



Extraction of feijoa (*Acca Sellowiana Berg*) fiber and its application in thick sausage meat products

Extracción de fibra de feijoa (Acca Sellowiana Berg) y su aplicación en embutido de pasta gruesa

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Abstract

This project aims to develop a thick pasta sausage with the addition of feijoa food fiber, for this you must know the properties of it. An experimental methodology is applied where several formulations and sensory analysis are performed, through which the degree of acceptance of the sausage is determined, thus defining the final formulation. The standard recipe with its respective process is also established, in addition a bromatological and microbiological examination is performed, to guarantee the safety of the product. This research shows that feijoa fiber is a variable product, because it integrates perfectly with meat products, in the process of making sausages, providing them with nutritional properties, highlighting their aroma, flavor and texture.

key words

addition - elaboration - sausage - feijoa - fiber.

Resumen

El presente proyecto tiene como objetivo elaborar un embutido de pasta gruesa con adición de fibra alimentaria de feijoa, para esto se debe conocer las propiedades de la misma. Se aplica una metodología experimental donde se realizan varias formulaciones y análisis sensorial, mediante los cuales se determina el grado de aceptación del embutido, definiendo así la formulación final. También se establece la receta estándar con su respectivo proceso, además se realiza un examen bromatológico y microbiológico, para garantizar la inocuidad del producto. Este trabajo demuestra que la fibra de feijoa es un producto variable, debido a que se integra perfectamente con los productos cárnicos, en el proceso de elaboración de embutidos, aportándoles propiedades nutricionales, destacando su aroma, sabor y textura.

Palabras clave

adición; elaboración; embutido; feijoa; fibra.

1. Introduction

The main objective of this project is the development of a coarse-grained sausage with the addition of feijoa fiber.

The NTE INEN 1217 standard mentions in section 2.26 that raw meat products are those made from meat (2.2) with the addition of permitted spices and food additives, stuffed in natural or artificial casings, which have not undergone cooking, aeration, curing, drying, and/or smoking processes, and whose shelf life is between 1 to 6 days under refrigeration conditions [1].

Feijoa is a little-known fruit currently cultivated in Ecuador, with the only canton dedicated to its planting and harvesting being Patate, located in the Tungurahua province. Thanks to the climate in this part of the country, it contributes to and favors the fruits grown in the canton. Feijoa can be found year-round, but its price is slightly higher when it is not in harvest season, while the months of February and March, when production is highest, offer the best prices.

Fiber promotes beneficial physiological effects. It consists of plant-based substances, which are usually very complex molecules, mostly carbohydrates. There are two types of fiber, soluble and insoluble: soluble fiber is very useful for preventing obesity, diabetes, or cardiovascular diseases, while insoluble fiber controls digestive tract diseases. Therefore, it is recommended that a person should consume at least 25 to 30 grams of fiber daily [2].

1.1 Origin of Feijoa

Feijoa is a fruit that belongs to the family of myrtle plants and originates from South America, specifically from areas shared by Brazil, Uruguay, western Paraguay, and Argentina. According to Cacioppo (1988), this plant was first observed by botanist Otto Berg, who was assisted by samples collected by Friedrich Sellow in Brazil, hence the species name "sellowiana" of this fruit [3].

This fruit has been used since pre-Hispanic times and was introduced to Europe via the French coast by the School of Horticulture in Versailles in the form of seeds, which were brought from Argentina in 1890. It was

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introduced to Spain at the beginning of the 20th century, and by 1990 there were already plantations in California. It later began being cultivated as a fruit in New Zealand [4].



Figure 1 Feijoa Plant and Fruit

1.2 Feijoa Worldwide

Uruguay stands out as one of the countries with 11 cultivars of feijoa, due to its flavor and maturation, known as "Botali." Meanwhile, Brazil has cultivars named Santa Eliza and Campineira, France has "La André" and "Besson," and California has the cultivars Apollo, Choiceana, Coolidge, and Edenvale. Currently, global feijoa production is centered in countries such as Azerbaijan, California, Colombia, Georgia, and New Zealand. This production does not take place year-round; the fruit is available only in October and November [5].

1.3 Feijoa in Ecuador

As mentioned by [6], feijoa is produced annually in Patate canton, with an average of 15 to 25 crates per week, which are exported nationally, primarily to the city of Ambato. A significant portion of the production remains in the area, as it is used to make the famous feijoa wine, utilizing the entire fruit. The remaining fruit is sold in the local market. The highest production season is in February. No chemicals are used for cultivating this fruit, ensuring it is entirely organic. Its growth and harvest take a year and a half, favored by the canton's climate. The varieties of feijoa can be distinguished more by the shape of the fruit than by its flavor..

1.4 Feijoa Varieties

Table 1.
Feijoa varieties

Feijoa Varieties		Fijoa Varieties
Triumph	Needs another variety for pollination	
Mammoth	Produces large fruits	
Gemini		
Apollo		

Source [7]



Figure 2 Feijoa Varieties in Ecuador

1.5 Characteristics

Feijoa is considered a subtropical fruit and a relatively undemanding species. The plant tolerates low temperatures and adapts well to warm climates, enduring temperatures as low as -10°C. Research indicates that the plant can withstand extreme conditions up to -15°C, showing resistance to drought. However, irrigation is necessary to obtain abundant yields and good quality fruit [3].

The harvest takes place in October and November, although this may vary depending on the planting area. The feijoa plant can grow to heights of 3 to 5 meters, with evergreen leaves that are dark green in color. The flowers can be small or large, depending on the size of the plant. The fruit varies in shape and size depending on the variety, and can have anything from a firm to a soft skin. Factors that influence its development include altitude, climate conditions, genotype, and nutrition [8].

1.6 Nutritional Value

Nutritionally, feijoa contains 85% water, 0.82% protein, 14% carbohydrates, 3.5% fiber, 13% citric and malic acids, and sucrose. It also contains 4.1% glucose and 4.6% fructose. This fruit is rich in vitamins A, E, and C, especially in its skin, which also contains high levels of



iodine and other compounds like potassium, calcium, sodium, magnesium, phosphorus, and iron.

The aromatic characteristics of feijoa are mainly attributed to ethyl and methyl benzoates, which enhance the fruit's resilience. Additionally, feijoa aids in cell regeneration, delays cellular aging, and improves digestion [9].

Table 2.
Feijoa chemical composition

Component	Amount
Water	85.00%
Protein	0.82%
Carbohydrates	14.00%
Fat	0.24%
Fiber	3.55%
Ash	0.52%
Total Acidity	1.80%
Sucrose	13.10%
Glucose	4.10%
Fructose	4.59%
Dry Matter	10.00%
Energy	45.00 cal
Potassium	5.00 mg
Calcium	6.00 mg

Source: [10]

1.7 Fiber

Bultó and Maestre (2016) affirm that fiber is a plant-based substance, and therefore no fiber can be of animal origin. It cannot be digested by the body, as it serves a specific function in promoting the proper functioning of the intestinal tract, helping certain substances to be digested, thus improving the digestive process. It is important to know fiber-rich foods and consume them at the appropriate times [11].

Since fiber is the part of food that cannot be digested, it contains no calories. For this reason, fiber was once considered a type of laxative, as it aids in the digestive process. However, this is a misconception, as fiber can be considered a carbohydrate that performs a specific function in the human body, without being digested. It is found in the walls of vegetables, fruits, cereals, etc. [12].

Juan Del Arco (2016) stated in his studies that the appropriate daily fiber intake should be 25 to 30 grams, which helps to stimulate bowel movements, increasing

their size and making them softer and easier to expel. He also mentions that a fiber-rich diet could reduce the risk of cardiovascular disease. However, excessive fiber consumption may cause discomfort, such as flatulence and abdominal pain, as insufficient fluid intake could lead to intestinal obstruction [13].

Previous studies consider fiber a fundamental part of a healthy diet, due to the fermentation of colonic bacteria that directly and indirectly benefit health. Although the exact recommended intake of dietary fiber has not been established, it is suggested to consume 20 to 35 grams daily, or 10 to 14 grams of fiber per 1000 kcal. Fiber can also be consumed by children, but only those over the age of two, with the recommended daily intake being 5 grams plus their age in years [14].

1.8 Properties of Fiber

The intake of dietary fiber provides multiple benefits, including the prevention of constipation and colon cancer. However, studies have not proven that fiber itself prevents this disease, but rather a balanced diet that includes the necessary amount of fiber does. Another property of fiber is that a high intake helps reduce obesity, and it can even be avoided. Depending on the type of fiber consumed, insoluble fiber is not absorbed, thus contributing fewer calories to the body [15].

1.8.1 Foods containing fiber

Fiber is naturally found in plant-based foods, especially in their edible parts and coverings, which have not been processed, such as peels and seeds. There are different types of fiber, each helping the body in different ways. [16]. Foods rich in fiber are high in phytonutrients, minerals, and vitamins, and these foods usually come from small but nutrient-dense plants. Below is a list of commonly consumed foods that contain fiber..

Table 3.
Alimentos de consumo habitual de contiene fibra

Food	Soluble Dietary Fiber (g/100g)		
	Soluble Dietary Fiber (g/100g)	Insoluble Dietary Fiber (g/100g)	Total Dietary Fiber (g/100g)
Regular bread	2,4	1,3	3,7
Special bread	2,2	1,6	3,8
Whole grain bread	5,3	1,6	6,9
Quaker oats	5,3	2,2	7,5
Oat bran	8,5	5,0	13,5
Wheat bran	42,2	2,3	44,5

Beans	11,2	4,2	15,2
Chickpeas	12,0	1,8	13,7
Lentils	13,9	1,6	15,5
Vegetables	1,9	0,9	2,8
Fruits	1,6	0,7	2,4
Seaweed	4,0	3,1	7,1

Source: [17]

1.9 Fiber extraction

According to NOM 2005 (Mexican Official Standard), foods with a high fiber content, from which fiber can be extracted, include cereals, fruits, vegetables, and legumes that should be raw and with their skins on. Dried fruits are another source with a high fiber content. For this reason, the aforementioned foods should be consumed raw and preferably as whole grains [18].

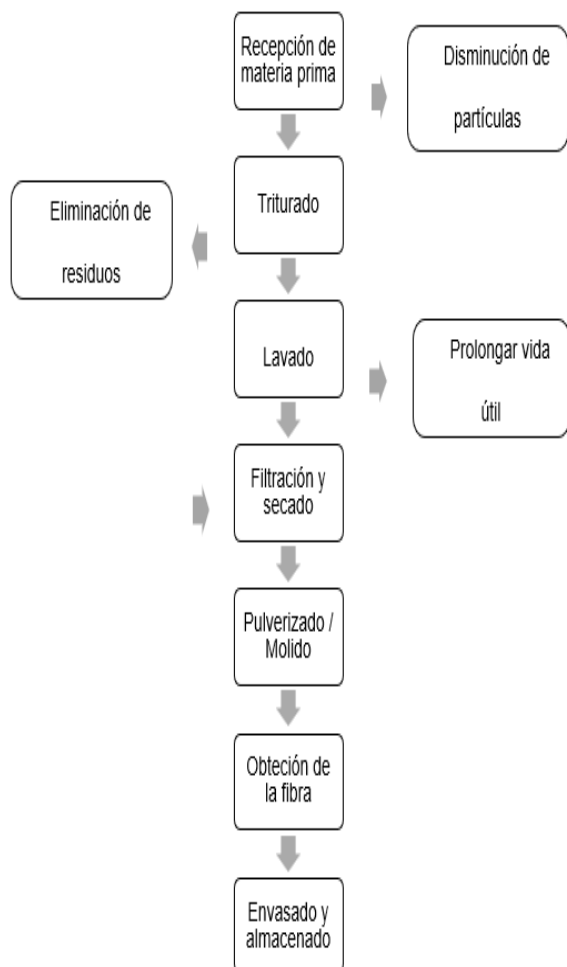


Figure 3 Process diagram for fiber extraction
Source: [18]

1.10 Processed meats

Processed meats refer to meat products or derivatives made from a mixture of ground meat, fat, salt, seasonings, spices, and other additives, packed into natural or artificial casings. Processed meats, with an ancient origin, emerged as a result of the need to preserve food. Their evolution has led to a wide variety of products with distinct characteristics due to different production processes determined by available raw materials and climate conditions. [19]. According to the Spanish Food Code, processed meats can be defined as meat derivatives made from high-quality meats, which can be minced or not, and subjected to a curing process with or without edible additives, fats, plant-based products, seasonings, or spices. The mixture is then packed into natural or artificial casings.

1.11 Types of meat products

According to NTE INEN 774: 2006, meat products are classified based on two criteria:

Table 4.

Types of meat products, by presentation

a.- According to its presentation	
Processed	Sausages, mortadella, chorizo, pâté, salami, and others
Unprocessed	Bacon, ham, chop, and others
Packaged	Hermetically sealed products

Table 5

Types of meat products, by cooking process

b.- Cooking Process
Raw
Cooked
Aged
Cured
Smoked
In hermetically sealed containers

Source: [20]

2 Materials and Methods

2.1 Fiber extraction from feijoa

Table 6.

Materials and ingredients for fiber extraction

Materials	Ingredients
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• Bowls	• 96% Alcohol
• Knife	• Feijoa peel and pulp
• Glass containers	
• Scale	
• Cloth	
• Sieve	
• Thermometer	

2.2 Ingredients for Cuenca-style chorizo

Beef and pork: These are the main proteins used in the production of sausages and must be kept in the cold chain to ensure their preservation. They should have a pH of 5.4-5.8 to prevent bacterial growth.

Pork fat: Pork lard, a hard fat that adds good flavor and serves as a binder for the other ingredients.

Natural casing: Natural casings are used and are preserved in brine to extend their shelf life and prevent bacterial growth. Before use, they must be thoroughly washed.

Feijoa fiber: This is obtained from the feijoa peels and pulp, which are turned into powder.

2.2.1 Materials and equipment

Sausage stuffer:

A piece of equipment used in charcuterie, with the main function of stuffing ground meat into natural (beef or pork) or artificial (synthetic, cellulose, or collagen) casings.

Mixer:

A commonly used kitchen appliance that mixes or kneads ingredients to obtain a homogeneous or compact dough.

Refrigerator:

An essential piece of modern kitchen equipment, it helps control the temperature of vegetables, fruits, and meats to prevent spoilage or temperature loss.

Knife:

A tool used for cutting or peeling fruits, vegetables, and meats.

Cutting board:

A kitchen tool commonly used for chopping or slicing vegetables, fruits, meats, fish, and seafood.

Bowl:

A container used to hold ingredients that have been cut and weighed.

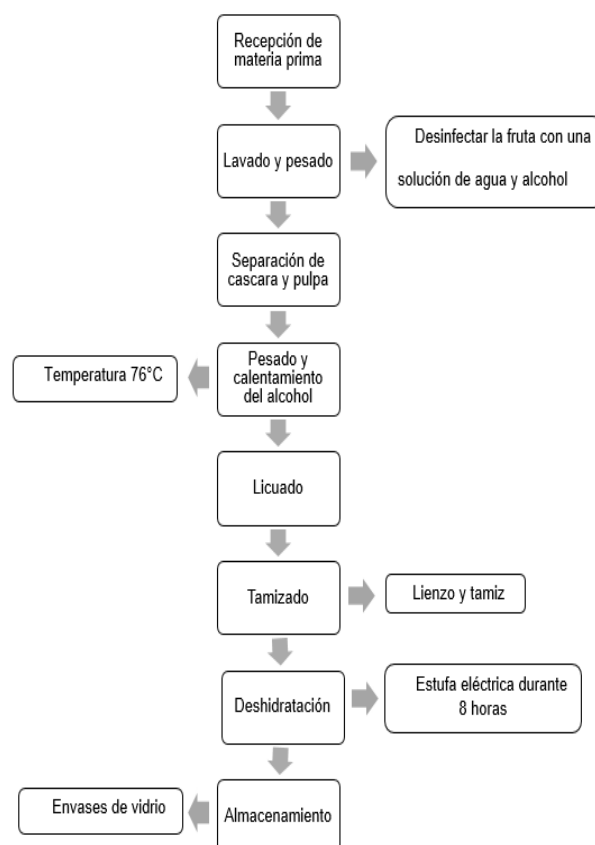


Diagram of the Feijoa Fiber Extraction Process

3. Results

3.1 Feijoa Fiber Extraction Process

1. The amount of feijoa to be processed was weighed, and it was kept frozen until the day of the fiber extraction process. The total weight of the fruit was 4000 grams.
2. The peel was then separated from the pulp, with the peel weighing a total of 453 grams. The peel was then cut into small pieces.
3. The alcohol used was 96%. Approximately 953 ml was weighed and heated on the stove until it reached the appropriate temperature (75°C).
4. The peel was placed in a blender along with the alcohol, and it was blended on low speed (1) for five minutes.
5. After the first blending, the mixture was strained using a cloth to separate the alcohol from the peel. The peel was then returned to the blender with 953

- ml of preheated alcohol and blended again at speed 1 for another five minutes.
- After five minutes of blending, the alcohol was separated from the peel again. The peel was then placed back in the blender with the alcohol used in the first step, which had been reheated, and blended at speed 1 for 10 minutes.
 - After 10 minutes of blending, the peel was separated from the alcohol using the cloth. The remaining peel, at the end of the entire process, weighed 88 grams. It was stored in glass containers until it was dehydrated.
 - Finally, the dehydration process was carried out in an electric oven at the Institute of Technological Research of the University of Guayaquil, at an internal temperature of 45°C and an external temperature of 30°C for 8 hours. After dehydration, the peel was removed from the oven, ground, and stored in glass containers.

3.2 Sausage Production Process

Receiving Raw Materials: Upon receiving the raw materials, it is important to verify that they are in good condition and at the appropriate temperature for use. If not, they should be discarded.

Refrigeration: After receiving the materials, the meat should be refrigerated at a temperature between 1°C and 4°C to preserve it until use.

Cutting and Weighing: For this process, the meat should be semi-frozen to allow better handling and avoid the presence of microorganisms. The ingredients are weighed to ensure the correct quantities.

Grinding: The meat should be ground in a grinder or cutter, using a 2 ml disc. First, all the meats are ground, followed by the fat.

Mixing: This step is carried out in an industrial mixer, where the meat is added first, followed by the fat, ice, chemicals, and seasonings, until a homogeneous mixture is obtained. The mixing process lasts for 5 minutes at a temperature of 10°C.

Stuffing: Once the mixture is ready, it is stuffed into a natural casing that has been pre-soaked in cold water. A manual stuffer is used for this process, which maintains the temperature of the mixture and prevents it from overheating.

Tying: After stuffing, the ends of the sausage are tied, and each portion is sectioned into lengths of 10 cm.

Vacuum Packing: This process is used to remove the air from the packaging in which the sausage is placed, which helps prolong its shelf life.

Storage: The sausages should be stored in refrigeration at a temperature between 1°C and 4°C to ensure their quality until consumption.

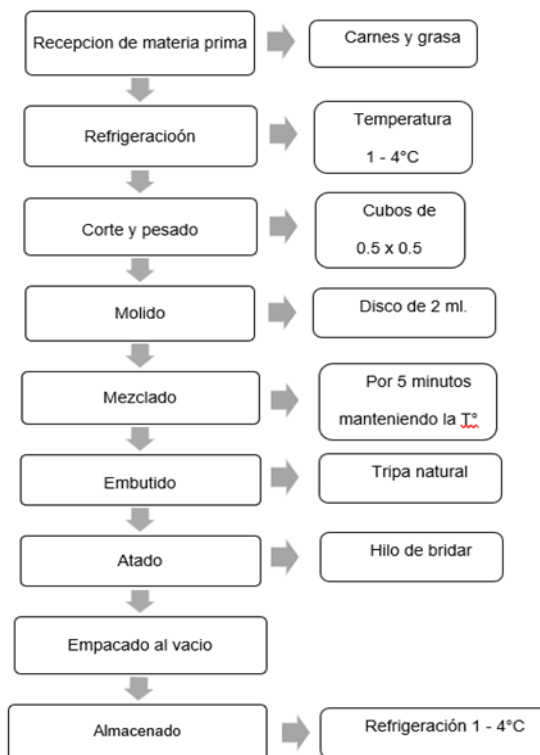


Diagram of Sausage Production

3.3 Initial Formula

The initial formula was developed in conjunction with our tutor, based on the charcuterie course. Thus, the experimentation began with the knowledge acquired throughout the degree program.

Experimentation #1

Table 7

Formulation #1 for Sausage Production

Ingredients	Grams	Percentage
Beef (lean cut)	0.250	25%
Pork	0.450	45%
Pork fat (pork loin)	0.250	25%
Ice	0.50	5%
Fiber	0.050	5%
Salt	0.016	1.6%
Nitrite	0.0001	0.0125%
Ascorbic acid	0.001	0.05%
Tripolyphosphate	0.005	0.5%
Cumin	0.004	0.4%
Black pepper	0.002	0.2%



Powdered oregano	0.003	0.3%
Monosodium glutamate	0.003	0.3%
TOTAL MASS	1.034	103.4%

Experimentation #2

Table 8

Formulation #2

Ingredients	Grams	Percentage
Beef (lean cut)	0.250	25%
Pork	0.450	45%
Pork fat (pork loin)	0.250	25%
Ice	0.50	5%
Fiber	0.100	10%
Salt	0.016	1.6%
Nitrite	0.0001	0.0125%
Ascorbic acid	0.001	0.05%
Triphosphate	0.005	0.5%
Cumin	0.004	0.4%
Black pepper	0.002	0.2%
Powdered oregano	0.003	0.3%
Monosodium glutamate	0.003	0.3%
TOTAL MASS	1.034	103.4%

Experimentation #3

Table 9

Formulation #3

Ingredients	Grams	Percentage
Beef (lean cut)	0.250	25%
Pork	0.450	45%
Pork fat (pork loin)	0.250	25%
Ice	0.50	5%
Fiber	0.150	15%
Salt	0.016	1.6%
Nitrite	0.0001	0.0125%
Ascorbic acid	0.001	0.05%
Triphosphate	0.005	0.5%
Cumin	0.004	0.4%
Black pepper	0.002	0.2%
Powdered oregano	0.003	0.3%
Monosodium glutamate	0.003	0.3%
TOTAL MASS	1.034	103.4%

4. Conclusions

- In the extraction of feijoa fiber through the alcoholic solution process, it was determined that from 500 grams of fruit peel or pulp, after being dehydrated in

an oven, the final extraction process yielded 6% of the initial amount, or 86 grams. This demonstrates the result the fruit must undergo to finally obtain the fiber.

- It was possible to produce a sausage, applying Good Manufacturing Practices (GMP) and preservation techniques such as cold chain management, ensuring a high-quality product. However, upon applying fiber to the sausage, it was discovered that the more fiber added to a meat product (depending on the type of fiber), the sandier the texture becomes. Therefore, the appropriate amount to achieve a quality product with adequate consistency is between 10% and 15% fiber.
- Based on sensory analysis, it was established that, out of the last three experiments, the eighth sample, in which 10% fiber was used, achieved the highest acceptance percentage in each product characteristic, as shown by the ANOVA variance analyses. The average of all characteristics was as follows: color (4.06), aroma (3.93), flavor (4.13), texture (3.50), and overall acceptability (3.94). In comparison, the seventh sample results were: color (3.91), aroma (4.06), flavor (3.84), texture (3.53), and overall acceptability (3.80), highlighting the eighth sample's superior color, flavor, and overall acceptability.
- The final product, which received the highest acceptance based on sensory analysis, underwent microbiological and bromatological tests to verify its safety and protein content, as required by the standard (INEN 1338, 2012), which specifies that it should not exceed 14 grams. The expected results were achieved, making the product safe for human consumption.

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Annex 1. Portioning of the peel



Annex 2. Mixing

6. Annexes



Annex 3. Grinding process



Annex 4. Pork product.