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**ARTÍCULO DE REVISIÓN**

# El potencial del pijuayo (Bactris gasipaes) como nuevo ingrediente de productos cárnicos y pesqueros

# The potential of pijuayo (*Bactris gasipaes*) as a new ingredient in meat and fish products

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## RESUMEN

La asociación del consumo de alimentos procesados con problemas de la salud viene despertando el interés de los consumidores y de la industria de alimentos para la producción de alimentos más saludables y sustentables. Las carnes procesadas, que se elaboran a partir del músculo esquelético de especies animales comestibles, presentan características desfavorables debido a la incorporación de ingredientes y aditivos sintéticos asociados a la ocurrencia de enfermedades y alergias. En este contexto, la presente revisión presenta al pijuayo como una alternativa saludable y sustentable en la formulación de productos cárnicos y pesqueros. Se describen los beneficios nutricionales de este recurso amazónico, así como sus usos reportados en la literatura. Del pijuayo se han aprovechado la pulpa, cáscara, tallo, y extractos oleosos para sustituir grasa animal y para actuar como extensores y colorantes en carnes procesadas. Los beneficios incluyen la mejora de las características sensoriales y la aceptabilidad relacionadas a la textura y sabor, así como la posibilidad de reducir la oxidación lipídica y la sustitución parcial de nitritos como colorante. Sin embargo, aún hacen falta más estudios que evalúen el efecto del pijuayo en carnes procesadas desde una perspectiva holística, que incluya los aspectos nutricionales y efectos en la salud.

**Palabras clave:** Carnes procesadas; Sustitutos de grasa; Ingredientes extensores; Colorantes naturales; Frutos amazónicos.

## ABSTRACT

The association of processed food consumption with health problems has sparked interest among consumers and the food industry in the production of healthier and more sustainable foods. Processed meats, which are made from the skeletal muscle of edible animal species, have unfavorable characteristics due to the incorporation of ingredients and synthetic additives associated with the occurrence of diseases and allergies. In this context, this review presents the pijuayo as a healthy and sustainable alternative in the formulation of meat and fish products. The nutritional benefits of this Amazonian resource are described, as well as its uses reported in the literature. The pulp, peel, stem, and oil extracts of pijuayo have been used to replace animal fat and to act as extenders and colorants in processed meats. The benefits include the enhance of sensory characteristics and acceptability related to texture and flavor, as well as the potential to reduce lipid oxidation and partially replace nitrites as a colorant. However, further studies are still needed to evaluate the effect of pijuayo on processed meats from a holistic perspective, including nutritional aspects and health effects.

**Keywords:** Processed meats; Fat substitutes; Extender ingredients; Natural colorants; Amazonian fruits.

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## INTRODUCTION

Currently, the food industry is facing challenges in producing less harmful and more sustainable foods. In this area, meat-based products are often questioned for their negative effects on health and for the production system with negative consequences on the environment (World Health Organization - WHO, 2023). High contents of sodium, saturated fats, cholesterol and synthetic additives derived from the consumption of processed meats have been associated with an increased risk of diseases such as obesity, type-2 diabetes, coronary heart disease, and various types of cancer (Beriain et al., 2018; Bouvard et al., 2015; Paglarini et al., 2018; Rios-Mera et al., 2021). However, processed meats continue to be widely consumed and pose a latent risk to public health. In this sense, a viable solution is reformulation into healthier alternatives, but traditional quality aspects, such as sensory characteristics and consumer perception, must be considered (Eduardo et al., 2024; Saldaña et al., 2021).

In the search for new ingredients for the reformulation of processed meats, harnessing local resources is an economically viable option. In this context, the Amazon biome offers countless botanical resources that could be harnessed to obtain new ingredients for the food industry. One of the most interesting resources is *Bactris gasipaes*, known as pijuayo in Peru, which offers nutritional benefits such as carbohydrates, fiber, unsaturated lipids, vitamins, and bioactive compounds, mainly carotenoids (Amorim et al., 2024; Jaramillo-Vivanco et al., 2022; Peixoto Araujo et al., 2021). In the use of pijuayo as an ingredient in meat and fish products, the pulp, peel, stem and oily extracts from fruit residues have been used (Echeverria et al., 2020; Guzmán et al., 2023; Llatas et al., 2024; Pinzón-Zárate et al., 2015; Zapata & de la Pava, 2015), which shows that the fruit offers possibilities for integral use, emphasizing not only the improvement of the nutritional profile of foods, but also sustainability due to the use of residues.

This review describes the nutritional aspects of pijuayo fruit, the nutritional problems of meat and fish products, and the functions of pijuayo in these products. Finally, the challenges to be addressed in future studies seeking to incorporate pijuayo as a new ingredient in processed meats are described.

## PIJUAYO: GENERALITIES AND NUTRITIONAL ASPECTS

*Bactris gasipaes* is an Amazonian palm whose domestication began in the southwestern Amazon, and from there it spread to the central and eastern Amazon via the Madeira River, to the western Amazon via the Ucayali River, and to the Pacific slope of Colombia and Costa Rica through the Andes (Clement, 2024). It has several common names, including chontaduro, palmier-peche, peach palm, pejibaye, pupunha, and pijuayo. It has evergreen leaves that grow to approximately 10 to 20 m in height and produces fruits measuring 2 to 5 cm in diameter with thick pulp and large or seedless seeds. Fruit production is estimated to reach 10 to 30 t/ha. In addition, the heart palm can be obtained from the trunk in quantities ranging from 4,000 to 10,000 hearts/ha per year. The fruit is consumed cooked with water and salt or as a fermented beverage; flour, oil, and animal feed can also be obtained. Other edible parts include the kernels, the palm heart, and immature inflorescences (FAO, 2022). Edible larvae also grow on the trunks, such as the *suri* of the species *Rhynchophorus palmarum* (Jaramillo-Vivanco et al., 2022). It is also used for ornamental purposes from the trunk; liquor and cellulose can be obtained from the stem (FAO, 2022), and other parts of the palm tree are used to make utensils, tools, handcrafted roofs, and for native medicinal preparations (Jaramillo-Vivanco et al., 2022). Images of the fruit are shown in Figure 1.

The nutritional composition of pijuayo fruit has been reviewed by various authors, including Amorim et al. (2024), Jaramillo-Vivanco et al. (2022), and Peixoto et al. (2021). Table 1 highlights the main nutrients, from which it can be seen that the peach palm fruit is an important source of lipids, carbohydrates, fiber, and micronutrients such as magnesium and potassium.

**Figure 1**

*Fruit of the pijuayo palm (Bactris gasipaes). a) Pijuayo bunch; b) Cooked fruits; c) Cooked pijuayo pulp.*

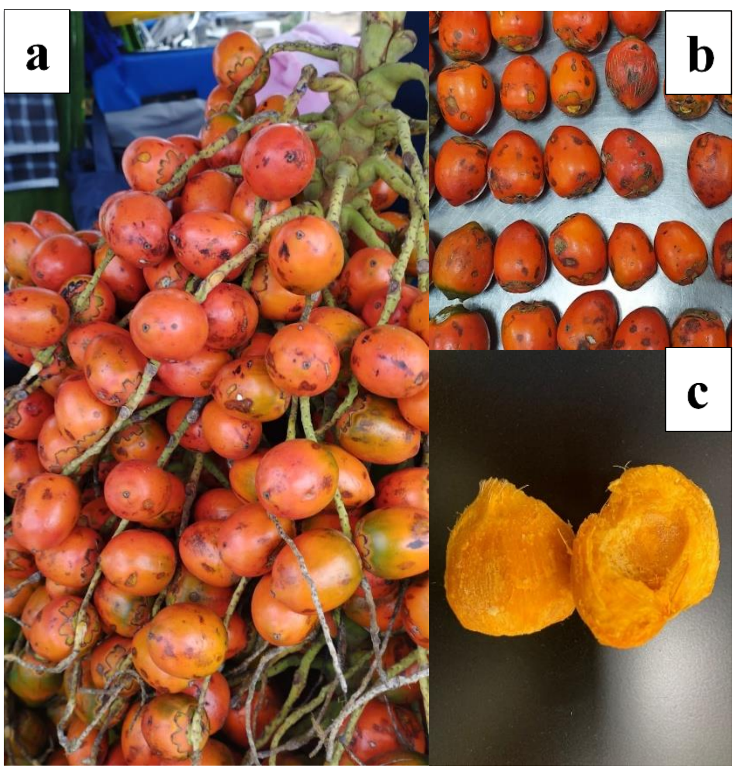

**Table 1**

*Nutritional composition of pijuayo fruit. Extracted from Amorim et al. (2024), Jaramillo-Vivanco et al. (2022), and Peixoto et al. (2021).*

| Nutrient | Composition |
|---|---|
| Moisture (%) | 10.7 – 82 |
| Lipids (%) | 6.88 – 23.6 |
| Proteins (%) | 0.6 – 3.9 |
| Ahs (%) | 2.64 – 2.74 |
| Carbohydrates (%) | 14.5 – 84.8 |
| Total dietary fiber (%) | 4.88 – 6.7 |
| Magnesium (mg/100 g) | 16.9– 81.6 |
| Potassium (mg/100 g) | 109.4 – 289.3 |
| Calcium (mg/100 g) | < 1.0 – 21.8 |
| Manganese (mg/100 g) | 0.08 – 0.54 |
| Iron (mg/100 g) | 0.57 – 2.65 |
| Zinc (mg/100 g) | < 0.2 – 0.2777 |
| Copper (mg/100 g) | 0.43 |
| Sodium (mg/100 g) | 0.2 |
| Chromium (mg/100 g) | 0.008 |
| Selenium (mg/100 g) | 0.0035 |
| Vitamin C (mg/100 g) | 14 – 19.7 |

As can be seen in Table 1, there is wide variability in some components, such as moisture, lipids, carbohydrates, potassium, and calcium, which may be due to agronomic factors. The lipid content is mainly composed of unsaturated fatty acids, of which linoleic acid (omega 6) and linolenic acid (omega 3) stand out (Amorim et al., 2024). Although the protein content of the pijuayo fruit pulp is relatively low, it contains most of the essential amino acids, such as: lysine, methionine, phenylalanine, threonine, tryptophan, and valine, in ranges from 0.8 to 4.6% of the total nitrogen value (Jaramillo-Vivanco et al., 2022), which makes pijuayo a recommended raw material from the point of view of biological value. The pijuayo also stands out for the presence of carotenoids, which in most cases are of the trans-β-carotene type, important for their antioxidant activity and in the biosynthesis of provitamin A. By consuming this product, 50% of the recommendation of the Food and Drug Administration (FDA) is already supplied, since its content reaches 72 µg β-carotene/g (Montero et al., 2022). It has also been reported that pijuayo increased HDL cholesterol and decreased body mass index in rats (Carvalho et al., 2013), suggesting its positive effect on health. Other important aspects of pijuayo include its high starch content, near-neutral pH, soluble pectin, and absence of gluten (Peixoto et al., 2021), characteristics that can be exploited by the food industry.

## MEAT AND FISH PRODUCTS

Meat and fish products are obtained from the skeletal muscle of edible animals and are classified as red meat, poultry, fish, and processed meat (Wang et al., 2023). Some commercial products include burgers, sausages, meatballs, surimi, among others, which are an important source of protein and essential amino acids, fatty acids with health benefits (e.g., omega 3), vitamins, and minerals (Rios-Mera et al., 2024). Processed meats are composed of a minimum of 30% meat and may contain animal fat and other non-meat components of the animal, such as liver, kidney, and heart (Lonergan et al., 2019; O'Farrell, 2011). Meat processing includes operations such as portioning, forming, emulsification, salting, curing, marinating, cooking, smoking, or drying (O'Farrell, 2011). Likewise, ingredients with technofunctional properties are added which improve moisture retention and favorably modify the texture, which include sodium chloride (salt), phosphates, carbonates, citrates and starches and hydrocolloids (Balestra & Petracci, 2019). This group also includes extenders, classified as non-meat ingredients such as animal and vegetable proteins and carbohydrates whose functions are to reduce cost and improve water retention, texture, appearance and palatability (Mills, 2014a). Other additives that improve the stability and sensory properties of the product are nitrite, nitrate, erythorbate, sweeteners, seasonings, flavorings, antimicrobials, and antioxidants (Mills, 2014b).

However, some of these ingredients can cause adverse health effects, due to a higher proportion of saturated fats and cholesterol derived from the addition of animal fat, and the use of additives of synthetic origin, which have been associated with the development of colon, stomach, pancreas and prostate cancer (Bouvard et al., 2015; Rios-Mera et al., 2024). In addition, the allergenic effects of the ingredients must be considered, for example, soy and wheat derivatives that are used as extenders (Mills, 2014a). In this sense, the reduction or substitution of ingredients and additives critical for health is an opportunity to search for new, healthier and more natural ingredients to improve the nutritional profile of meat and fish products.

## PIJUAYO IN THE FORMULATION OF MEAT AND FISH PRODUCTS

Applications of the pijuayo fruit in food products include pasta, mayonnaise, biscuits, extruded cereals, snacks, cakes, bread, fermented drinks, sausages, and burgers, in which the flours from the fruits, peel, stems, and extracted oils were used (Amorim et al., 2024; Costa et al., 2022; Rios-Mera et al., 2024). Flours from the pulp and peel have been reported to have high fat and carbohydrate contents, ranging from 7% to 11% and 71% to 76%, respectively; while the oils were used for their carotenoid content (de Souza Mesquita et al., 2020; Llatas et al., 2024; Silva Ribeiro et al., 2021). These properties highlight pijuayo as an ingredient in meat and fish formulations, with functions such as a fat substitute, due to its lipid content (Echeverria et al., 2020; Guzmán et al., 2023; Llatas et al., 2024), extender due to its carbohydrate content (Zapata & de la Pava, 2015), and colorant due to the presence of carotenoids (Noronha et al., 2019; Pinzón-Zárate et al., 2015). Likewise, other characteristics such as the presence of phenolic compounds, fibers, essential amino acids and unsaturated lipids provide antioxidant, antimicrobial and anti-obesogenic properties to the pijuayo (Rios-Mera et al., 2024).

To obtain flours, the pijuayo fruit must be cooked in boiling water for a period of time that can vary from 30 to 40 minutes. The pulp is then separated from the peel and the seed is discarded. The flour then undergoes a dehydration process in an oven at temperatures not exceeding 55°C or by freeze-drying (Guzmán et al., 2023; Llatas et al., 2024; Zapata & de la Pava, 2015). A similar procedure has been reported by Echevarria et al. (2020) when they obtained flour from the pijuayo stem to be incorporated into lamb burgers, but the stems were not cooked. As fat substitutes, pijuayo flours have been incorporated into burgers at substitution levels of 25% to 100%. In lamb burgers, pijuayo stem flour increased cooking yield, moisture retention, and dietary fiber content because the flour exhibited a high water and oil absorption capacity and fiber content. Instrumental color was not affected, nor was the microorganism count; however, higher pijuayo stem flour content increased instrumental hardness, but springiness and cohesiveness were not affected. A 67% fat replacement yielded the highest sensory scores for flavor and texture, as well as a higher purchase intention, suggesting that pijuayo improves the sensory acceptability of lamb burgers (Echeverria et al., 2020).

In another study, Llatas et al. (2024) substituted pork fat with pijuayo pulp and peel flours at levels of 25% and 50%. Using a multivariate statistical evaluation, they observed that at the highest substitution level, burgers tended to contain high carbohydrates and yellowness intensity (b*), while hardness, springiness, chewiness, cohesiveness, ash, cooking losses, diameter reduction, redness (a*), fat, and lipid oxidation were better associated with the treatment without fat reduction. In a previous study, Guzmán et al. (2023) demonstrated that pijuayo pulp and peel flours reduced lipid oxidation in burgers from 62% to 87% compared to the control, with the peel flour showing a greater effect. This may be due to the high carotenoid content of the peel, which may have antioxidant activity (Noronha Matos et al., 2019; Peixoto Araujo et al., 2021). In this context, pijuayo pulp and peel flours, in addition to being a fat substitute, can act as an antioxidant in meat products.

Similar to Echevarria et al. (2020), Llatas et al. (2024) also observed improvements in the sensory profile of reduced-fat burgers. Thus, the 25% fat substitution significantly increased the sensory acceptance of the burgers, which were associated with sensory terms such as tender and tasty, suggesting that the pijuayo flour improves the texture and flavor of the burgers. This fact was reinforced by the segmentation of the 112 consumers who participated in the study, where 89% of them preferred the reformulated burgers, except for the one with the highest content of pijuayo peel flour. The authors speculated that the flavor improvement may be associated with the presence of amino acids that are precursors to umami flavor (savory flavor), such as glutamic acid and aspartic acid, but this statement needs to be evaluated in future studies.

As an extender ingredient, Zapata and de la Pava (2015) used pijuayo flour in the formulation of tilapia sausages, assessing their texture and sensory acceptability. It was observed that the gumminess and springiness were greater in sausages with pijuayo flour, contrary to the observation in adhesiveness and cohesiveness. The shear force increased with pijuayo flour, but the opposite was observed for the cutting work. One hundred consumers participated in the sensory analysis, whose sensory acceptance responses for flavor, odor, and texture were much higher in sausages containing pijuayo flour compared to the conventional sausage, reinforcing the idea that pijuayo derivatives improve the texture and flavor of meat and fish products.

Another application of pijuayo in meat products is as a colorant. Pinzón-Zárate et al. (2015) evaluated the oily extract of pijuayo fruit residues as a natural colorant in frankfurters. The extract was added in quantities ranging from 0 to 97 ml/kg, containing total carotenoids with equivalent amounts of 0 to 28.13 mg/kg extract. In turn, the increase in extract in the formulation was accompanied by a reduction in sodium nitrite in quantities ranging from 200 to 100 mg/kg. As a result, the higher the extract content, the higher the lightness, yellowness (b*), chroma, and hue values. Furthermore, the authors suggested that the nitrite content can be reduced by up to 20% using the oily extract, but the decrease in red coloration (a*) could hinder its application in frankfurters. This statement should be confirmed in studies that include sensory evaluation with consumers.

## CONCLUSIONS

Meat and fish products are critical for health due to their composition and the ingredients and additives used in their production, particularly their lipid profile, which is rich in saturated fats and cholesterol, the use of synthetic additives and ingredients that can cause allergic reactions in consumers. Therefore, it is necessary to improve their nutritional profile through the incorporation of healthy and natural ingredients. Pijuayo (*Bactris gasipaes*) is an Amazonian fruit with excellent nutritional properties and has been explored in meat and fish formulations as a fat substitute, extender, and natural coloring agent. Its use has not been limited to the commonly edible portion (pulp), but also to other by-products, such as the peel and stems. In adequate quantities, peach palm has been shown to improve the sensory profile of meat and fish products, primarily enhancing flavor and texture. Future studies should explore compounds associated with flavor enhancement, as well as their rheological properties to optimize the textural properties of meat and fish products. It is also necessary to study compounds associated with the antioxidant capacity of pijuayo, as well as the potential for replacing sodium nitrite and nitrate from a sensory perspective. In this line, the replacement of other ingredients and additives commonly used in the formulation of meat and fish products, such as soy and wheat flour, synthetic antioxidants, phosphates, among others, could also be explored.

However, despite the technofunctional and sensory benefits of pijuayo, nutritional aspects must be taken into account, involving *in vitro* and *in vivo* studies. Scientific advances in this regard include the study by Santos et al. (2023), who observed that the phenolic fraction of pijuayo flour decreased the *in vitro* protein digestibility of yogurt formulated with 30% pijuayo flour. Later, Souza-Santos et al. (2025) demonstrated that the type of processing (freeze-drying, cooking followed by freeze-drying, convection-drying, and cooking followed by convection-drying) to obtain pijuayo flour can decrease antinutritional compounds that affect protein digestibility. In meat and fish products, which are often questioned due to their negative health effects, these previous scientific evidence suggest the possibility of studying the applications of pijuayo from a holistic perspective, addressing not only the technological and sensory aspects of the products, but also the study of processing factors, chemical and nutritional characterization, interactions of pijuayo components with nutrients of the food matrix, the digestibility of nutrients of interest, the identification of safe doses, and the reduction of compounds that are detrimental to health. Thus, the future is challenging but promising for the proposal of pijuayo as a new ingredient in the formulation of processed meats.

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