, As is known, fat and carbohydrates are not always good to be consumed abundantly, since they take longer to decompose within the human body, producing certain diseases in the medium and long term. Despite this, the processed product, T2, complies with all the requirements established in the NTE INEN 2561: 2010 Standard, referring to snacks of vegetable products, concluding that, if it is a product suitable for consumption, since it contains the necessary nutrients to have a good diet, produced with flours of low amounts of gluten (<1), Free of artificial additives and contaminants that harm the health of the consuming public.

## 5. Conclusions

- At the laboratory level, candied flakes were made from barley and chocolate flavored pork. Therefore, through experimentation, the variables of the process were identified: temperature and time, important parameters that allowed to obtain a product of good taste, crunchy and pleasant aroma, characteristic of box cereals. Likewise, for this process, different unit operations were used formed for the 3 stages, in the first stage: dehydration in the and roasting in the barley; In the second stage: grinding and sifting in obtaining flour and barley and finally, in the third stage for the production of candied flakes, mixing, rolling, cutting and drying was applied.

- The quality of the candied flakes of treatment 2 was evaluated, being the formulation most accepted by the direct judges (administrative staff, teachers and students of the ESPOCH) based on the tasting survey carried out. Therefore, this quality was based on the NTE INEN 2561:2010 Standard, in which, through physicochemical analysis, a humidity of 0.75% and ash of 1.96% was obtained; In the bromatological analysis, a protein content of 32.0% was determined; 3.5% fiber; 1.99% fat and 61.6% carbohydrates. Finally, a microbiological analysis was performed to establish the amount of molds and yeasts of 0% (absence) and *Escherichia Coli* of 0% (absence). In this way, it was possible to verify that the product produced was of good quality, since it complied with the requirements established in the regulations, being the most suitable for consumption by the general public.

- The technical and economic feasibility of the production of candied flakes in Ecuador was determined. In this way, it was possible to calculate the cost of production of \$ 1.00 per unit of processed product and the retail price will be \$ 2.00, with a 50% profit. On the other hand, the annual production cost of \$ 15714.56 was also established, producing 150 units of 350g per month, with which the annual income would be \$ 21209.80. In addition, the calculation of the Net Present Value (NPV) of \$20831.28 was estimated, reaching an Internal Rate of Return (IRR) of 27% and a Recovery Period (PDR) of 2 years and 4 days, concluding that this project is feasible for its execution, since it has the estimated time for obtaining benefits (profits) in it.

## 6. Recommendations

- To obtain flour, it is important to use unbittered grains, since these were previously processed with water and heat to reduce the content of alkaloids, substances that give them a bitter taste, making them unfit for human consumption.

- It is essential to control the variables of time and temperature in the processes of roasting barley grains and drying of pork grains and candied flakes, since, if the limit established for each process is exceeded, products of bad taste and smell would be obtained, thus losing their ideal characteristics.

- It is recommended to carry out the molding process in a dough laminator to obtain very thin sheets that will help reduce the drying time of candied flakes.
- For the process of dehydration of corn grains, it is recommended to do it using a dryer with recirculation, since the time to eliminate the largest amount of water contained is less than when doing it in a normal dryer or in the fluidized bed, also more amount of dry product is obtained without so many losses during the process.
- It is necessary to carry out an adequate and periodic cleaning of all equipment and materials, before and after being used, also, the personnel must use all the protective equipment (mask, gloves and cap) to carry out a handling of food in a hygienic and contamination-free manner.

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