Evaluation of a vegetable meat made with Pigeon Pea (*Cajanus cajan* (L.) Huth), Lentils (*Lens culinaris* Medik) and Chia (*Salvia hispanica* L.)

Evaluación de una carne vegetal elaborada con Gandul (*Cajanus cajan* (L.) Huth), Lenteja (*Lens culinaris Medik*) y Chía (*Salvia hispanica* L.)

Avaliação de uma carne vegetal elaborada com feijão bóer (*Cajanus cajan* (L.) Huth), lentilha (*Lens culinaris* Medik) e Chia (*Salvia hispanica* L.)

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Abstract

The nutritional values of pigeon pea, lentils and chia are factors to consider promoting nutrition and providing healthy alternatives, seeking to improve people's quality of life. The objective of this research was to evaluate the nutritional contribution, physicochemical, sensory and microbiological parameters of a vegetable meat made from pigeon pea and lentils, fortified with chia and vacuum-packed. Quantitative variables (pH, humidity, proteins, carbohydrates, fats, ashes and fiber), qualitative (color, smell, taste and texture) and microbiologicals (total coliforms, molds and yeasts) were evaluated. The treatments were T1 (55 % lentil, 40 % pigeon pea and 5 % chia), T2 (50 % lentil, 45 % pigeon pea and 5 % chia) T3 (40 % lentil, 55 % pigeon pea and 5 % chia) and T4 (control, 50 % lentil and 50 % pigeon pea). 30 experts were considered for sensory acceptance in terms of color, smell, taste and texture. The vegetable meat from pigeon pea, lentil and chia vacuum-packed, had a great nutritional contribution. T3 had the best values of proteins, carbohydrates, fats, ashes, fiber and acceptable values of pH and humidity, being the best treatment. The lentil used in the highest percentage (T3), obtained greater sensory acceptance, presenting better characteristics in terms of color, smell, flavor and texture, demonstrating positive organoleptic properties in the final product. The microbiological analysis performed showed values that are within the provisions of the respective standard.

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Resumen

Los valores nutricionales de gandul, lenteja y chía son factores a considerar para promover la nutrición y brindar alternativas saludables, buscando mejorar la calidad de vida de las personas. El objetivo de esta investigación fue evaluar el aporte nutricional, parámetros fisicoquímicos, sensoriales y microbiológicos de una carne vegetal elaborada a partir de gandul y lenteja, fortificada con chía y empacada al vacío. Se evaluaron variables cuantitativas (pH, humedad, proteínas, carbohidratos, grasas, cenizas y fibra), cualitativas (Color, olor, sabor y textura) y microbiológicas (Coliformes totales, mohos y levaduras). Los tratamientos fueron T1 (55 % lenteja, 40 % gandul y 5 % chía), T2 (50 % lenteja, 45 % gandul y 5 % chía) T3 (40 % lenteja, 55 % gandul y 5 % chía) y T4 (testigo, 50 % lenteja y 50 % gandul). Se consideraron 30 expertos para aceptación sensorial en cuanto a color, olor, sabor y textura. La carne vegetal a partir de gandul, lenteja y chía empacada al vacío, presentó un gran aporte nutricional. El T3 presentó los mejores valores de proteínas, carbohidratos, grasas, cenizas, fibra y valores aceptables de pH y humedad, siendo el mejor tratamiento. La lenteja utilizada en mayor porcentaje (T3), obtuvo mayor aceptación sensorial, presentando mejores características en cuanto a color, olor, sabor y textura, demostrando propiedades organolépticas positivas en el producto final. El análisis microbiológico realizado presentó valores que se encuentran dentro de lo establecido en la respectiva norma.

Palabras clave: Características fisicoquímico y sensoriales, valores nutricionales.

Resumo

Os valores nutricionais do feijão bóer, lentilha e chia são fatores a ter em conta para promover a nutrição e oferecer alternativas saudáveis, procurando melhorar a qualidade de vida das pessoas. O objetivo desta pesquisa foi avaliar a contribuição nutricional, físico-química, sensorial e microbiológica de uma carne vegetal elaborada a partir de guandu e lentilha, fortificada com chia e embalada a vácuo. Foram avaliadas variáveis quantitativas (pH, umidade, proteínas, carboidratos, gorduras, cinzas e fibras), qualitativas (cor, cheiro, sabor e textura) e microbiológicas (coliformes totais, bolores e leveduras). Os tratamentos foram T1 (55 % lentilha, 40 % feijão bóer e 5 % chia), T2 (50 % lentilha, 45 % feijão bóer e 5 % chia) T3 (40 % lentilha, 55 % feijão bóer e 5 % chia) e T4 (controle, 50 % lentilha e 50 % feijão bóer). 30 especialistas foram considerados para aceitação sensorial em termos de cor, cheiro, sabor e textura. A carne vegetal de feijão bóer, lentilha e chia embalada a vácuo, apresentou grande aporte nutricional. O T3 apresentou os melhores valores de proteínas, carboidratos, gorduras, cinzas, fibras e valores aceitáveis de pH e umidade, sendo o melhor tratamento. A lentilha utilizada em maior porcentagem (T3), obteve maior aceitação sensorial, apresentando melhores características em termos de cor, cheiro, sabor e textura, demonstrando propriedades organolépticas positivas no produto final. A análise microbiológica realizada apresentou valores que estão dentro do previsto na respectiva norma.

Palavras-chave: Características físico-químicas e sensoriais, valores nutricionais.

Introduction

Studies of Food and Agriculture Organization of the United Nations (FAOSTAT, 2015), affirms that excessive consumption of animal protein produces coronary diseases or cardiovascular disorders, due to high percentage of fat it possesses, which in turn causes health problems in people, recommending a consumption of 25 % animal protein and 75 % vegetable protein in the daily diet. In this sense, the nutritional values of Pigeon Pea (*Cajanus cajan* (L.) Huth), Lentils (*Lens culinaris* Medik) and Chia (*Salvia hispanica* L.) are factors to consider promoting and encourage their consumption, providing healthy alternatives to improve the life quality of the people, taking advantage of the agricultural resources that each country possesses.

The pigeon pea is a high nutritional value legume, it is a source of proteins, starches, fiber, among others, well adapted to meet the demands of consumers concerned about their health, whole seeds can be used, debarked or in flour, also as forage and green manure, its potential is due to the fact that it is an economic crop with a high protein value (Liendo and Silva, 2015). It has a high production of dry matter and establishment, adapting better to the environmental conditions of the tropics (López *et al*., 2018).

The lentil is an herbaceous plant of the Fabaceae family; it is a plant whose grains have a high nutritional value and has the peculiarity of being resistant to drought; it also presents starch, proteins, fats, phosphates and chlorides (Cárdenas *et al*., 2014). In this context, Puebla (2016) states that lentil meat is also indirectly considered vegetable meat and is used as a response to the problems that currently exist with processed foods. Lentil consumption in the daily diet is important because it provides protein, starch, calcium, iron and has eight (8) essential amino acids (Moreira *et al*., 2014).

Chia is an herbaceous plant from the Lamiaceae family. It was used by the Aztecs as food and for medicinal purposes (Ayerza and Coates, 2004). It is one of the richest sources of omega-3 fatty acids, containing 60 % alpha linoleic acid (Omega-3) and 20 % alpha linoleic acid (Omega-6), which corresponds to an ideal ratio of 3:1, respectively; These fatty acids are essential for the functioning of the organism. Additionally, chia is made up of protein, fat, carbohydrates and fiber. It contains minerals such as iron, calcium, magnesium and potassium and has a great antioxidant capacity (Mosquera, 2018).

About sensory characteristics, Tipán and Ushiña (2012) indicated that vegetable meats must have an adequate texture to prevent the product from crumbling easily or causing discomfort when chewing it and another important factor to consider when preparing. vegetable meat is moisture, because it is one of the variables that can affect the organoleptic properties of the final product. Additionally, the authors pointed out that the lack of macronutrients such as proteins in the human body can lead to serious diseases in the organs. On the other hand, Biotrendies (2017) stated that the human body takes longer to eliminate animal meat, so vegetable meat provides better digestion.

An important aspect that must be considered is the storage of the final products. In this regard, Atlas (2019) indicated that the most sought-after characteristic in meat packaging is that they be able to resist moisture and thus ensure the shelf life of the product, they must also be moldable and resistant to breakage.

Due to the nutritional contribution and health benefits provided by pigeon peas, lentils and chia, they are considered as an alternative for the production of vegetable meat, with high quality standards and adequate sensory characteristics that allow consumer acceptance and integration of the product in the daily diet; likewise, due to its content of essential nutrients, they make it an excellent option for vegetarian consumers and for those who have decided to start a healthy life. Therefore, the objective of this research was to evaluate the nutritional contribution (proteins, carbohydrates, fats and fiber), the physicochemical parameters (pH, and humidity), the microbiological quality (total coliforms, molds and yeasts) and sensory (color, odor, flavor and texture) of a vacuum-packed vegetable meat made with pigeon peas and lentils, fortified with chia.

Materials and methods

Description of the study area

The research was carried out at the Facultad de Ciencias Agrarias de Ecuador, located in Milagro, province of Guayas, Ecuador, which is 45 kilometers from Guayaquil and is located at coordinates 2°08´05´´S, 79°35´14´´O, with a predominant altitude of 8 and 15 meters above sea level. The area has an average annual temperature of 25 °C and a rainfall of 1,361 mm per year (Instituto Nacional de Meteorología e Hidrología INAMHI, 2018).

Preparation of vegetable meat

The lentil, pigeon pea and chia samples were obtained from the experimental area of the Facultad de Ciencias Agrarias de Ecuador. The reception of raw material was carried out, verifying that they were in good condition and free of any foreign material. The grains were soaked separately in plastic containers, pigeon peas and lentils (500 g in 1 L of water for 60 min), chia (50 g in 500 mL of water for 15 min), subsequently, the drained in a plastic strainer to remove all the water. Next, water was heated to 100 °C in separate containers and the pigeon peas and lentils were added to cook for 30 minutes.

After the cooking process, each of the products was weighed on an electronic scale (KERN brand, model PCB 350-3, Germany), to establish the percentages to be used in the treatments and subsequently, they were ground in a mill (Nogueira brand, model DPM, Junior, Brazil), to then add the chia; additionally, salt, garlic, onion, pepper and potassium sorbate were added as a preservative; moving in a circular way constantly to give a homogeneous appearance. Then it was placed in a polypropylene bag (15 cm x 25 cm), making sure not to contaminate the product and that no air enters at the time of packaging and sealing, with a slight pressure to remove the air inside. The samples obtained in each of the treatments were kept refrigerated at 4 °C. In Figure 1, the flow diagram of the process of making vegetable meat based on pigeon peas, lentils and chia is presented.

Formulation of vegetable meat

For the formulation of vegetable meat, three concentrations of pigeon peas and lentils were evaluated, in which 5 % chia (thickener) at a constant concentration and a control treatment with 50 % lentils and 50 % pigeon peas were also included (table 1).

Description of the variables to be evaluated in the process of obtaining vegetable meat based on pigeon peas, lentils and chia.

Physico-chemical parameters

Samples were taken from each treatment to evaluate the pH and humidity, after preparing the vegetable meat, taking as reference the NTE INEN 1338-2010 standards (table 2).

The samples were sent to a certified laboratory in which the analyzes of proteins (MMQ-241 method), carbohydrates (MMQ-198 method), fats (MMQ-230 method), ashes (INEN ISO 520:2013 Gravimetry method) and fiber (MMQ-12 NTE INEN 522 MOD method) were performed.

Moisture determination

It was obtained through the measurement of the initial mass and the final mass, in each of the samples, following the formula of Giraldo (1999), for the determination of humidity.

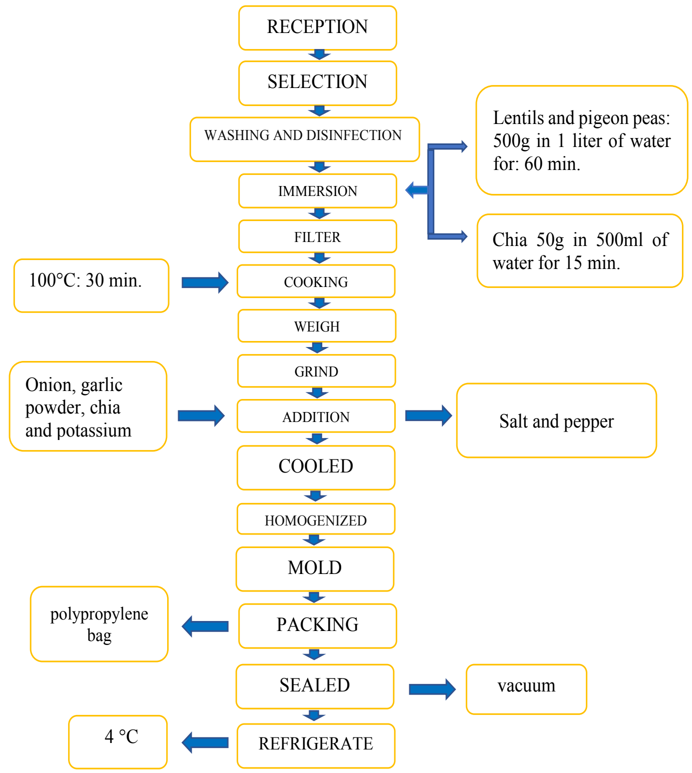

Figure 1. Flow chart for obtaining vegetable meat based on pigeon pea, lentils and chía.

Table 1. Formulation of vegetable meat made with pigeon pea, lentils and chia.

Treatments	Gandul (%)	Lentils (%)	Chía (%)
1	55	40	5
2	50	45	5
3	40	55	5
4	50	50	(Control)

Table 2. Physicochemical and bromatological requirements for meat products.

Requirements	Unit	Min.	Max.	Testing method
Total fat	%	---	---	INEN 778
Protein	%	18	---	INEN 781
Ashes	%	---	6	INEN 786
pH	-	---	6.8	INEN 783
Ascorbic acid	$mg.kg^{-1}$	---	100	INEN 791
Sodium or potassium nitrite	$mg.kg^{-1}$	---	125	INEN 784
Polyphosphates	$mg.kg^{-1}$	---	3000	INEN 782

NTE INEN 1347- 1985-11

pH determination

Ten grams (10 g) of vegetable meat were liquefied with 5 mL of distilled water, then they were placed in a beaker, the pH meter (Brand Metrohm, portable PH meter model 913 pH Meter, Switzerland) was taken to neutral and then the the pH value.

Sensory parameters (smell, taste, color and texture)

They were evaluated using a hedonic criterion, on a scale of six (6) points: 6, I like it very much and 1, I do not like it. For sensory evaluation, a panel of 30 judges was used. The format of the evaluation form used is indicated in table 3. The samples for sensory evaluation were represented by 40 g of vegetable meat from each treatment and the interval time between each evaluation was five (5) minutes.

Table 3. Hedonic scale.

Category	Numerical valuation
I like it a lot	6
Very good	5
Good	4
Regular	3
I like it a little bit	2
Dislike	1

Microbiological analysis (total coliforms, molds and yeasts)

The samples were sent to a certified laboratory to determine the stability of the product at 0, 7 and 15 days, according to the NTE INEN 1338-2012 standard (table 4).

Table 4. Microbiological requirements for meat products.

Requirements	n	c	M	M	Testing method
Aerobic mesophilic (ufc.g^{-1})	5	3	1.0 x 10^5	1.0 x 10^7	NTE INEN 1529-5
Escherichia coli (ufc.g^{-1})	5	2	1.0 x 10^2	1.0 x 10^3	AOAC 991.14
Staphilococus aureus (ufc.g^{-1})	5	2	1.0 x 10^3	1.0 x 10^4	NTE INEN 1529-14
Salmonella (25 g)	5	0	Ausencia	-	NTE INEN 1529-15

NTE INEN 1338:2012 Third review 2012-04, n: number of units in the sample, c: number of defective units, accepted, m: acceptance level y M: rejection level

Experimental design and statistical analysis

The quantitative variables were evaluated considering a completely randomized design with three replicates per treatment that allowed obtaining a total of 12 experimental units.

The sensory analysis was performed under a hedonic criterion, a completely randomized block design was used, in which the blocking source was represented by the sensory panel of 30 judges. The trial consisted of four formulations and 120 experimental units.

The experimental unit was approximately 500 g of vegetable meat for each formulation. An approximate amount of 40 g of each sample was given to the 30 experts who made up the panel; that they analyzed according to the attributes detailed in the sensory analysis form.

The data obtained from the sensory assessment were organized in an Excel spreadsheet of Microsoft Office® 2010 version, for processing and then subjected to analysis of variance to detect significant differences between treatments. Likewise, as a mean comparison test, the Tukey test was used at 5 % probability; the statistical package SAS® (SAS, 2014) was used.

Results and discussion

Humidity and pH

Table 5 shows the results obtained for humidity and pH of the vegetable meats made with the different formulations.

Table 5. Humidity and pH values obtained in vegetable meats made with the different formulations.

Treatment	Humidity (%)	pH
T1	72.00^b	6.78^b
T2	71.05^c	6.74^c
T3	72.01^b	6.70^d
T4	72.57^a	6.85^a
CV (%)	0.30	0.25

The control vegetable meat (T4) had the highest percentage of moisture (72.01 %), while the one made with 55 % pigeon peas and 40 % lentils (T1) and with 40 % pigeon peas and 55 % lentils (T3) showed similarity in the humidity results. On the other hand, the lowest humidity values (71.05 %) were obtained for T2 (50 % pigeon peas and 45 % lentils). These results coincided with those published by Haro (2015), in his work on the elaboration of a vegetable meat of lentil with wheat gluten, seasonings and natural preservatives, in which it indicates that the optimal humidity for the conservation of vegetable meat is in a range of 70-75 %. On the other hand, the humidity values obtained are in accordance with the NTE INEN 2728 standard (maximum 75 % humidity).

Regarding pH, T4 had the highest value with 6.85, followed by T1 and T2 with 6.78 and 6.74, respectively, while T3 had the lowest pH value with 6.70. The pH values in vegetable-type meat made from pigeon peas, lentils and chia were in accordance with the NTE INEN 1347-1985-11 standard, which indicates a maximum pH value of 6.8 (table 5).

Bromatological analysis

The results obtained in the bromatological analysis of the vegetable meats made with the different formulations are presented in table 6.

Table 6. Bromatological analysis of vegetable meats made with the different formulations.

Parameters	Method	T1	T2	T3	T4
Carbohydrates (g.100g^{-1})	MMQ-198	12.35	12.2	18.71	-
Ashes (g.100g^{-1})	INEN ISO520:2013 (Gravimetry)	1.07	1.07	1.53	1.06
Fiber (g.100g^{-1})	INEN 522 MOD	6.66	6.98	9.90	6.52
Fat (g.100g^{-1})	MMQ-230	0.68	0.70	0.78	-
Protein (g.100g^{-1})	MMQ-241	6.10	6.12	6.92	6.10

All the values obtained in the bromatological analysis of the meat samples were within the NTE INEN 1338: 2012 standard. Based on 100 g of final product, T3 had values of 1.53 g 100 g^{-1} of ashes; 9.9 g.100 g^{-1} fiber; 0.78 g.100 g^{-1} of fat; 18.71 g.100 g^{-1}

of carbohydrates and 6.92 g.100 g^{-1} of protein. The results coincided with those reported by Cruz and Jaguaco (2016), who assessed the nutritional content of the best sensory formulation of a vegetable meat based on amaranth and lentil, concluding that vegetable meat formulations can be established from other Andean grains and the same or better nutritional value will be obtained than traditional soy meat.

Sensory evaluation

The means of the variables color, smell, flavor and texture are detailed in table 7, specified according to the Tukey comparison test ($p<0.05$). Acceptance levels in terms of color were between 3.00 and 5.80 within the hedonic scale, resulting in T3 with the highest acceptance mean. T1 was the least accepted. For the odor attribute, T3 had the mean of greater sensory acceptance (5.00), while T1, T2 and T4 showed similar values, because in its formulation the most attenuating odor was that of pigeon pea, which was presented in greater percentage in those treatments.

For the flavor attribute, T3 also had the highest average with 5.40, presenting a higher percentage of lentils, which helped improve the organoleptic characteristics. T1, T2 and T4 had similar effects between them. Regarding texture, in the same way T3 had the highest mean with 6.00; T1, T2 and T4 had equal effects between them (table 7).

Table 7. Sensory analysis of vegetable meats made with the different formulations.

Treatments	Color	Smell	Taste	Texture
T1	3.00[c]	3.40[b]	3.60[b]	4.20[b]
T2	4.20[b]	3.40[b]	3.40[b]	4.00[b]
T3	5.80[a]	5.00[a]	5.40[a]	6.00[a]
T4	3.00[c]	3.60[b]	3.40[b]	4.00[b]
CV (%)	19.81	19.65	22.15	19.66

[a, b, c]Different letters indicate significant differences ($p<0.05$).

According to the above, T3 (40 % pigeon peas and 55 % lentils) was the best evaluated meat by the sensory panel, in terms of its sensory attributes color, smell, flavor and texture. Similar results were reported by Haro (2015), indicating that the incorporation of lentils as a base in vegetable meat positively influences the sensory characteristics of the final product.

On the other hand, Montesdeoca *et al*. (2020) carried out a sensory analysis of a vegetable meat to which three (3) types of potato starches were added, indicating that vegetable meats are well accepted in the market, with a good score by tasters in terms of color, smell, taste and texture. Regarding the nutritional aspect, Rojas *et al*. (2017) pointed out the advantages of vegetable meats and the contribution of protein, omega 3 fatty acids, iron, zinc, iodine, vitamin D, vitamin B12 that can generate benefits for the health of people. Likewise, Vera *et al*. (2017) indicated that the elaboration of vegetable meat is a nutritional option to reduce the collateral effects of animal meat, being more accessible due to its extensive production system, presenting a great nutritional contribution to complement the nutritional needs in more unprotected populations and in segments with less purchasing power.

Microbiological analysis

According to the microbiological results observed in table 8, there is a growth of yeasts and total coliforms after seven (7) days.

Table 8. Results Microbiological analysis of vegetable meats.

Parameter	Units	0 days	7 days	15 days
Yeasts and molds	up.g^{-1}	< 10	3.4×10^3	1.2×10^3
Total coliforms	ufc.g^{-1}	< 10	2.1×10^6	8.3×10^3

In the case of molds and yeasts, they are maintained for up to 15 days, unlike total coliforms, where a decrease is observed after 15 days; these factors mean that the longer the meat is exposed to cold, the microbiological load decreases. It is worth mentioning that the microbiological count is within the parameters established by the NTE INEN 1346:2015 standard (1.0×10^4) molds and yeasts and (1.0×10^3) total coliforms. Sorbate (used as a preservative) did not influence the results obtained in this work. In this sense, Vera *et al*. (2017) stated in their research that vegetable meats can last up to 30 days using chemical preservatives.

The microbiological analysis of molds, yeasts and total coliforms carried out on the final product showed microbial growth at 15 days, however, its values remain within the permitted range as indicated by the respective standard for vegetable meats, therefore, the final product it is of quality and suitable for human consumption.

Conclusions

Vacuum-packed vegetable meat made with pigeon peas, lentils and chia, had a great nutritional contribution, being an alternative in the diet of people. The meat with 40 % pigeon peas and 55 % lentils, had the best values of protein, carbohydrates, fats, ashes and fiber and acceptable values of pH and humidity, being the best treatment.

The meat in which the lentil was used in the highest percentage (T3), obtained better sensory acceptance and had better characteristics in terms of color, smell, flavor and texture, showing positive organoleptic properties in the final product. Chia did not negatively influence meat texture. The microbiological analysis of total coliforms, molds and yeasts performed on the final product, had values that are within the provisions of the respective standard.

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