

Desenvolvimento e caracterização de brownie de cacau adicionado de farinha de albedo do maracujá (*Passiflora edulis* Sims)

Development and characterization of cocoa brownie added of passion fruit albedo flour (*Passiflora edulis* Sims)

Desarrollo y caracterización de brownies de cacao con harina de albedo de maracuyá (*Passiflora edulis* Sims)

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Resumo

O objetivo do presente trabalho foi estudar o efeito da adição da farinha do albedo do maracujá, como proposta de aproveitamento integral dos alimentos, na elaboração de um brownie de cacau, bem como avaliar suas características tecnológicas e microbiológicas. Para isso, foram desenvolvidas quatro formulações de brownie, utilizando farinha de aveia (controle) e sua substituição parcial pela farinha do albedo do maracujá. Todo processo de elaboração seguiu as normas técnicas para controle de qualidade. Em sequência foram realizadas as avaliações físico-químicas (umidade, cinzas, açúcares totais, lipídeos, proteínas, carboidratos e parâmetros de cor) e microbiológicas (coliformes termotolerantes, *Estafilococcus* coagulase positiva e *Salmonella*). Alterações tecnológicas e sensoriais foram percebidas, de modo que quanto maior o teor da farinha do albedo de maracujá adicionado, mais volumoso, seco e com consistência rígida ficavam os brownies. Os resultados das análises físico-químicas ficaram dentro dos parâmetros referenciados para esse tipo de produto, mantendo características favoráveis à elaboração dos brownies. Com relação aos atributos colorimétricos pode-se observar que a cor do brownie de cacau tornou-se menos intenso com o aumento da concentração de farinha de albedo de maracujá. Em todos os aspectos microbiológicos avaliados, os resultados apresentaram conformidade com os padrões estabelecidos pela legislação. Dessa forma a farinha do albedo do maracujá apresentou grande potencial para produção de brownies sem interferir na sua qualidade nutricional e microbiológica.

Palavras-chave: Sustentabilidade; Produtos de confeitaria; *Passiflora edulis*; Características tecnológicas e microbiológicas.

Abstract

The objective of the present work was to study the effect of the addition of passion fruit albedo flour, as a proposal for full use of food, in making a cocoa brownie, as well as evaluate its technological and microbiological characteristics. For this, four brownie formulations were developed, using oatmeal (control) and its partial replacement with passion fruit albedo flour. The entire elaboration process followed the technical standards for quality control. In sequence, physical-chemical evaluations were performed (moisture, ash, total sugars, lipids, proteins, carbohydrates and color parameters) and microbiological (thermotolerant coliforms, coagulase-positive *Staphylococcus* and *Salmonella*). Technological and sensory changes were noticed, so that the higher the flour content of the added passion fruit albedo, the more voluminous, dry and with a rigid consistency the brownies stayed. The results of the physical-

chemical analyzes were within the parameters referenced for this type of product, maintaining characteristics favourable to the preparation of brownies. Regarding colourimetric attributes, it can be seen that the colour of the cocoa brownie has become less intense with the increase in the concentration of passion fruit albedo flour. In all microbiological aspects evaluated, the results showed compliance with the standards established by the legislation. In this way, the passion fruit albedo flour showed great potential for brownie production without interfering with its nutritional and microbiological quality.

Keywords: Sustainability; Bakery products; *Passiflora edulis*; Technological and microbiological characteristics.

Resumen

El objetivo del presente trabajo fue estudiar el efecto de la adición de harina de albedo de maracuyá, como propuesta para el uso completo de los alimentos, en la preparación de un brownie de cacao, así como evaluar sus características tecnológicas y microbiológicas. Se desarrollaron cuatro formulaciones, incluida la muestra control y el proceso de preparación siguió todos los normas de control de calidad. En secuencia, se realizaron evaluaciones fisicoquímicas (humedad, cenizas, azúcares totales, lípidos, proteínas, carbohidratos y color) y microbiológicas (coliformes termotolerantes, *Staphylococcus* coagulasa positivas y *Salmonella*). Se notaron cambios tecnológicos y sensoriales, de modo que cuanto mayor era el contenido de harina del albedo de maracuyá agregado, más voluminosos, secos y con una consistencia rígida se volvían los brownies. Los resultados de los análisis físico-químicos estuvieron dentro de los parámetros referenciados para este tipo de producto, manteniendo características favorables para la producción de brownies. Con respecto a los atributos colorimétricos, se observó que el color del brownie de cacao se volvió menos intenso con el aumento de la concentración de harina de albedo de maracuyá. En todos los aspectos microbiológicos evaluados, los resultados mostraron cumplimiento con los estándares establecidos por la legislación. Por lo tanto, la harina de albedo de maracuyá mostró un gran potencial para la producción de brownie sin interferir con su calidad nutricional y microbiológica.

Palabras clave: Sustentabilidad; Confeiteria products; *Passiflora edulis*; Características tecnológicas y microbiológicas.

1. Introduction

According to the Brazilian Agricultural Research Corporation – Embrapa, Brazil is the third-largest fruit producer in the world with a volume of 45 million tons per year, of which 65 % is consumed internally and 35 % are destined for the foreign market (Embrapa, 2020). However, it is known that part of this production is wasted at some stage in the production chain or by the production of agro-industrial waste by discarding unconventional parts of food, as is the case with passion fruit albedo (*Passiflora edulis* Sims).

Data from the Food and Agriculture Organization of the United Nations (2013) point out that about 1.3 billion tons of food are discarded per year in the world, that is, one-third of total food production is wasted. Thus, activities that minimize these food losses are extremely relevant to lessen the economic impacts, environmental, in addition to enabling the idea of sustainability and provide enrichment of preparations with plant parts. This because these residues are usually natural sources of nutrients, such as vitamins, minerals, fibers and bioactive compounds that have high nutritional potential (Souza et al., 2020).

Therefore, surveys have reported the growing consumer search for food that provide additional benefits to the body either by inherent properties of food or by adding plant parts in formulations to improve nutritional quality (Nystrand & Olsen, 2020). In this perspective, different studies have been developed using fruit residues in the formulation of new products, some being specifically adding passion fruit peel and/or albedo in the formulation of products such as pasta, cookie and bread (Cunha & Cattelan, 2019).

The passion fruit peel is composed of the flavedo (yellow coloured part) and albedo (white part), this being rich in pectin, kind of soluble fiber that helps in reducing blood glucose rates, niacin source (vitamin B3), iron, calcium, and phosphorus (Silva et al., 2016). Studies suggest the use of passion fruit peel as flour or the study of obtaining other products aimed at people who need to increase their fiber intake to prevent diseases, mainly those related to the gastrointestinal tract and the heart (Dias et al., 2011; Silva et al., 2016).

Among the food products well accepted by the population are brownies, especially when they taste chocolate. These are defined as a confectionery product that falls into the category of cakes, but with a darker colour and a firmer consistency than conventional cakes. They are obtained by mixing, homogenizing and conveniently cooking pasta prepared with different flours and adding various food substances that can provide functional properties (Widanti & Mustofa, 2015).

For these aspects and because it is a product that can be substituted for its ingredients, the present work aimed to study the effect of adding the passion fruit albedo flour, as a proposal for full use of food in making a cocoa brownie, as well as evaluate its technological and microbiological characteristics.

2. Methodology

Materials

The yellow passion fruit albedo (*Passiflora edulis* Sims) was acquired from a company specialized in the processing of fruit pulps, located in the municipality of Bananeiras-PB, in maturation stadium mature (fully yellow peel) (Silva et al., 2016). It was instructed that the by-product (shell and bast) stay stored under refrigeration ($12 \pm 2^{\circ}\text{C}$) until the time of collect. The acquisition of the other ingredients used to make brownies (oatmeal, brown sugar, baking powder, cocoa powder, eggs and butter), occurred in the local market in the municipality of Solânea-PB. All materials were sent to the Nutrition and Dietetics laboratory of the Federal University of Paraíba, Campus III, Bananeiras-PB, where they were processed to make brownies.

Process of preparing the passion fruit albedo

To obtain the albedo, initially, the passion fruit by-product was washed in running water and sanitized in sodium hypochlorite solution (200 ppm dilution) for 15 minutes, with subsequent rinsing under running water and drying at room temperature. Then the flavedo and the shells were separated, leaving only the albedo, that was washed again (for removing pulp remnants) and drained to remove excess water.

The final product went through the maceration process, aimed at removing a substance known as naringin, that gives it a bitter taste. This process consisted of immersing the passion fruit albedo in water for 12 hours, under refrigeration with water change every 3 hours (Dias et al., 2011). The macerated albedo was packed in containers with a lid and packed under freezing at -18°C for 24h. After that time, albedos were kept at refrigeration temperature until thawed, also for 24 hours, to start the drying process.

Drying and obtainment the passion fruit albedo flour

The thawed albedos were directed to the drying stage (total 4.7 Kg). The material was distributed in drying greenhouse trays with air circulation at 60 ° C until constant weight. This process took approximately 12 hours and resulted in a 467 g serving of dry albedo, representing only 9,94% of total yield. The dry material was packed in sealed plastic packaging and stored at room temperature (25°C), in a dry place, until use in the formulation of brownies. Before preparation, the dry albedo was crushed in an industrial blender and sieved (Silva et al., 2016).

Brownies preparation process

For making the brownie ingredients were chosen to enhance the nutritional profile of the final product. Among them cocoa which has high acceptability and several functional claims (González-Barrío et al., 2020). The experiment was developed using a formulation as a control (F0) with oatmeal flour, and in the rest added 25 %, 35 % and 45 % albedo flour to replace oatmeal flour, representing F1, F2, F3, respectively. These percentages were selected based on preliminary tests, aiming not to supply changes in the general characteristics and in the sensory quality of the product (brownie). The items present in each formulation are described in Table 1.

Table 1. Formulation for cocoa brownie: Control and with addition of passion fruit albedo flour (*Passiflora edulis* Sims).

Ingredients	F0*	F1	F2	F3
Oatmeal flour (g)	80	60	52	44
Passion fruit Albedo Flour (g)	0	20	28	36
Chemical yeast (g)	4	4	4	4
Whole egg (g)	10,4	10,4	10,4	10,4
Coconut oil (g)	70	70	70	70
Cocoa (g)	60	60	60	60
Raw sugar (g)	140	140	140	140

*(F0) formulation control. Source: Authors (2020).

The brownie was processed by mixing eggs, butter, sugar and cocoa in an industrial blender. Then, it was added the flours until a homogeneous mass was obtained. Right after the product was formed and subjected to baking at 180 °C for 20 minutes. After cooling, the brownies were packed separately in a glass with lids and kept refrigerated until the time of analysis.

Evaluation of the physical and chemical parameters of the brownie

The physical-chemical analyzes of the brownies were carried out at the Physical-Chemistry Laboratory of the Federal University of Paraíba, Campus III, according to the quality control parameters required for the product. Humidity was determined by the desiccation method, oven-dried at 105 °C until constant weight, and total ash determined by gravimetry, by incinerating the sample in a muffle at 550 °C until light ash is obtained, as described by the Adolfo Lutz Institute (IAL, 2008). For protein determination, the Kjeldahl method was used, the correction factor of 5,83 (oats, barley, rye), and for the analysis of lipids, the cold extraction technique was used by the Folch method (IAL, 2008). Total sugars were determined by titulometric Eynon-Lane redox method, according to the methodology described by IAL (2008); and carbohydrates were calculated by the difference between 100 and the sum of percentages of moisture, protein, total lipids and ash.

The instrumental colour of the brownies was evaluated with the DELTA COLOR brand electronic colourimeter, model DELTA VISTA d.8, through the CIE L*a*b* scale, obtaining the values of L* (luminosity (clear/dark); a* (chromaticity on the axis from green (-) to red (+); b* (chromaticity on the axis from blue (-) to yellow (+). The parameters C* (chromacity) were also evaluated, h* (hue) that represents tint angle (Starting at 0°, which would be +a* (red), 90° would be (yellow), 180° would be -a*(green) and 270° would be -b* (blue) (CIE, 1986).

Microbiological analysis

For hygienic-sanitary control, the samples were sent to the Food Microbiology Laboratory of the Federal University of Paraíba, Campus III, where the evaluation was performed for Coliforms at 45 °C/g using EC broth (*Escherichia coli* broth) at 44,5-45° C in a water bath for 24 hours. *Staphylococci* Coagulase Positiva, *Salmonella* sp and moulds and yeasts were determined using the standard plate counting method, with results described by

the number of Colony Forming Units (CFU). Cultivation conditions varied according to the investigated microorganism: Coagulase positive *Staphylococcus* was on Baird Parker agar (BP), with incubation at $35 \pm 2^\circ \text{C}$, for 48 h; *Salmonella* on *Salmonella-Shigella* agar (SS), with incubation at $35 \pm 2^\circ \text{C}$, for 24 h and moulds and yeasts on molten Sabouraud agar, with an incubation period of five days at $25 \pm 1^\circ \text{C}$ (APHA, 2007).

Statistical analysis

The analysis of the evaluation of the general quality parameters (physical-chemical and microbiological) was performed in triplicate and all results were expressed as the average values of the data obtained. Statistical analyzes were performed using descriptive statistics (mean and standard deviation) and inferential (ANOVA tests, followed by the Tukey test) to determine differences ($p \leq 0,05$) between the results obtained. For statistical analysis, the Sigma Stat software. 3.5.

3. Resultados e Discussão

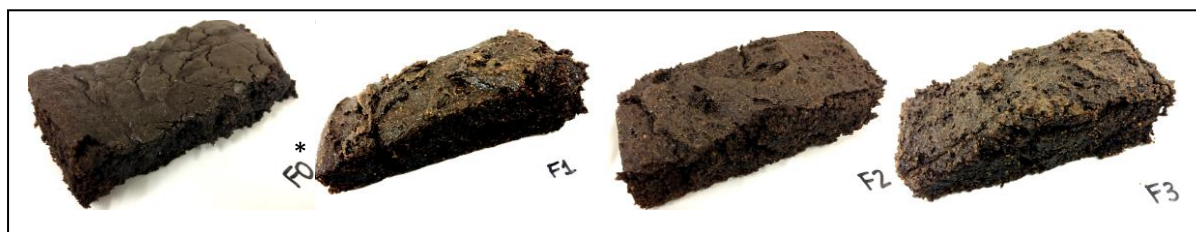
Brownies formulation

The different formulations of the brownies are shown in Figure 1. It was possible to observe the possibility of developing them using different concentrations of passion fruit albedo. Technological and sensory changes were noticed, so that the higher the flour content of the added passion fruit albedo, the more voluminous, dry and with a rigid consistency the brownies stayed.

Probably this relationship is associated with the high fiber content contained in the passion fruit albedo can be used as an alternative in food enrichment and included in the diet to offer the benefits of eating this rich source of nutrients, benefits these associated with cardiovascular disease prevention and gastrointestinal infections, colon cancer, hyperlipidemia, diabetes and obesity (López-Vargas et al., 2013).

The use of dietary fiber in functional food product formulations provides nutrition and health for the population leading to adhere to beneficial eating patterns (Silva et al., 2016). Such criteria are interesting since they are also factors that encourage the acceptance of the product by those who consume it.

Figure 1. Cocoa brownies with passion fruit albedo flour (*Passiflora edulis*).



*(F0) formulation control; (F1) addition 25 % albedo flour; (F2) 35 % albedo flour; (F3) 45 % albedo flour. Source: Authors (2020).

Physical-chemical characterization

Table 2 below illustrates the results regarding the centesimal composition of the Brownies according to each formulation

Table 2. Characterization of physical-chemical parameters of cocoa brownies with passion fruit albedo flour (*Passiflora edulis*).

Formulations	Moisture (%)	Ashes (%)	Lipids (%)	Proteins (%)	Total sugars (%)	Carbohydrates (%)
F0	18,80 ($\pm 0,47$) ^a	3,06 ($\pm 2,09$) ^a	16,90 ($\pm 0,37$) ^a	7,59 ($\pm 1,12$) ^a	34,7 ($\pm 1,95$) ^a	53,7 ($\pm 1,00$) ^b
F1	18,40 ($\pm 1,13$) ^a	2,88 ($\pm 0,94$) ^a	16,30 ($\pm 0,81$) ^a	7,77 ($\pm 0,87$) ^a	32,4 ($\pm 2,24$) ^a	54,6 ($\pm 2,08$) ^{ab}
F2	17,40 ($\pm 0,65$) ^a	2,47 ($\pm 0,40$) ^a	16,60 ($\pm 0,74$) ^a	7,83 ($\pm 0,30$) ^a	32,1 ($\pm 4,39$) ^a	55,6 ($\pm 1,50$) ^{ab}
F3	15,30 ($\pm 2,45$) ^a	2,97 ($\pm 1,65$) ^a	16,30 ($\pm 1,20$) ^a	7,25 ($\pm 0,16$) ^a	34,0 ($\pm 4,38$) ^a	58,2 ($\pm 1,60$) ^a

Values constituted by average (n=3) \pm standard deviation; on the same line with different lowercase letters are significantly different ($p \leq 0,05$), based on the Tukey post-test. Source: Authors (2020)

Brownies proved to be the major sources of carbohydrates, lipids and proteins, with variations from 58,2 to 53,7; 16,3 to 16,9%; and 7,83 to 7,25 respectively. For carbohydrates, it was possible to verify a statistical difference ($p \leq 0,05$) between the standard formulation and the one containing the greatest amount of albedo flour. However, the quantities found were similar to those of cocoa brownies added from green banana biomass (53,37%) and the traditional pasta (55,95%) proposed in the study by Souza & Roselino (2019). It should be noted that the quantities of total sugars were also similar in all formulations, which suggests the presence of other sources of carbohydrates in brownies added to albedo flour.

As for the protein content, the results obtained were superior to those found by Santana & Silva (2007) who formulated biscuit with passion fruit peel flour (4,97%) and lower than that found by Souza & Roselino (2019) who formulated cocoa brownie with green

banana biomass but also added whey protein, finding a value of 10,31% protein in the elaborated product.

The formulated brownies also presented themselves as sources of minerals, important compounds for a balanced diet, which reflected in the ash contents obtained (2,47 to 3,06%), these superior to those found by Souza & Roselino (2019) in a cocoa brownie with green banana biomass and whey protein (2,07%).

Regarding the moisture content, it was observed that, although it does not differ statistically, the higher the percentage of *Passiflora edulis* albedo flour in the formulation, lower was the moisture of the brownies, what corroborates with Martins' studies; Borges & Orsine (2016), that identified that foods that contain products with high fiber content in their formulation, like oats and passion fruit albedo, have a greater possibility of water retention.

Still, about humidity that ranged from 18,80 (F0) to 15,30% (F3), this result was superior to that found by Santana & Silva (2007) in biscuits using 16,8% passion fruit peel flour (1,10%). However, the moisture content found in the different brownies was lower than the value stipulated by the Brazilian Food Composition Table - TACO (2011) for cakes made with chocolate flour (19.3%), this factor is relevant, as it would hinder the proliferation of microorganisms responsible for compromising the final quality of the products.

The samples showed higher values concerning the lipid content than those found by Santana & Silva (2007) in biscuits with 16,8% passion fruit peel flour (5,10%). However, most of the lipids found in the present study came from coconut oil used as the major lipid matrix. Coconut oil has been increasingly studied due to its high content of medium-chain fatty acids that represent around 60 % of its composition, becoming responsible for increasing satiety, are also involved in several modulation mechanisms of the intestinal microbiota and all benefits associated with this, besides being considered as easy to use fatty acids for energy (Maia et al., 2020).

Passion fruit albedo flour also has in its composition relevant fiber indices, which contributes to the nutritional enrichment of products formulated with this ingredient, thus contributing to consumer health. This can be evidenced in the study by Silva et al. (2016) in which the flour obtained proved to be a rich source of crude fiber (58,8 g/100 g) and different minerals (calcium, magnesium, potassium, phosphorus, sulfur, iron, zinc and copper).

Based on the analytical results, the potential for using passion fruit albedo flour obtained through agro-industrial residues to enrich products is evident, improving its technological properties, nutritional qualities, in addition to contributing to the reduction of

environmental impacts generated by the disposal of passion fruit albedo as waste (Macêdo et al., 2019).

Colorimetric analysis

Table 3 shows the colour parameters (L, C*, H°, G) of the different formulations. According to the data obtained, only for G there was no significant difference. The luminosity (L) of the formulations F1, F2, F3 varied between 0,18 and 0,20 concerning F0 (0,07), but they did not differ statistically from each other. This demonstrates that the presence of passion fruit albedo flour intensified the dark cocoa colour of the formulations. However, the statistically significant variations in the chromaticity values (C*) and tint angle (H°) values of the formulations affected the colour of the cocoa brownie since this became less intense with the increase of passion fruit albedo flour (F3).

The incorporation of fiber-rich products in a food system can affect organoleptic characteristics and the colour of the product. These are the most important quality parameters when dietary fiber products are used. One of the challenges that industries face in increasing dietary fiber and whole grain content in food occurs in the change in colour and texture that these foods cause (López-Vargas et al., 2013).

Table 3. Color parameters of cocoa brownies with passion fruit albedo flour (*Passiflora edulis*).

Formulations	L	C*	H°	G
F0	0,07 ($\pm 0,02$) ^b	0,06 ($\pm 0,02$) ^b	94,50 ($\pm 3,20$) ^c	4,63 ($\pm 1,32$) ^a
F1	0,18 ($\pm 0,04$) ^a	0,24 ($\pm 0,08$) ^b	80,98 ($\pm 2,63$) ^b	4,65 ($\pm 1,57$) ^a
F2	0,18 ($\pm 1,09$) ^a	0,26 ($\pm 0,12$) ^b	81,33 ($\pm 2,82$) ^b	4,75 ($\pm 1,44$) ^a
F3	0,20 ($\pm 0,06$) ^a	0,79 ($\pm 0,16$) ^a	22,65 ($\pm 1,58$) ^a	5,00 ($\pm 2,2$) ^a

a-c: the average values in the same column with different lowercase letters are significantly different ($p \leq 0,05$), based on the Tukey post-test. Source: Authors (2020).

Regarding colourimetric attributes, it is observed that the passion fruit albedo flour is directly related to the significant differences presented. In this sense, it becomes a vegetable ingredient with strong characteristics in terms of the principles and applications of food colourimetric data.

Mycobiological analysis

Table 4 presents the results of the microbiological evaluation of brownies enriched with passion fruit albedo flour. All parameters analyzed were within the limits established by ANVISA legislation (Brasil, 2001).

Table 4. Microbiological characteristics of cocoa brownie with passion fruit albedo flour (*Passiflora edulis*).

Formulations	Coliforms 45 °C	Moulds and Yeasts*	PCS*	<i>Salmonella</i> ssp.
F0	<3,0 MLN/g	<5x10 ²	<1x10 ²	Absent
F1	<3,0 MLN/g	<5x10 ²	<1x10 ²	Absent
F2	<3,0 MLN/g	<5x10 ²	<1x10 ²	Absent
F3	<3,0 MLN/g	<5x10 ²	<1x10 ²	Absent

*CFU/g: Colony Forming Units per gram; MLN: Most Likely Number; PCS: Positive Coagulase Staphylococci. Source: Authors (2020).

The National Health Surveillance Agency ANVISA in Resolution RDC n° 02, January 2001 (Brazil, 2001) determines as a microbiological standard for confectionery products the maximum of 10² CFU/g of Coliforms at 45 °C, the result of the study in question can be considered as absent. Concerning coliform research at 45 °C, the values found were within the standards for all formulations. Microbiological analyzes were performed to ensure the quality of the products obtained, as these are absent from fungi, yeasts, bacteria because the values found are within the standards established by the legislation, without compromising food quality and safety.

Although Resolution n° 12/2001 (Brazil, 2001) does not specify limits for the group of coliforms in flours, the result obtained for total coliforms showed values lower than <3 MLN for formulations F0, F1, F2 and F3 thus evidencing the lack of contamination during processing. The absence of *Salmonella sp.* in the brownies was also observed, therefore, complying with current legislation (Resolution n° 12/2001) which determines absence in 25 g for filamentous fungi and yeasts, the values found were less than 5x10², being considered within the standard according to Resolution n° 12/2001, establishing values between 15 and 150 CFU/g as the maximum standard for this category of microorganisms. Thus, these results suggest the application of good manufacturing practices in the processing and obtaining of brownies. However, it must be taken into account that in addition to the low humidity of the product, these were also subjected to a furnishing process.

4. Final Considerations

In this study, passion fruit albedo flour had great potential for partial replacement of oat flour, in the production of brownies without interfering with their nutritional quality, since it presented satisfactory nutritional characteristics. However, other research with passion fruit albedo flour is viable in particular the sensory analysis of products, where it is possible to evaluate the intention of acceptability of the studied formulation. The brownies formulations showed physical-chemical and microbiological characteristics within the standards established by the country's current legislation or referenced in previous studies

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