DEVELOPMENT OF ACTIVE PACKAGING WITH ANTIOXIDANT POTENTIAL FROM TUCUMÃ-DO-AMAZONAS WASTE

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ABSTRACT

Nowadays, many researches are focused on the elaboration of plastic incorporated with extracts of agroindustry residues, aiming at accelerated degradation, protection of food due to the bioactive compounds present in the packaging. The objective of this study was to physically characterize fruits of tucumã-do-Amazonas in order to use the peels to obtain an extract and incorporate it into a film with a starch matrix in order to obtain a film with antioxidant capacity. For the physical characterization, each component of the fruits was weighed, the tucumã peel extract was carried out by the hydroalcoholic method and the production of the packages was carried out by the casting method. Tucumã fruits are widely consumed in the urban region of Manaus, generating a high amount of waste. The physical characterization of the fruits showed that the residues add up to 70% of the weight of the fruit. The incorporation of tucumã peel extract in starch-based films showed that films with 15% extract have a 90% reduction of DPPH radical. Research has shown a high amount of β-carotene in the peels of the tucumã, due to these compounds there was the production of the packaging with antioxidant potential of this study.

Keywords: Agro-industrial waste 1. Peels of tucumã 2. Plastic pollution 3.

1 INTRODUCTION

There is a growth in the biopolymer sector, due to the demand for sustainable alternatives coming from the packaging areas, as the pressure to reduce the use of fossil-based plastics is due to pollution and the volume of waste generated [1]. The use of plastic packaging in food poses serious risks to human health because they contain petroleum-based compounds that can be released into food [2]. In order to contain or reduce pollution derived from plastic and reduce the use of fossil fuels, aiming at a circular economy system, where there is greater use of products and by-products derived from agribusiness, many studies have been and are being approached with the theme of extraction and use of bioactive compounds from agro-industrial waste aiming at the manufacture of biopolymers [3, 4, 5].

The manufacture of active and intelligent packaging is a probable solution for the reduction of plastic pollution, due to its components, its degradability is faster [6]. Agroindustry waste, especially from fruit processing, is a source of natural antioxidants, such as carotenoids and phenolic compounds [7]. An Amazonian fruit that has high concentrations of bioactive compounds is the tucumã-do-Amazonas (*Astrocaryum aculeatum* Meyer).

Due to the high consumption of the fruit, a large amount of waste is generated [8, 9, 10, 11]. Methods of disposing of organic waste or disposal in landfills deplete resources and contribute to environmental problems [12]. With the above, the objective of this research was to physically characterize fruits of tucumã-do-Amazonas, aiming at the use of the peel to obtain hydroalcoholic extract and incorporation in films in order to obtain films with antioxidant capacity.

2 MATERIAL & METHODS

The tucumã fruits from the municipality of Urucará/AM, from the Agrofrutifera Cooperative of Urucará producers (AGROFRUT) were sent in raffia sack to the Separation Processes Laboratory (LABPROS), located at the Faculty of Agrarian Sciences of the Federal University of Amazonas (FCA-02), South sector, where the analyses were carried out. The fruits were sorted, 100 tucumã fruits were selected for physical characterization, and each component of the fruit was measured. The tucumã shells were dried in an oven at 45 ºC for 48 hours, then crushed in a knife mill and classified in a particle size sieve (100 MESH/TYLER). The extract was obtained by the hydroalcoholic extraction method (peels + 70% alcohol). The production of starch-based films containing extract was carried out by casting (5% starch and 0.9% glycerol) in the following proportions: 0; 5; 10 and 15% v/v [7]. The produced films were evaluated for the content of total phenolics (Foline Ciocalteu colorimetric reaction method) expressed in mg of gallic acid (mg of GAE/100g) with reading at 765 nm, the calibration curve ranged from 0.0 to 20.0 mg/mL. The antioxidant capacity of the films (scavenging of DPPH free radicals) was performed at 515 nm [4, 5, 6].

3 RESULTS & DISCUSSION

3.1 Physical characterization of the fruits of the tucumã-do-Amazonas

The physical characteristics of the Amazonian tucumã are shown in Table 1. From the analyses, it was inferred that the percentage of peel (epicarp) of the tucumã corresponds to 16.72% ± 1.97 in relation to the total weight of the fruit, added to the rest of the residues (pyrene) a proportion of 77.89% is obtained. The pulp (mesocarp) in relation to the tucumã residues is much lower. The pulp of the tucumã corresponds to only 21.4% ± 3.23 of the weight of the fruit. There were losses of 0.69% due to the processing of the fruits at the time of separation of the components, peel, pulp, and stone. In the separation of the almond (endosperm) and woody part (endocarp) of the tucumã there was a loss of 2.69% due to the breakage, if using a mechanical press, parts of the woody material were lost. The woody part and almond after separation corresponded to 58.51% in relation to the total weight of the stone (pyrene). The perianth of the fruit was not analysed because it presented a very low proportion in relation to the total weight of the fruits, being less than 0.5% [8].

Table 1 Physical characteristics of each component of the fruits of tucumã-do-Amazonas (Astrocaryum aculeatum Meyer) followed by the standard deviation. The last two references did not present the standard deviation of the data.

	Mesocarp (%)	Epicarp (%)	Pyrene (%)	Endosperm (%)	Endocarp (%)	Reference
Average	21,42 ± 3,23	16,72 ± 1,97	61,17 ± 4,31	25,32 ± 2,07	33,16 ± 2,98	This study
	19,42 ± 4,8	16,32 ± 2,18	63,84 ± 9,35	-	-	8 *
	19,00 ± 6	11,00 ± 2	70,00 ± 7	-	-	9
	20,00	10,00	70,00	39,00	61,00	10
	25,00	15,00	61,30	-	-	11

Source: The authors; * Standard Deviation calculated from the average fruit weights

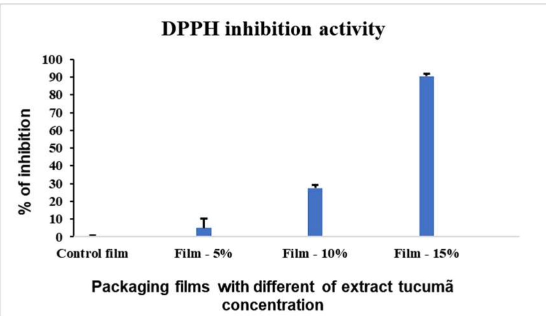
The residues of tucumã (peel) are still being studied, since the high consumption of the fruit in the urban region of Manaus generates a high rate of organic waste [8, 9, 10, 11], there is research focused on the use of the peel due to the various chemical compounds present, such as flavonoids, tannins, β-carotene, rutin, quercetin, etc [13].

In a study analysing the production chain of the tucumã-do-Amazonas, it was found that 49,840 kg of pits (woody material and almonds) and 12,460 kg of peel are discarded Monthly [11]. This waste goes directly to the Manaus landfill, contributing to a shorter life span or is deposited in the urban environment, generating environmental problems [11]. The studies mentioned above show the large amount of waste generated after the consumption of tucumã, about 70% of the fruit corresponds to the waste that is discarded.

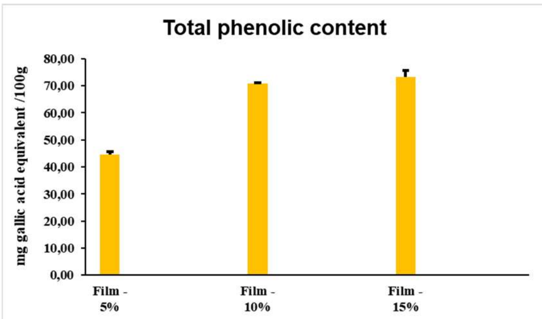
Several studies carried out with tucumã residues show the high concentration of phenolic compounds (in the peel), fatty acid (almond). The use of these residues would generate greater added value to the fruit, could further boost the bioeconomy of the State of Amazonas, would not contribute to environmental pollution due to the accumulation of these residues in the urban environment, its use would be aimed at the circular economy and sustainable use of the compounds present in the fruit with application in a range of products [9, 10, 11, 13].

3.2 Antioxidant capacity of films incorporated with extracts from tucumã-do-Amazonas peels

The antioxidant potential of the films was analysed based on the ability to eliminate the DPPH radical. The results obtained are shown in Graph 1. Control films, without the incorporation of tucumã peel extract, showed an insignificant result, less than 0.4% reduction of DPPH. From the incorporation of 5% of extract in the films, a reduction of approximately 5% of DPPH is observed, films with 15% of extract showed a high capacity of reduction of DPPH, being 90%. The films showed a high concentration of phenolic compounds (Graph 2), with 73.13 mg of GAE/100g (15% extract), this value was based on the calibration curve: $y = 0,0608x + 0,3049$ e $R^2 = 0,9016$.



Graph 1 Antioxidant activity of films incorporated with tucumã (*Astrocaryum aculetaum* Meyer) peel extract, in proportions of: 0, 5, 10 e 15%.



Graph 2 Total Phenolic Content in films with incorporation of tucumã (*Astrocaryum aculetaum* Meyer) peel extract in proportions of: 5, 10 and 15%. Control films did not present phenolic content.

The calculation of the IC50 for the films with extract from tucumã bark showed an R2 of 0.93. The results showed that for a 50% reduction of DPPH, a concentration of 11.05% of extract is required in the incorporation of the films. At a concentration of 20µg/mL, tucumã extracts inhibited >80% of the DPPH [13] radical, and this study also showed the high capacity to reduce DPPH in biofilm incorporation. Research indicates that the phenolic content can be used as an indicator of antioxidant capacity and the greater the incorporation of the extract in the films, the increase in the concentration of phenolics [2]. Phenolic compounds are secondary metabolites of plants, they are effective hydrogen donors possessing ideal structural properties to fight free radicals, having a good antioxidant potential [14].

In tucumã peel extract, a high concentration of total phenolics (941.8 mg/GAEg), flavonoids (92.8 mg/g), tannin (31.4), alkaloid (1.5) and β-carotene (52.83 mg/100g) were found. The bioactive molecules present in tucumã peel extracts contribute to the antioxidant capacity [13]. Carotenoids are widely distributed in fruits and vegetables and are responsible for the reddish-yellow color [5] tucumã has a high concentration of these compounds, with a higher proportion in the peels [13]. Carotenoids are related to important physiological functions and actions due to their antioxidant capacity. The antioxidant capacity of biodegradable polymers has been evidenced in several studies [3, 4, 7] the incorporation of extracts from agroindustry residues have high concentrations of bioactive compounds and are being analyzed in the incorporation of films with diversified matrix (starch, PVA, gelatin, chitosan, etc.), with the increase in the concentration of the extract the greater are the reduction of DPPH, [3, 4, 5, 6] corroborating this study, since with the increase in concentrations there was an increase in the reduction of DPPH.

4 CONCLUSION

The tucumã (*Astrocaryum aculeatum* Meyer), an endemic fruit of the Amazon, is widely consumed in the urban centers of Amazonas, especially in the state capital (Manaus). The high consumption of the fruit produces 49,840 kg of waste per month, which is deposited in dumps and ends up in the city's landfill or is deposited in the urban environment, generating environmental problems. In this study it was found that 70% of the weight of the fruit corresponds to the residues, due to the greater economic value of the fruit is focused on the pulp, these residues are not used, however several studies have already shown that the use of these residues would generate greater added value to the fruit and enhance the bioeconomy of the state. The fruit peels correspond to 16.72% of the fruit's weight, in this residue there is a high rate of phenolic compounds (total phenolic content, β-carotene, etc.). The use of the peels to obtain an extract is effective and can be used in a range of products. For example, we can mention the use of β-carotene in the pigmentation industry. The incorporation of tucumã peel extract into starch-based films proved to be effective, where it was shown that with an increase in the concentration of the extract, the antioxidant capacity of the films increased. The films with 15% extract reduced the DPPH radical by 90% and after IC50 calculations, it was found that with a concentration of 11.05% there will be a 50% inhibition of the DPPH radical. The total phenolic content in the films was considered high, 73.13 mg of GAE/100g for films with 15% extract, the content of phenolic compounds is associated with antioxidant activity. The production of films incorporating extracts from agro-industrial waste is a sustainable way to achieve a circular economy and reduce the generation of pollutants, mainly from plastic from non-renewable sources.

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