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Analysis Of The Nutritional Contribution Of *Arachis pintoi* (Forage Peanuts) Under The Conditions Of The Ecuadorian Amazon

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ABSTRACT
In the Ecuadorian Amazon, the production of efficient pastures for feeding animals of zootechnical interest is affected by different factors such as: soil pH, high saturation of metals such as iron (Fe) and aluminium (Al) and low nutritional levels of the earth's layer. Due to the edaphoclimatic characteristics of the region, high rainfall causes soil acidity which blocks the correct absorption of nutrients; therefore, pastures cannot meet their nutritional needs for their development, directly affecting animal production. The objective of this study was to analyse the nutritional contribution of *Arachis pintoi* (forage peanut) in a challenging environment due to the edaphoclimatic conditions of the Amazon. The research was based on the review of related scientific literature such as: Publications, including articles, academic books and theses, to understand how these conditions affect the subsistence of pastures in the region. The importance of the association of grasses with legumes, such as forage peanut, to improve the diet of animals of zootechnical interest and ensure adequate nutritional intake is highlighted. Previous studies have shown that the inclusion of *Arachis pintoi*, in animal feed, it can result in greater weight gain, as observed in research with Pekin ducks. In addition, the need to consider the climate and soils where forage peanuts are grown to optimize their production is mentioned. Forage peanuts emerge as a promising alternative to improve livestock productivity in the Ecuadorian Amazon, offering nutritional benefits and contributing to the sustainability of the region.

Keywords: Forage peanuts, nutritional contribution, Ecuadorian Amazon, weight gain.

Introduction

The production of different forage resources, according to González (2020), indicates that, according to studies carried out in Mexico and Latin America, it has not been possible to incur cutting- edge technology in the productive sector, which is why they allude that there is a lot of work to be done to obtain positive results in the production of any forage species.

According to Aquino Gómez (2022), the forage peanut *Arachis pintoi.* Its production began between the Amazon and La Plata Rivers, where Gerardo CP *pintoi* collected the legume in 1954 near the city of Belmonte, Bahia, Brazil, and later distributed it throughout South America. In Ecuador, the Amazon region occupies an area of 116,441 km^2, comprising 2% of the Amazon River basin, which represents 45% of its territory, due to the great variety of biodiversity in fauna and flora, it is reputed to be an ecosystem of great national and global interest (Andrade Yucailla et al., 2022).

In the Ecuadorian Amazon, many varieties of grasses and legumes have been used for the establishment of pastures that over the years have been introduced in the same way but in the different types of ecosystems of the region, denoting a slow decrease in their nutritional value and their performance that do not satisfy the needs of the species of livestock interest that feed on these pastures, due to the edaphoclimatic conditions of the Amazon, thus being legumes an option to improve the quality of the lands destined for animal feed due to their resistance (Benitez Gonzalez, Sanchez, Jumbo, & Chamba Ochoa, 2016).

Climatic conditions play a very important role in this type of crop, considering that, forage peanuts *Arachis pintoi*. It has an optimal adaptation from 0 - 1200 meters above sea level. Regarding the edaphoclimatic demands, this crop has a resistance to droughts, thus producing a high quality of forage with excellent nutritional value and palatable for animals (González Reyes, 2022). Similarly, according to Aquino (2022) indicates that, the use of non- conventional raw materials such as forage peanuts *Arachis pintoi*. Due to its rapid growth, spread and nutritional value, it is an appropriate candidate to be produced in this region.

In the Ecuadorian Amazon, the production of efficient pastures for feeding animals of zootechnical interest is affected by different factors such as: soil pH, high saturation of metals such as iron (Fe) and aluminium (Al) and low nutritional levels of the earth's layer. Due to the edaphoclimatic characteristics of the region, high rainfall causes soil acidity which blocks the correct absorption of nutrients, therefore, pastures cannot meet their nutritional needs for their development, directly affecting animal production, since they will not provide the nutritional requirements to the animals in their diet either (Sarabia Coello & Pilamala Aragón, 2020).

For this reason, the purpose of this work was to review documents, where the general objective is to analyse the nutritional contribution of forage peanuts. *Arachis pintoi* under the conditions of the Ecuadorian Amazon, specifying the nutritional properties and weight gain according to the line and feed.

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Literature Review

This work is focused on analysing how the conditions of the Ecuadorian Amazon influence the nutritional contribution of forage peanuts. *Arachis pintoi*, in relation to the unproductive edaphoclimatic conditions that the region has, due directly to the acidic soils, high rainfall, muddy topsoil and high levels of heavy metals that prevent the subsistence of pastures, having as a conservation measure the association of grasses with legumes to implement in the diet of animals of zootechnical interest and thus provide a diet with good nutritional levels. After having carried out a thorough search for information related to the research topic, some criteria expressed by different authors from various institutions that have carried out studies on the subject in the Ecuadorian Amazon are mentioned below, which are detailed below.

According to what was mentioned by Pauchi Carrillo (2016), the implementation of peanuts forage farmer *Arachis pintoi*, in the Amazon region it is convenient due to its speed of growth, spread and nutritional composition, thus being a good forage option to improve the region's pastures, obtaining sustainable production since it promotes biological diversity, recovers degraded soils and is a source of metabolizable protein for animals that require high nutritional levels.

Soil.

Arachis pintoi, is a legume that can adapt to soils of medium to high fertility, but it can also be established in infertile soils and serves as a vegetal cover contributing to the improvement of soil quality (Gómez Forero, 2015). This forage crop develops adequately in different types of soils such as oxisols, which are very acidic and poor in nutrients, to soils with better fertility. Another type of soil where it develops well is clayey loam with a content of more than 3% organic matter (Andrade Yucailla et al., 2022).

Table 1. Soil types in the Ecuadorian Amazon.

Main types of soils in the Ecuadorian Amazon				
Provinces	**Order**	**Suborder**	**Texture**	**Characteristics**
Sucumbíos	Inceptisol	ANDEPT	Loam	Humid and sub-humidity areas present an acid reaction to be productive and require liming and fertilization.
Orellana	Oxisol	ORTOX	Clayey	Red and old soils have very low fertility and high toxic aluminum content.
Napo	Entisol	TIPYC UDIFLUVENTS	Silty	Recent soils have no formed horizons and little organic matter content.
Pastaza	Inceptisol	TROPEPT + ANDEPT	Clay Loam	Shallow to moderately deep, sloping to very steep topography. Humidity tropical climate soils.
Morona Santiago	Inceptisol	TROPEPT	Silty Clay	Soils formed on residual materials, superficial to moderately deep, topography between inclined to very steep. Basic saturation less than 40%. Base saturation percentage greater than 60%. Clay and very humid soils.
Zamora Chinchipe	Entisol	TIPYC UDIFLUVENTS	Clayey	Poorly differentiated, slightly acidic, moderately saturated soils.

Source: (INIAP, 2018).

Climate.

Camacho (2018) indicates that *Arachis pintoi*, it adapts to very humid climates where rainfall exceeds 2000 mm/year and with temperatures ranging from 22 to 25°C. This forage species is persistent, which is why it adapts to acidic soils with low fertility and has a rapid recovery after grazing. It benefits from the shade provided by grasses for adequate development. Its nutritional quality varies depending on the age of the forage and the fertility of the soil.

Table 2. Main climatic factors in the Ecuadorian Amazon.

Provinces	**Precipitation (mm)**	**Temperature (°C)**	**Humidity relative (%)**	**Speed wind (km/h)**	**Sensation termal (°C)**
Sucumbíos	3488	26	94	6	22
Orellana	3132	26.6	75.9	3	22
Napo	3600	21.6	82	5.6	21
Pastaza	4604	22	95	5	22
Morona Santiago	2463	22.3	95	3	24
Zamora Chinchipe	2848	25.6	92	2	22

Source : (INAMHI, 2016).

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Forage peanut (*Arachis pintoi*).

Arachis pintoi, commonly known as forage peanut, is a tropical fabaceous plant that has great nutritional value. This crop is easy to manage since it has a wide adaptation to climatic and soil conditions.

It has an adaptation to acidic soils with low fertility and can associate with different types of grasses in the establishment of crop and livestock systems (Sotelo et al., 2018).

Taxonomic classification.

Table 3. Taxonomic classification of the *Arachis pintoi*.

Order:	**Fabales**
Family:	Fabaceae (Papilonaceae)
Subfamily:	Faboideae
Tribe:	Aeschynomeneae
Subtribe:	Stylosanthinae
Section:	Caulorhizae
Gender:	*Arachis*
Species:	*Pintoi*

Source: (Sarabia Coello & Pilamala Aragón, 2020).

Origin of forage peanuts.

Forage peanut, scientifically known as *Arachis pintoi*, had its origin in South America, between the Amazon and La Plata rivers.

This leguminous plant as it is known today was collected in 1954 by Gerardo CP *pintoi* in the surroundings of the city of Belmonte, Bahia, Brazil, and is currently distributed throughout America, used as food for animals of zootechnical interest and as decoration in patios, parks and gardens (Santi Cáceres, 2018).

Features.

It is a creeping and stoloniferous plant, which forms a dense layer of stolon that are rooted, have short internodes and many underground seeds, its roots form nodules that in symbiosis with bacteria fix nitrogen in the soil which contributes to its regeneration and persistence. The shape of its leaves is oval, large and wide formed by four dark green leaves (Salazar Yugcha & Sigcha Suatunce, 2021).

Nutritional contribution.

Forage peanuts *Arachis pintoi*, it has a high nutritional value in terms of protein, digestibility and palatability, the level of crude protein concentrated in the leaf's ranges between 13 and 18% in winter and summer. The stems are in ranges of 9 and 10% protein in both seasons of the year, the digestibility of the leaves presents an average of 67%, while in the winter season it is reduced to 62%, the content of phosphorus and calcium contained in the plant are 0.18 and 1.77% respectively (Orozco Ramírez, 2018).

Sowing season.

For the sowing of forage peanuts, it mainly depends on the climatic conditions of the area, if there is no irrigation system, it is ideal to sow in winter or rainy seasons, since an adequate humidity of the soil is obtained optimal for the germination of the seed, it is not advisable to sow in time of maximum rainfall, because excessive humidity could cause the seed to rot, in the same way, sowing carried out in times of drought, could cause delays in the development of the plant, therefore, it is recommended to sow three months in advance of the dry season (Yepez Cedeño, 2012).

Methods

Research method.

The present research work is non-experimental, since a search was carried out in the databases: Google Scholar, academic repositories of universities, Scopus, Tylor & Francis online, Scielo, Redalyc and Dialnet, with a clear focus on the documentary exploration of: The analysis of the nutritional contribution of forage peanuts ¨Arachis pintoi under the conditions of the Ecuadorian Amazon.

Choice of information sources.

The article includes studies carried out during the last 10 years (2014 – 2024), which were published in Spanish or English. Likewise, review articles, experimental studies, digital academic books related to the topic, and undergraduate and graduate theses were included.

Data Analysis

For the preparation of the document, information was stored from review articles, experimental studies, academic books in digital format related to the topic and undergraduate and graduate theses, which had the purpose of searching for

documentation related to: The analysis of the nutritional contribution of forage peanuts *Arachis pintoi,* under the conditions of the Ecuadorian Amazon, from which 25 publications were obtained. A classification of the collected files was then carried out to select the precise information according to the main theme.

Results and Discussions

The main objective of this bibliographic review was to analyse the nutritional contribution of forage peanuts. (*Arachis pintoi*), under the conditions of the Ecuadorian Amazon, which is why it is considered a relevant study due to its importance in the production and marketing of species that feed on this forage. Below, in the following tables, the results obtained from different authors are presented.

Table 4. Nutritional properties according to the line and feeding with *Arachis pintoi*.

Species	**Feeding**	**DM (%)**	**OM (%)**	**CP (%)**	**FB (%)**	**GB (%)**	**CNZ (%)**	**H (%)**	**Autors**
Sheep	T1 Forage peanuts	92.42	89.21	19.99	30.08	2.26	----	----	(Miguez Garófalo, 2019)
Sheep	T2 Forage peanuts + Purple kinggrass	91.68	88.62	14.56	33.59	1.37	----	----	
Sheep	T3 Forage peanuts + marandú	90.96	91.02	12.97	37.65	1.8	----	----	
Sheep	T4 Forage peanuts + green kinggrass	86.86	89.57	14.91	53.31	2.92	----	----	
Guinea pigs	Forage peanuts + Gramalote	24.00	----	16.20	23.00	2.76	12.00	12.49	(Japa Cando, 2022)
Guinea pigs	Flour of Forage peanuts	----	89.16	18.59	23.18	1.55	10.85	----	(Sotelo *et al*., 2018)
Guinea pigs	Forage peanuts + White Kinggrass	18.33	----	23.06	21.95	4.02	6.51	----	(Santi Cáceres, 2018)
Pigs	Flour of Harina Forage peanuts	89.0	93.9	17.7	29.2	2.2	6.1	11.0	(Cueva Espinoza, 2016)
Duck	Forage peanuts	----	----	20.00	23.20	5.69	----	81.86	(Corrales Tigasi, 2015)

Source: Own elaboration. (CP – crude protein. DM – dry matter. OM – organic matter. FB – crude fiber. GB – crude fat. CNZ – ash. H – humidity).

According to Miguez Garófalo (2019), who conducted studies on the nutritional contribution of peanuts forage in sheep with four treatments combined with other forage species, indicates that, in the treatment based on forage peanuts T1 obtained better results in dry matter (DM) with 92.42% and in crude protein (CP) with 19.99%. On the other hand, the best contributions of crude fiber (CF) and crude fat (GB) were obtained with T4 (forage peanut + green king grass) with contributions of 53.31 and 2.92% respectively. Regarding the contribution of organic matter, a better result was obtained with T3 (forage peanut + marandu) with a value of 91.02%.

Table 5. Weight gain according to the line and feeding with *Arachis pintoi.*

Line	Feeding	Weight gain (g)						AUTORS
		Initial phase			Fattening phase			
		14 days	28 days	Total	42 days	56 days	Total	
Duck Beijing	T1 Concentrate Nutril + Peanut Forage	199.55	580.40	780.94	641.83	249.40	891.23	(Corrales Tigasi, 2015)
Duck Beijing	T2 Concentrate Pronaca + Peanut Forage	201.03	681.98	883.00	810.05	263.45	1073.50	
Duck Beijing	T3 Concentrate Expalsa + Peanut Forage	190.02	806.38	996.40	752.96	240.33	993.29	
Chickens	T1 Peanut	----	----	897.53	----	----	2559.	(Mashianda

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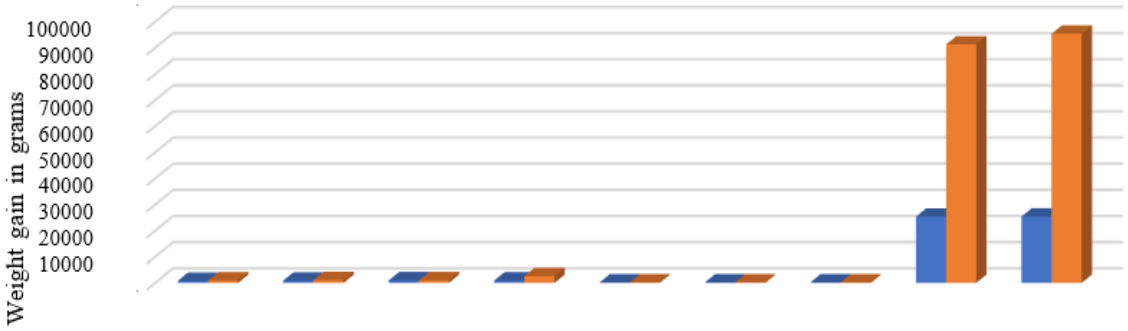
Broiler	forage al 10%						75	Ayuy, 2018)
Guinea pigs	T1 maní forrajero 5% + Concentrate	120.6	98.9	219.5	111.6	105.1	216.7	(Sotelo *et al*., 2018)
Guinea pigs	T2 Peanut forage 10% + Concentrate	107.2	103.9	211.1	108.6	97.6	206.2	
Guinea pigs	T3 Peanut forage 15% + Concentrate	106.5	109.7	216.2	109.4	101.0	210.4	
Pigs	T1 Peanut forage (Control)	----	----	25380	----	----	95730	(Chalán Ordóñez, 2016)
	T2 Peanut forage al 15%	----	----	25370	----	----	91280	

Source: Own elaboration

Chart 1 shows the weight gains according to the species and feed used in each study, where the inclusion of forage peanuts in pigs obtained greater weight gains both in their initial and final phases.

Chart 1. Weight gain according to the line and feeding with *Arachis pintoi*.



	Duck Beijing C. Nutril + M. Forager either	Duck Beijing C. Pronaca Ex + M. Forager either	Duck Beijing C. Expalsa Fo + M. Forager either	Chickens broiler M. Forage or 10%	Guinea pigs M. Forage or 5% + C	Guinea pigs M. e Forage or 10% + C	Guinea pigs M. Forage Fo or 15% + C	Pigs M. rage either	Pigs M. or 15%
Initial weight	780,94	883	996.4	897.53	219.5	211.1 .2	216,2	25370	25380
Final weight	891.23	1073.5	993.29	2559.75	216.7	206.2 .4	210,4	91280	95370

Source: Own elaboration.

Regarding the nutritional contribution of forage peanuts in Guinea pigs, according to Japa Cando (2022) in a diet of forage peanuts + gramalote obtained better results in dry matter (DM) and crude fiber (CF) with values of 24 and 23% respectively. Contrasting the above, (Sotelo et al., 2018) in a study conducted on the "Use of forage peanut flour (*Arachis pintoi* Krapov & WC Greg) on feeding guinea pigs (*Cavia porcellus* L)" obtained a similar crude fiber (CF) contribution with 23.18%, likewise, Santi Cáceres (2018) with a forage peanut diet + White king grass obtained a crude fiber (CF) contribution close to those mentioned above with a value of 21.95% and a higher crude protein (CP) contribution with 23.06%.

Regarding the feeding of pigs with inclusions of forage peanut flour, Cueva Espinoza (2016) indicates that he obtained a higher contribution of crude fiber (CF) with 29.2% and a lower contribution of crude protein (CP) with 17.7%, on the other hand, Chalán Ordóñez (2016), who carried out a study on the valuation of fattening pigs fed with forage peanut flour in the Ecuadorian Amazon, indicates that he obtained higher results both in crude fiber (CF) and crude protein (CP) with 60.7 and 19.5% respectively, giving greater results and therefore the weight gain also increased which significantly benefits the producer.

Finally, Corrales Tigasi (2015) an evaluation of the "Peking Duck Production (*Anas platyrhynchos*) with four levels of concentrate plus forage peanuts (*Arachis pintoi*)" obtained a higher contribution of crude protein (CP) with 20% and a crude fiber (CF) of 23.20%. On the other hand, contrasting the above, Sánchez (2016) in a test carried out on the

"Forage peanut (*Arachis pintoi*) as a source of feed in the Peking duck farm (*Anas platyrhynchos domesticus*)", indicates that, it obtained higher results in terms of fiber (FB) with 24.62% and lower results in crude fiber (FB) with 19.49%.
According to the weight gain in animals of zootechnical interest in associations with *Arachis pintoi*, Corrales Tigasi (2015) in research on the "Production of Peking Duck (*Anas platyrhynchos*) with four levels of concentrate plus forage peanuts (*Arachis pintoi*)", mentions that a greater weight gain was obtained in the initial phase with the EXPALSA concentrate + forage peanut treatment with a weight gain of 996.40 grams in a period of 28 days. On the other hand, in the fattening phase, a greater weight gain was obtained with the PRONACA concentrate + forage peanut treatment, its yield was 1073.50 grams, being significantly higher in relation to the other weight gain treatments in the fattening phase.
According to O Ayuy (2018), who conducted a study on: "Evaluation of the effect of including wheat flour" *Arachis pintoi*, (forage peanuts), in the diet of broiler chickens in the Morona canton, shows that it obtained weight gain values of: 897.53 and 2559.75 grams both in its initial and final phase respectively. On the other hand, counteracting the aforementioned, Guaraca Gualaquiza (2016), in a study carried out on: "Productive behavior of broiler chickens of the cobb 500 line fed with four levels of inclusion of forage peanut meal(*Arachis pintoi*)at the Center for Research, Graduate Studies and Conservation of Amazonian Biodiversity (CEIPA)¨, indicates that it obtained weight gain values of: 404 grams in its initial phase with an inclusion of 15% forage peanut flour, thus being significantly lower the weight gain obtained in the initial phase of the two studies carried out.
On the other hand, Sotelo.,et al (2018) in a study carried out on the "Use of forage peanut flour (*Arachis pintoi* Krapov & WC Greg) in the feeding of guinea pigs (*Cavia porcellus* L)", indicates that treatment 1, with the inclusion of 5% forage peanuts + concentrate, obtained a greater weight gain of: 219.5 and 216.7 grams in the initial and final phase respectively. On the other hand, confirming the above, (Ortiz Pérez, 2017) who used different levels of flour *Arachis pintoi* (forage peanuts) at 0 (T_0), 10 (T_1), 20 (T_2) and 30% (T_3) in the feeding of guinea pigs in the gestation and lactation stages, whose initial weights were 1.05, 1.07, 1.06 and 1.08 kg respectively, obtained better weight gain results in T2 and T3 with 0.27 and 0.25 kg which affirms that *Arachis pintoi*, it is one of the best legumes that provide high levels of nutrients, protein and energy in the diet of guinea pigs during all its phases.
Finally, Chalán Ordóñez (2016), in a study carried out on the: "Valuation of the carcass of pigs fed with forage peanut flour" *Arachis pintoi* in the CEBA growth stage, it indicates that there were no significant differences in weight gain in the initial phase, since the dissimilarity was 10 grams. On the other hand, in the final phase there was a large difference, since the grams of discrepancy were 4450, which indicates that, during its last stage of production, the pig had a worse weight gain conversion to the 15% forage peanut incursion.

Conclusion

The research showed that forage peanuts (*Arachis pintoi*) provides a good contribution of nutrients, thus obtaining good levels of crude protein, dry matter, organic matter, crude fiber, crude fat, ash and moisture, either alone or with the inclusion of another forage species, or in turn, with some concentrate, where, among all the species investigated, sheep production best assimilated the inclusion of forage peanuts, in which, T_1(forage peanuts) and T_3 (forage peanut + marandu), obtained a greater contribution of nutrients.
Finally, the assimilation of nutrients from forage peanuts varied depending on the species with which it was worked and the geographic area in which the study was carried out, specifically in the Amazon region, good results were obtained in the feeding of pigs with the inclusion of forage peanuts at 15% and 10% in broiler chickens, where the final weight gains were 95370 and 2559.75 grams respectively, with the pig species achieving the best weight gain.

Limitations and Future Studies

The authors declare that the experiments were carried out in accordance with the current laws of the country. The research undoubtedly contains information of great relevance for agricultural producers in the Ecuadorian Amazon Region.

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