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CRISTINE VANZ BORGES

PERFIL BIOQUÍMICO NA PÓS-COLHEITA DE FRUTOS DE *Musa* spp., ÊNFASE EM COMPOSTOS BIOATIVOS

Botucatu

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Orientadora: Giuseppina Pace Pereira Lima

Co-orientadores: Edson Perito Amorim
Igor Minatel
Magali Leonel

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TÍTULO DA TESE: PERFIL BIOQUÍMICO NA PÓS-COLHEITA DE FRUTOS DE *Musa* spp. ÊNFASE EM COMPOSTOS BIOATIVOS

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Botucatu, 30 de novembro de 2018

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RESUMO

O objetivo desse trabalho foi avaliar o perfil físico-químico e bioquímico, de genótipos de bananeiras (*Musa* spp.), com ênfase em amido resistente, carotenoides, aminas bioativas, compostos fenólicos e minerais. Todos os genótipos (bananas e plátanos) fazem parte do programa de seleção de germoplasmas da Embrapa que visa obter cultivares biofortificados e com melhor qualidade na pós-colheita. Os frutos obtidos de cada genótipo foram avaliados ao longo do amadurecimento em 3 estádios (verde: estádio 2; maduro: estádio 5 e super maduro: estádio 7) e 4 métodos de cocção (fervura em água – com e sem casca, micro-ondas – com e sem casca e fritura). No primeiro capítulo, constam as análises físico-químicas e bioquímicas de 19 genótipos de bananas e plátanos. Foi verificada ampla variação no comprimento, diâmetro dos frutos, massa fresca dos frutos, relação polpa casca e atributos físico-químicos, diferenciando os subgrupos e/ou diferentes tipos de bananas. A banana de sobremesa 'Ney Poovan' contém alto teor de sólidos solúveis totais e relação polpa-casca, um resultado interessante para a promoção do consumo *in natura* desse fruto. Os resultados encontrados mostram que bananas e plátanos são fontes importantes de compostos fenólicos. Os genótipos 'Ney Poovan', 'Ouro da Mata', 'Pelipita' e 'Tiparot' foram os que se destacaram nestes compostos antioxidantes. Níveis elevados de carotenoides foram encontrados em plátanos e/ou bananas de cocção e elevados teores de vitamina C foram verificados em plátanos (AAB) e na banana de sobremesa 'Prata' (AAB), principalmente nos frutos maduros. Os genótipos 'Pelipita' e 'Samurá B' são promissores para o uso industrial, principalmente para o processamento de *chips* de banana, tanto em frutos verdes, quanto maduros. No segundo capítulo, polpas e cascas de 22 genótipos foram analisados para a obtenção do perfil de carotenoides e potencial provitamina A. O conteúdo de pró-vitamínicos A foi variável entre os genótipos, e os plátanos foram os que apresentaram os maiores teores (e.g. 'Samurá B.'). O teor de carotenoides é afetado pelo estádio de amadurecimento e teores elevados são encontrados nos frutos maduros (estádio 5). Entre os métodos de cocção avaliados é possível destacar a ebulição dos frutos com casca, que aumentam a bioacessibilidade dos compostos bioativos, independente da cultivar utilizada. No capítulo 3, é apresentado o perfil de aminas bioativas em 20 genótipos ao longo do processo de amadurecimento e após o processamento térmico. As aminas tiramina, histamina, dopamina, serotonina, espermidina e espermina diminuíram ao longo do

amadurecimento e a amina putrescina aumentou. No entanto, em plátanos a serotonina e a dopamina não diminuíram no estádio 7, demonstrando uma possível diferenciação do perfil destas aminas por grupo de consumo. A casca é um subproduto importante na indústria de alimentos como fonte potencial de aminas bioativas, principalmente dopamina e serotonina. Além disso, o processamento térmico altera o conteúdo de aminas nos frutos, dependendo do composto e do genótipo analisado, principalmente a ebulição dos frutos com a casca, que deve ser o método preferido em preparações domésticas, principalmente para o consumo de maiores quantidades de catecolaminas e indolaminas. No quarto e último capítulo, foram avaliados os teores de amido, amido resistente, minerais e compostos fenólicos dentre os 22 genótipos. Os plátanos e as bananas de cocção se destacaram no teor de amido e amido resistente (até 49,9%). As polpas dos frutos das bananas de sobremesa 'Khai' e 'Ouro da Mata', e os frutos da banana de cocção 'Pacha Nadam', destacaram-se na maioria dos minerais analisados (P, K e Fe; Zn e Fe; Ca, Mg e Zn, respectivamente). O conteúdo de compostos fenólicos totais foi elevado nas bananas de sobremesa (e.g., 'Ney Poovan') e nas bananas de cocção (e.g., 'Tiparot'), principalmente nos frutos maduros (estádio 5), conferindo a estes frutos uma maior capacidade antioxidante. Além disso, o processamento térmico aumentou o valor funcional e nutricional dos frutos, principalmente quando fervidos (ebulição) com casca, o qual deve ser o preferido em preparações domésticas.

Palavras-chave: Processamento térmico. Amadurecimento. Biofortificação. Compostos bioativos. Antioxidantes.

ABSTRACT

The objective of this work was to evaluate the physico-chemical and biochemical profile of 22 accessions of banana trees (*Musa* spp), with emphasis on resistant starch, carotenoids, bioactive amines, phenolic compounds and minerals. All accesses (bananas or plantains) are part of the Embrapa germplasm selection program, which aims to obtain cultivars biofortified and with improved postharvest quality. Fruits obtained from each access were evaluated at 3 ripening stages (green: stage 2; ripe: stage 5; and super-ripe, stage 7) and 3 cooking methods (boiling, microwaving and stir-frying). In the first chapter, the physical-chemical and biochemical analyzes of 19 accessions were included. It was verified a wide variation in length, fruit diameter, fresh mass, pulp ratio and physical-chemical attributes, differentiating the subgroups and/or bananas types. The banana for dessert 'Ney Poovan' contain high total soluble solid content and pulp-to-peel ratio, an interesting result to promotion the *in natura* consumption of this fruit. Results show that bananas and plantains are important sources of phenolic compounds. The genotypes 'Ney Poovan', 'Ouro da Mata', 'Pelipita' and 'Tiparot' were the ones with remarkable antioxidant compounds. Increased levels of carotenoid were found in cooking bananas and/or plantains. High levels of vitamin C were observed in plantains (AAB) and dessert banana 'Prata' (AAB), especially in ripe fruits. The genotypes 'Pelipita' and 'Samurá B' are promising for industrial use, mainly for the production of banana chips, in both green and ripe fruits. In the second chapter, pulp and peel of 22 accessions were analyzed to obtain the profile of carotenoids and pro-vitamin A potential. The provitamin A carotenoids (pVACs) content varied according to the genotypes and high quantities were identified in plantains (e.g. 'Samurá B.'). Carotenoid content is affected by ripening stage and highest pVACs quantity was verified in the ripe fruit (stg 5). Among the evaluated cooking methods, it´s possible to emphasize the boiling of fruits with peel, which increased the bioaccessibility of the bioactive compounds, regardless of the cultivar used. In chapter 3, the profile of bioactive amines in 20 accessions is presented along the ripening and after the thermal processing. The amines tyramine, histamine, dopamine, serotonin, spermidine and spermine decreasing during the fruit ripening and the amine putrescine increased. However, in plantains serotonin and dopamine did not decrease in stage 7, showing a possible differentiation of the profile of these amines

by consumption group. Peel is an important by-product in the food industry as a potential source of bioactive amines, mainly dopamine and serotonin. In addition, the thermal processing changes the amine content in the fruits, depending on the compound and the genotype analyzed, mainly when fruits with peel are boiled, which should be the favorite in domestic preparations, mainly for the consumption of larger amounts of catecholamines and indolamines, regardless of the cultivar used. In the fourth and last chapter, the contents of starch, resistant starch, minerals and phenolic compounds among the 22 accessions were evaluated. Plantain and cooking bananas highlighted in terms of starch and resistant starch (up to 49.9%). The pulps of dessert bananas 'Khai' and 'Ouro da Mata', and cooking banana 'Pacha Nadam', stand out in most of the analyzed minerals (P, K and Fe, Zn and Fe, Ca, Mg and Zn, respectively). The content of total phenolic compounds was elevated in dessert bananas (e.g., 'Ney Poovan') and cooking bananas (e.g., 'Tiparot'), mainly in ripe fruits (stg 5), giving to these fruits a higher antioxidant capacity. In addition, the thermal processing increases the functional and nutritional values of the fruits, mainly by boiling with peel, which should be the favorite in domestic preparations.

Keywords: Boiling. Ripening. Biofortification. Bioactive compounds. Antioxidants

SUMÁRIO

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thermal processing affects the content of amines present in the fruit, depending on the compounds and on the analyzed genotype. The bioactive amines can suffer chemical modifications and alterations in their contents as a function of the thermal process used in the different methods of fruit preparation. For *Musa* spp. fruit, boiling with peel might be preferred in domestic preparations, mainly when the objective is to consume higher quantities of catecholamines and indolamines, regardless of the cultivar used.

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(e.g., phenolic compounds and minerals) and is a very important byproduct for the use in pharmaceutical and food industries. The determination of these metabolic profiles can be used to select possible crossings for genetic improvement programs for the banana tree, aiming the creation of biofortified cultivars and/or for promotion and incorporation in agricultural systems of genotypes with substantial quantities of phenolic compounds and minerals. The phenols, mainly the flavonoids catechin and quercetin, are the compound that contribute the most to the antioxidant activity of the *Musa* spp. germplasm. It is worth to stress out that the phenolic compounds content is affected by the ripening stage and superior values were found in the ripe fruit (stg. 5). In addition, the thermal process increases the functional and/or nutritional value of the *Musa* spp. fruit, mainly the ebullition cooking method (fruit with peel), which should be the preferred method in domestic preparation, regardless of the cultivar.

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CONSIDERAÇÕES FINAIS

A banana apresenta potencial como alimento promotor de saúde, em face de suas características funcionais. Entretanto, estas características estão dispersas em vários genótipos, requerendo ações do melhoramento genético com foco no desenvolvimento de cultivares biofortificadas que contribuam ao incremento da ingestão de nutrientes em populações menos favorecidas. Por meio deste trabalho é possível concluir que a identificação de genótipos em bancos ativos de germoplasma com teores superiores de compostos bioativos e seu uso em programas de melhoramento genéticos assistidos bioquimicamente, ou diretamente na alimentação humana, constituem estratégias racionais de uso de uma importante fração da biodiversidade em proveito de populações menos favorecidas, com menor impacto ambiental e econômico, no contexto de programas de mitigação da hipovitaminoses, e.g. De fato, a identificação de cultivares ricas em compostos funcionais possibilitará a incorporação em sistemas agrícolas existentes e tradicionais, (e.g., agricultores familiares), criando um nicho diferenciado de mercado, agregando valor ao produto e, consequentemente, aumentando a renda do produtor rural. Dentro do banco ativo de germoplasma da Embrapa Mandioca e Fruticultura pode-se afirmar que há grande variabilidade de características químicas e bioquímicas, sendo que há acessos com boas características pós-colheita, que poderiam ser explorados, tanto para o consumo *in natura*, como para a indústria de alimentos, principalmente quando comparados com as cultivares mais comercializadas atualmente (Capítulo 1). Além disso, foi constatada a presença de acessos divergentes e com quantidades superiores de compostos antioxidantes e/ou funcionais (vitamina C, aminas bioativas, pro-vitamínicos A, compostos fenólicos e vitamina C) que podem ser explorados em estudos bioquímicos que visam à caracterização e seleção de acessos com características químicas diferenciadas para serem utilizados em programas de melhoramento genético vegetal da cultura, bem como para a incorporação de cultivares biofortificadas nos sistemas agrícolas existentes (Capítulo 1, 2, 3 e 4). O modo em que são consumidos estes genótipos podem afetar o valor nutricional dos frutos, sendo o cozimento em água o preferível nas preparações domésticas, independente da cultivar utilizada (Capítulo 2, 3 e 4).

Tomados em conjunto, em um futuro próximo, espera-se que os resultados encontrados possam ser usados para selecionar possíveis cruzamentos em

programas de melhoramento genético da bananeira para a criação de cultivares com características importantes pós-colheita, além de biofortificadas, aumentando assim o valor nutricional e funcional da fruta. Concomitantemente, o conhecimento do perfil destes compostos ao longo do processo de amadurecimento dos frutos e na sua forma de consumo, pode contribuir para o aumento da qualidade dos frutos na pós-colheita, bem como para a escolha da melhor maneira de consumi-los quando o objetivo da população for a promoção e/ou prevenção da saúde humana.

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