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RESEARCH ARTICLE OPEN ACCESS

INCORPORATION OF NATIVE FRUITS FROM BRAZILIAN BIOMES INTO CHOCOLATE: A LITERATURE REVIEW

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ABSTRACT

Chocolate, a food product widely appreciated for its flavor and versatility, has been undergoing innovation. The incorporation of native fruits from Brazilian biomes into its formulation has become a promising alternative to combine sensory pleasure with nutritional benefits. Thus, this study aimed to review recent scientific literature on the use of these fruits in chocolate production, focusing on their nutritional, functional, and technological impacts. The research was conducted through a systematic review following the PRISMA 2020 protocol, including articles published between 2020 and 2025 in the ScienceDirect database that presented information on fruit-based formulations and nutritional composition data. Fruits such as cupuaçu, palm, elderberry, and sacha inchi demonstrated potential to enrich chocolates due to their bioactive and nutritional compositions, in addition to contributing to sustainable practices through the use of agricultural by-products. The analysis revealed significant gains without interfering with sensory acceptability, as well as opportunities for regional innovation and valorization of Brazilian biodiversity. Therefore, it was evident that the integration of native fruits into chocolate strengthens the development of healthier and more natural foods and stimulates the circular economy and biodiversity.

I. INTRODUCTION

The search for healthy, innovative, and sustainable food products has driven the incorporation of natural ingredients that enhance nutritional, functional, and sensory profiles [1], [2]. In this context, several native fruits from Brazilian biomes have been explored and studied for numerous applications, particularly in the food sector. Beyond the interest in their bioactive and sensory composition, there is also a growing effort to promote their utilization, as many of these fruits remain underexploited [3-6]. Chocolate is characterized as a product obtained from the mixture of cocoa derivatives (cocoa mass, cocoa powder, and/or cocoa butter) with other ingredients, and it must contain at least 25% (g/100 g) of total cocoa solids.

White chocolate is also defined, requiring a minimum of 20% (g/100 g) of total cocoa butter solids [7]. These criteria are essential to ensure chocolate quality and the maintenance of its sensory and nutritional characteristics, providing consumers with a safe product that complies with current regulations [8], [9]. This food product is highly appreciated for its unique flavor and versatility, as it can be consumed in bar form or used as a base in the confectionery sector [10]. The formulation of chocolates, as with any food product incorporating fruits, requires rigorous technical control to ensure product stability, preservation of sensory characteristics, and commercial viability [11], [12]. Analyses such as moisture content, acidity, chemical composition, and ingredient interactions are indispensable to guarantee product safety.

Therefore, the development of such foods demands advanced knowledge of the properties of each fruit used, as well as their compatibility with the food matrix to which they are added [13], [14]. Thus, the addition of fruits to chocolate, beyond promoting biodiversity, also represents an innovation for the development of products that, in addition to sensory attributes, provide health benefits such as antioxidant, anti-inflammatory, and cardiovascular effects [15-17]. Therefore, the growing demand for natural, sustainable foods with functional appeal reinforces the importance of research and development of chocolates enriched with native Brazilian fruits. The integration of technological knowledge, nutritional composition, and sensory aspects is essential to foster innovation in this segment, promoting health, flavor, and sustainability [18], [19]. In this context, the objective of this study is to identify, select, and synthesize evidence on the formulation and nutritional composition of chocolates enriched with native fruits.

II. METHODOLOGY

II.1 TYPE OF STUDY

This study consists of a systematic review of the scientific literature, conducted in accordance with the recommendations of the PRISMA 2020 statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), encompassing only publications from 2020 to 2025. The implementation of the PRISMA protocol ensures greater methodological rigor, transparency, and reproducibility of the processes of data searching, selection, extraction, and analysis [18-20].

II.2 SEARCH STRATEGY

The search strategy was conducted in the ScienceDirect database in 2025. For this purpose, the following Boolean operator was used to enable a comprehensive and specific search within the established criteria: “chocolate AND fruit AND formulation AND ‘nutritional composition’”. The following filters were also applied: language (no restriction), document type (research articles and meta-analyses), and open-access availability.

II.3 SELECTION CRITERIA

To select the articles, inclusion and exclusion criteria were applied to ensure the relevance and quality of each study within the defined scope. The inclusion criteria considered studies addressing chocolate formulations containing fruits or their derivatives, with analysis of nutritional composition, original research articles, no language restriction, and full texts available in open access. Exclusion criteria were applied to studies that did not present analyses of nutritional composition. Literature reviews were also excluded, as well as studies focused exclusively on sensory, microbiological, or toxicological aspects without nutritional data, conference abstracts or documents, duplicates, and articles with restricted access.

II.4 SELECTION PROCESS

After importing the records from the database, all existing duplicates were removed. Study selection was performed through the screening of titles and abstracts for preliminary exclusion, followed by full-text reading to confirm eligibility according to the previously defined criteria.

II.5 DATA EXTRACTION

Data extraction was carried out using a table containing study identification (authors, year of publication, and DOI), type and description of the formulation (species used, fruit form, concentration, incorporation method, and processing parameters), quantitative results related to nutrients and bioactive compounds, and, when available, observations on technological and sensory aspects.

II.6 DATA SYNTHESIS AND ANALYSIS

The filtered and selected data were organized into descriptive tables and graphs, which facilitated the understanding of the effects of adding different fruits on the nutritional composition of chocolates. In addition, a complementary qualitative analysis based on study frequency was performed, allowing the identification of existing gaps in the literature, emerging trends, and potential areas for future investigations.

III. RESULTS AND DISCUSSION

Figure 1 shows the annual frequency of publications in the ScienceDirect database related to research articles addressing the incorporation of native fruits into chocolate, highlighting the evolution of interest in the topic over the years.

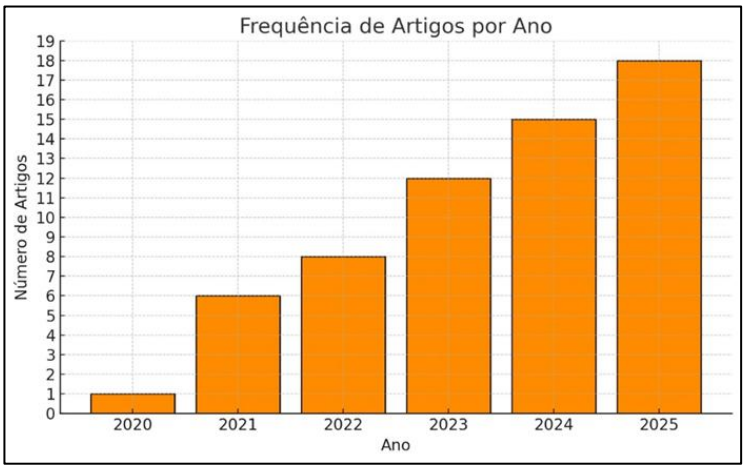

Figure 1: Annual frequency of review articles on native fruits incorporated into chocolate (ScienceDirect).
Source: Authors, (2026).

Based on the analysis of Figure 1, it is observed that in the ScienceDirect database, until a few years ago, there was a limited number of articles addressing the incorporation of native fruits into chocolate. This low initial volume likely reflects a scientific and technological underexploration of these ingredients in the chocolate industry. Consequently, the nutritional, sensory, and economic potential of native species has been constrained [21]. Between 2023 and 2025, a gradual increase in publications is evident, with a higher concentration in more recent years, indicating growing interest in the valorization of native fruits, particularly those from Brazilian biomes, as innovative and sustainable alternatives.

This increase may be associated with the demand for products with functional appeal, the appreciation of biodiversity, and the food industry's pursuit of more natural and regionally based formulations [22], [23]. The selected studies demonstrate diverse approaches regarding the choice of fruit parts, ingredient combinations, processing techniques, and analysis of nutritional composition. Table 1 summarizes this information, also highlighting technological applications, functional benefits attributed to the formulations, and the corresponding references.

Table 1: Chocolate formulations with native fruits and their nutritional composition.

Native fruit	Product or part used	Applications in chocolates	Functional benefits	Reference
Palm	Panattu Choco Bar	Energy chocolate with the addition of tropical fruit	Rich in minerals, high energy value, good sensory acceptance potential	[24]
Cupuaçu	Pulp	Source of texture and flavor; can partially replace cocoa in the formulation	Antioxidant, anti-inflammatory, improves intestinal health and has immunomodulatory effects	[25]
Cupuaçu	Seeds (cupulate)	Used as a base for "cupulate"-type chocolate	Sustainable cocoa substitute; rich in antioxidants and bioactive compounds	[26]
Elderberry (*Sambucus* sp.) by-product	Fruit residues (peels/seeds)	Dark chocolate (75%) enriched with 2–10% by-product; optimization of conching time and addition of sacha inchi oil	Increased antioxidant capacity, preservation of phenolic compounds during processing, valorization of by-products	[27]
Sacha inchi oil (*Plukenetia volubilis*)	Pure oil incorporated into chocolate	Partial replacement of cocoa butter in dark chocolates; formulations with up to 5% sacha inchi oil in ganache and chocolate mass	Improved lipid profile (higher antioxidant content), fibers and polyphenols; reduced saturated fat; anti-inflammatory and cardioprotective potential	[26-28]
Sacha inchi ganache	Ganache with 10% seed or oil	Filled chocolates with enriched ganache (5–10%) in milk and dark chocolates	Increased fiber, phenolic compounds, and antioxidants; good sensory acceptance	[29]

Source: Authors, (2026).

The incorporation of native fruits and their by-products into the chocolate industry has resulted in expressive nutritional gains, mainly associated with increased levels of phenolic compounds, fiber, and antioxidants, which, when combined with sensory perception, favor greater consumer acceptance [30], [31]. Thus, studies involving cupuaçu, elderberry, and sacha inchi have shown that the partial replacement of cocoa butter and the addition of by-products (peels, seeds, and pulps) not only enrich the bioactive profile but also preserve or even improve certain product attributes [26-28], [32].

Moreover, there is considerable potential to explore other regional fruits, such as açaí, juçara, and araçá, as viable alternatives for reducing sugar content in formulations. By using pulps or freeze-dried powders of these ingredients, it becomes possible to develop chocolates with a more favorable glycemic profile, meeting the demand for healthier and more sustainable products [33-35]. Figures 2 and 3 illustrate the distribution and relevance of terms related to the use of native fruits in chocolate development.

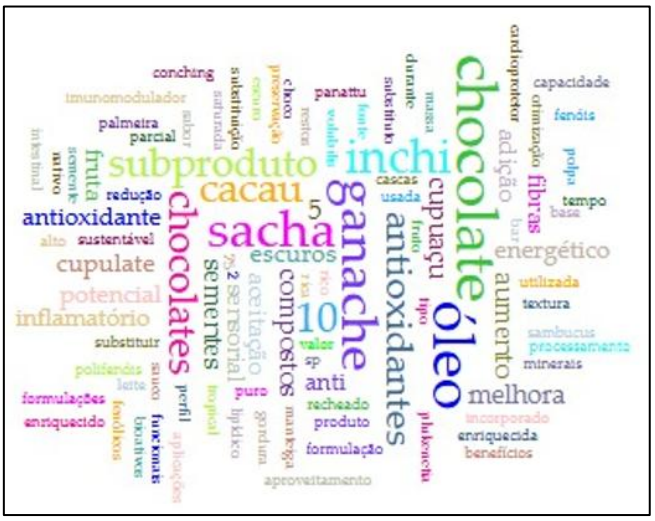

Figure 2: Word cloud of the main terms related to native fruits and applications in chocolates.
Source: Authors, (2026).

Figure 2 presents, through a word cloud, a visual representation of the most recurring terms, as well as their connections with functional attributes, technological applications, and potential nutritional benefits. This visual analysis allows a better understanding of the emphasis placed on native ingredients in chocolate formulations.

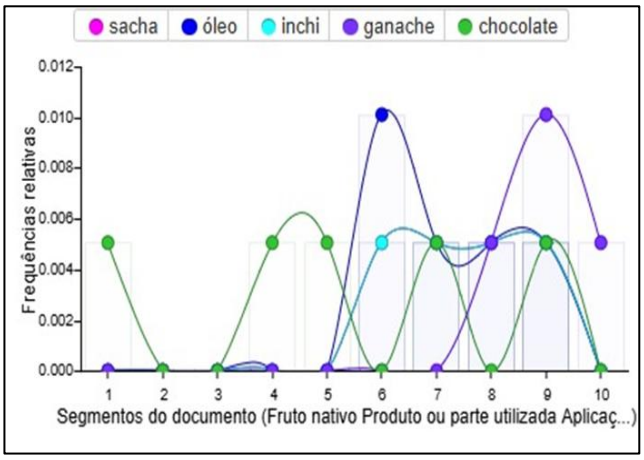

Figure 3: Word cloud of the main terms related to native fruits and applications in chocolates.
Source: Authors, (2026).

Figure 3 illustrates how keywords such as sacha, oil, inchi, ganache, and chocolate appear across the segments, revealing thematic patterns.

III.1 TECHNOLOGICAL AND SENSORY POTENTIAL OF NATIVE FRUITS IN CHOCOLATE FORMULATION

The incorporation of cupuaçu pulp (*Theobroma grandiflorum*) as a source of texture and flavor reinforces the versatility of this Amazonian fruit, whose application can partially replace cocoa in chocolate formulations, supporting flavor innovation and reducing dependence on the traditional raw material [25]. This partial substitution not only introduces a fruity and exotic note to the product but also enables the development of new chocolate lines with regional identity, strengthening the appeal of origin and the connection with consumers seeking authentic and differentiated products [22], [23]. The use of cupuaçu seeds for the production of "cupulate" represents a sustainable alternative to cocoa, as it valorizes residues that would otherwise be discarded, adding value and reducing waste.

Cupulate maintains the texture and shape of traditional chocolate, but with a differentiated bioactive profile due to the presence of antioxidants in the seeds [25]. This approach contributes to a circular economy model within the cocoa and cupuaçu production chains. The use of *Sambucus* sp. by-products, specifically peels and seeds, in dark chocolates (75%) enriches the product with phenolic compounds and antioxidants, while preserving these compounds during processing through the optimization of conching time and the addition of sacha inchi oil [27]. This strategy highlights the potential of by-products for the development of functional chocolates that add nutritional value beyond sensory pleasure, transforming residues into valuable ingredients.

III.2 FUNCTIONAL BENEFITS AND ENHANCED NUTRITIONAL PROFILE

Native fruits such as palm (Table 1), used in the Panattu Choco Bar, stand out for their high energy value and mineral richness, qualifying them as ideal ingredients for energy chocolates designed to meet specific consumer demands, such as those of athletes or individuals with increased nutritional requirements [24]. In addition to the energetic benefit, favorable sensory acceptance is essential for the commercial viability of this type of product.

Sacha inchi oil, also known as sacha peanut, incorporated into dark chocolates as a partial substitute for cocoa butter, provides a healthier lipid profile, with higher concentrations of antioxidants, fiber, and polyphenols, as well as reduced saturated fat content [26], [27]. Its anti-inflammatory and cardioprotective effects further enhance the functional appeal of chocolate, positioning it as a food that combines pleasure and health.

Ganache enriched with sacha inchi seeds or oil, used in milk and dark chocolates, promotes a significant increase in fiber and phenolic compound intake, thereby enhancing the antioxidant capacity of the product [27]. This enrichment does not compromise sensory acceptability, a crucial condition for commercial success, demonstrating that the incorporation of functional ingredients can coexist with the maintenance of the sensory experience desired by consumers [27], [29].

III.3 SUSTAINABILITY AND FULL UTILIZATION OF RAW MATERIALS

The valorization of by-products, such as elderberry fruit residues and cupuaçu seeds, demonstrates the growing concern for sustainability in the chocolate industry. The reuse of residues minimizes or even prevents waste and contributes to reducing the environmental impacts of production, while also increasing economic competitiveness through the development of new high value-added products [11], [33]. The use of cupulate as a cocoa substitute enables diversification of the production base and fosters the regional economy in areas where cupuaçu is abundant. In addition, the partial replacement of cocoa butter with sacha inchi oil represents a technological innovation that supports sustainability [25], [26].

III.4 PERSPECTIVES AND CHALLENGES FOR INNOVATION IN CHOCOLATES WITH NATIVE FRUITS

Despite the evidence from studies highlighting the nutritional and functional benefits of incorporating native fruits into chocolate, several challenges still hinder large-scale implementation. These include raw material variability, processing constraints, the need to ensure sensory acceptance, and compliance with regulations governing health claims [36], [37]. Nevertheless, innovations in the conching process using some of the species listed in this study demonstrate that it is possible to preserve antioxidant and phenolic compounds without negatively affecting product texture or flavor. The growing demand for healthier, more sustainable, and value-added foods represents a real opportunity for products based on native fruits to gain market space, fostering innovation and promoting the valorization of Brazilian biodiversity [36], [38].

IV. CONCLUSIONS

It was observed that the incorporation of fruits from Brazilian flora into chocolate and related product formulations emerges as a promising strategy for the development of chocolates with enhanced nutritional value. Fruits such as palm, cupuaçu, and elderberry have been incorporated to enrich chocolates, bars, spreads, and desserts with attractive sensory characteristics. Some of these fruits contributed to improved texture, reduced sugar content, or acted as partial substitutes for cocoa fat. Overall, the data suggest that the use of native fruits in chocolate formulations not only adds nutritional value to the product but also promotes Brazilian biodiversity and meets current demands for healthier, more sustainable, and innovative foods.

V. AUTHOR'S CONTRIBUTION

Conceptualization: Elisangela Santos Reis de Oliveira, Elisangela Carvalho Nunes and Edson Pablo da Silva.
Methodology: Elisangela Carvalho Nunes and Edson Pablo da Silva.
Investigation: Elisangela Santos Reis de Oliveira
Discussion of results: Elisangela Santos Reis de Oliveira and Elisangela Carvalho Nunes
Writing – Review and Editing: Elisangela Santos Reis de Oliveira, Elisangela Carvalho Nunes and Edson Pablo da Silva.
Resources: Edson Pablo da Silva
Supervision: Elisangela Carvalho Nunes and Edson Pablo da Silva
Approval of the final text: Elisangela Santos Reis de Oliveira, Elisangela Carvalho Nunes and Edson Pablo da Silva.

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