ISSN 0101-2061

DOI: http://dx.doi.org/10.1590/1678-457X.18916

Characterization and study of functional properties of banana starch green variety of Mysore (*Musa* AAB - Mysore)

Sabrina de Medeiros FONTES[1*], Mônica Tejo CAVALCANTI[1], Roberlúcia Araújo CANDEIA[1], Eveline Lopes ALMEIDA[2]

Abstract

So that there is innovation in the development of food products with starch in its formulation, it can take into account the banana starch, which has higher content when the fruit is fully green. The starches and derivatives are used as ingredients or additives basic components added in small amounts to enhance the production, presentation and preservation of the product. This study aimed to characterize the green banana variety Mysore (*Musa* AAB - Mysore), studying their functional properties as well as its importance and use in the food industry. The starch extracted from green bananas were performed physico-chemical studies and functional properties. The yield amounted to a starch quality, with characteristics similar to other species of bananas. The results of studies of its functional properties reveal a less prone to starch retrogradation phenomenon. Starch showed results that indicate its use in many areas of the food industry (chilled foods, soups, pates), especially for the preparation of sauces sector, becoming an alternative technology and development of food products.

Keywords: amylopectin; amylose; extraction; regress; syneresis.

Practical Application: The study of unconventional starches assists in new technologies for the food sector.

1 Introduction

The banana belongs to the genus Musa of Musaceae family and the most important varieties grown in Brazil are: Silver, Pacovan, Dwarfed Silver, Apple, Mysore, Land and D'Angola, belonging to the group AAB genome; and Nanica, Nanicão and Grande Naine, belonging to the genome group AAA (Mota et al., 2000).

Fundamental characteristics of quality for consumers as flavor, aroma and texture (Matsuura et al., 2004) they are not always favorable in all varieties, so it should be considered processing options after the improvement of fruits for their increased use in the food industry.

The market starches, resistant, native and modified rapidly growing and products from starchy have been continuously developed. Consequently, its features are widely studied to meet specific technological properties (Jambrak et al., 2010). Besides the interest of ingredients containing components that influence in physiological or metabolic beneficial activities, the food industry search starches with features that provide increase your range of options in the processing of certain foods.

Given the importance of the banana crop in our country and taking into account the possibility of a nonconventional source of starch, the objective of this study was to characterize the green banana variety, Mysore (*Musa* AAB - Mysore), used as a raw material for the extraction of starch. And, out of this native starch, to perform the characterization and study of the functional properties.

2 Materials and methods

2.1 Materials

Unripe fruits of Mysore banana (*Musa* AAB - Mysore) were obtained in the town of Sousa, semiarid region of the state of Paraiba, Brazil. Immediately after harvest were used for the extraction of starch. All chemicals used in experiments were of analytical grade: sodium bisulphite, sodium hydroxide (Nuclear®), sulfuric acid (Chemical Moderna®), phenolphthalein, potassium sulfate (Impex®), copper sulfate (Impex®), boric acid (Impex®), methyl orange, green bromocresol, hydrochloric acid, dinitro-salicylic acid, anthrone (Vetec®), glucose (Labtest®), hexane, sodium carbonate, tannic acid (Cinética®), Folin-Ciocalteu method (Imbralab®), potato amylose (Sigma®) and iodine (Modern Chemistry).

2.2 Physical characterization of banana

The firmness of the bananas was evaluated by penetrometer (Instrutherm Measuring Instruments Ltda.®, Brazil).

2.3 Extraction and purification of starch

The extraction of starch was carried out according to the methodology described by Adebowale et al. (2006) with adaptations: 3.3 kg of bananas cut into slices were soaked in 6 L sodium bisulfite solution (0.1%) at 4 °C for 24 h. Bananas were grind in a UCB-950A industrial blender (Urano®, Brazil)

Received 11 July, 2016
Accepted 11 Dec., 2016
[1]*Unidade de Ciências e Tecnologia de Alimentos, Centro de Ciências e Tecnologia Agroalimentar, Universidade Federal de Campina Grande – UFCG, Pombal, PB, Brazil*
[2]*Departamento de Engenharia Bioquímica, Escola de Química, Universidade Federal do Rio de Janeiro – UFRJ, Rio de Janeiro, RJ, Brazil*
*Corresponding author: sabrina_fontes@hotmail.com

at full speed for 8 sec. The obtained suspension was sieved mesh 200 meshes and allowed to stand for 24 h at 4 °C. The obtained starch was washed twice with distilled water before drying in an stove with forced air circulation for 3 h at 45 °C ± 2 °C. It was then stored in polyethylene bags until further use.

2.4 Chemical composition

The banana and starch were characterized by the moisture content infrared balance, protein by Kjeldahl distiller and ash through the muffle according to the methods 44-15.02, 46-12.01 and 08-01.01 (American Association Cereal Chemists, 2010). The titratable acidity and pH were determined by pH meter according to the methods 981.12 and 942.15 (Association of Official Analytical Chemists, 2005).

The content of reducing carbohydrates is performed by DNS method proposed by Miller (1959). Quantification of the starch was carried out according to the method of anthrone (Moraes & Chaves, 1988) and the determination of phenolic compounds was performed according to procedures Goldstein & Swain (1963) based on tannin content present in the banana. The apparent amylose content of the starches was previously degreased was determined according to the methodology described by Martínez et al. (1989).

2.5 Morphology of the starch granules

The Scanning Electron Microscopy (SEM) was performed with energy dispersive x-ray detector Leo 440i (LEO Electron Microscopy Ltd.®, Cambridge United Kingdom). Before the analysis, the samples were placed on stubs and coated with gold in a sputter coater model SC7620 (VG Microtech, Uckfield, UK). A treatment of images was performed for the approximate determination of the size of the particles using the software ImageJ.

2.6 Thermal starch property

The Differential Scanning Calorimetry (DSC - Differential Scanning Calorimetry) was used to evaluate the thermal properties of starches although the DSC-60 calorimeter (Shimadzu, Japan) calibrated with indium. The transitions were characterized by the initial temperature (T_0), peak (T_p) and end (T_e), and the change in the enthalpy (ΔH) associated with the gelatinization process of the starch. These parameters were calculated using the TA60 software version 2.11 (Shimadzu, Japan). Two replicates were performed for each sample (proportion starch: water 1: 2).

2.7 Degree of molecular organization of starch

The degree of molecular organization was examined by infrared spectroscopy Fourier Transform (FT-IR). Infrared spectra (4000 to 400 cm^{-1}) of the samples (pellet formed by 2 mg of the starch and 200 mg of KBr) were obtained in Fourier transformed spectrophotometer (FT-IR) IR Prestige-21 (Shimadzu, Japan). Measurements were taken at a resolution of 4 cm^{-1} with 45 scans scan. It was used the IR Solution software version 1.21 (Shimadzu, Japan) to analysis of the curves fit.

2.8 Gelation study

The study of capacity of the starch gelation was analyzed according to the method described by Lawal & Adebowale (2005), in which starch suspensions at different concentrations were heated and cooled to obtain the minimum gelation concentration.

2.9 Paste properties

The starch paste properties were determined in the viscometer RVA (Rapid Visco Analyzer) Model 4+ (Newport Scientific Pty. Ltd.®, Australia) using the standard heating program 1. The viscosity profile and the parameters were calculated using the Thermocline software for Windows version 2.4 (Newport Scientific Pty. Ltd., Sydney, Australia). The measurements were performed in triplicate.

2.10 Syneresis

The syneresis was measured as the percentage (%) of water mass released over the initial weight of the starch, after centrifuging the samples at 1500 g for 15 minutes (Singh et al., 2004).

2.11 Swelling and solubility of starch

The methodology used for quantifying the swelling power and solubility of starch in function of the temperature is described as De La Torre-Gutiérrez et al. (2008), and then in function of pH were used the procedures described by Lawal & Adebowale (2005).

2.12 Absorption capacity of water and oil

Water absorption capacity (% WAC) and oil (OAC%) of green banana starch was performed by the method proposed by Beuchat (1977), using centrifugal Cientec® CT-5000R at 2000 rpm for 15 minutes at room temperature.

2.13 Clarity folder

The clarity of the paste was determined using the Singh et al. (2004) method with some modifications, with reading performed in spectrophotometer Biospectro® SP-220-650 nm transmittance at 24, 48, 72 and 120 h time.

2.14 Statistical analysis

The results were analyzed by analysis of variance (ANOVA) and submitted to the mean comparison test by Tukey, at a significance level of 5%, using Assistat program (Silva & Azevedo, 2009). Moreover, the data obtained in the study of some properties were expressed in graphs form in Figure 1, prepared by Excel software.

3 Results and discussion

The bananas had 28.72 N of firmness; it is the best parameter to determine the degree of ripeness of the fruit according Ditchfield (2004). The yield of extracted starch was 13.57%. The various techniques and existing varieties of banana, as well

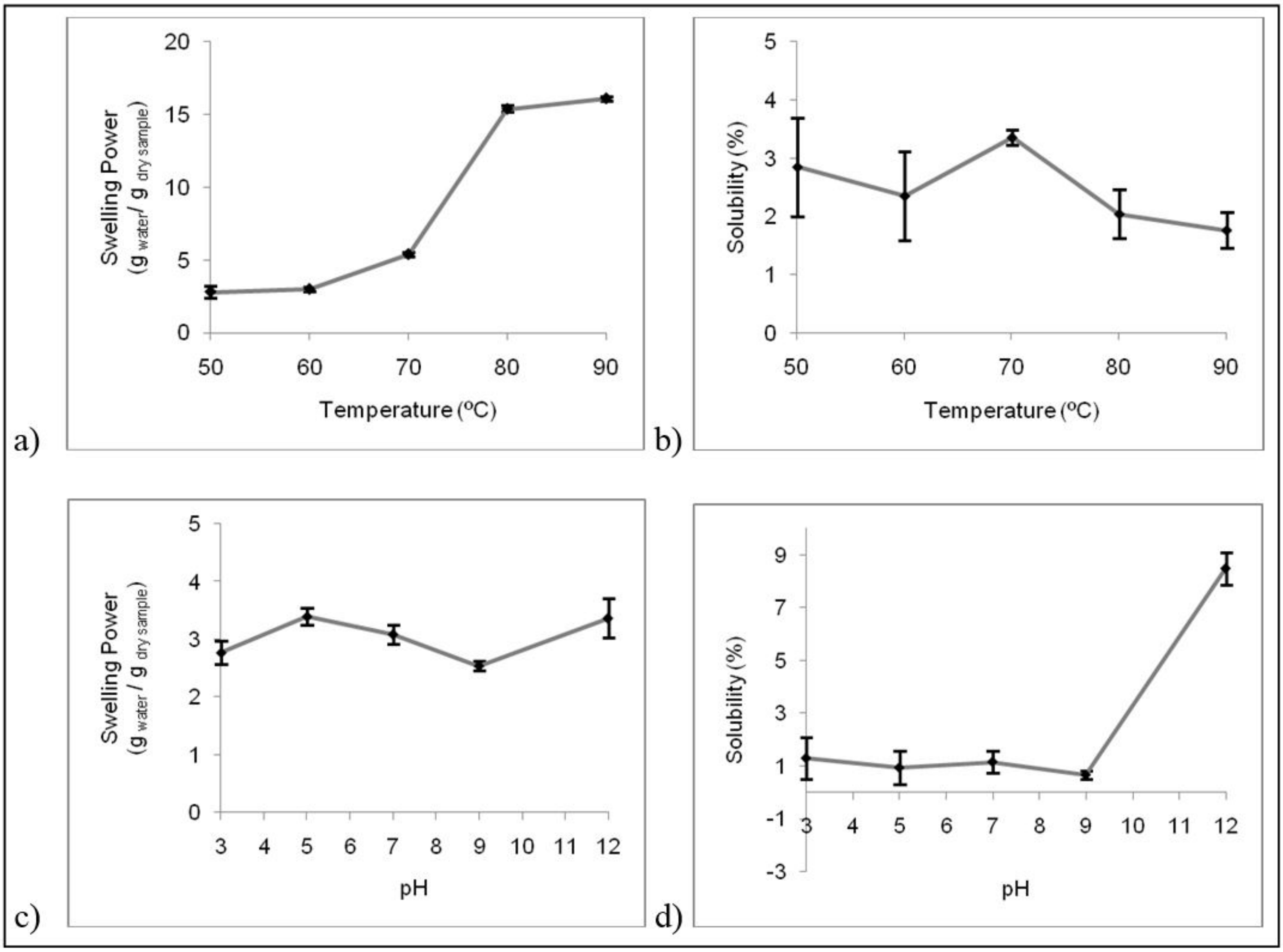

Figure 1. Swelling power (a) and solubility (b) in function of the temperature of the Mysore banana starch. Swelling power (c) and solubility (d) in function of the pH of the Mysore banana starch.

as various forms of extraction used in obtaining que starches are not a pattern exists in relation to the yield of this type of starch.

3.1 Chemical composition

In the Table 1 shows the results of the characterization of Mysore banana and starch extracted from the same. The moisture content presented results already expected, considering the banana in maturation stage must contain certain water content (60.07%) and after the extraction procedure, the starch has a high reduction of this content is falling percentage of 30.12%. The ash and protein content of the banana was 1.37% and 0.72%, respectively. Low ash and protein content indicate a higher quality of extracted starch as well as the procedure used in order that after extraction, the starch carries some constituents present in the tissues, even though in low amounts, may interfere with their properties (Leonel & Cereda, 2002). The values of acidity and pH of banana and starch were within expectations. The content of reducing sugars of the banana (0.36%) was within the range 0.10 to 0.90% (Leonel et al., 2011; Carvalho et al., 2011), value conducive to a still green fruit.

Table 1. Physical-chemical assessment of the green banana and the extracted starch.

Parameters	Green Banana	Starch
Humidity (%)	60.07 ± 0.63	12.30 ± 0.92
Ashes (%)	1.37 ± 0.07	0.09 ± 0.05
Proteins (%)	0.72 ± 0.25	0.44 ± 0.25
Acidity ($g_{ac. malic}$/100 g_{sample})	0.39 ± 0.07	-
pH	5.69 ± 0.03	5.25 ± 0.09
Reducing sugar (%)	0.36 ± 0.01	-
Starch (%)	52.22 ± 0.95	90.08 ± 0.18
Phenolic compounds ($g_{ac. tannic}$/100 g_{sample})	0.0026 ± 0.01	0.0024 ± 0.01
Amylose (%)	-	37.88 ± 0.44

Triplicate average ± standard deviation.

The starch content of banana (52.22%) show superior to other varieties such as Nanica (21.7%), Nanicão (23.1%) and Gold Colatina (22%) according to Mota et al. (1997). In the starch (90.08%) was similar to / or above the Nanica varieties of starches (79.7%), Male (98.10%) and Valery (99%) (Cardenette, 2006; Núnez-Santiago et al., 2004; Waliszewski et al., 2003). The amylose content of the starch was of 37.88%, which can influence effects such as starch granule swelling, gelatinization, and downgrading behavior during ingestion. The content of phenolic compounds found in banana and in the starch were low, being favorable for checking the undesirable features to food because it is an anti-nutritional factor (Pino & Lajolo, 2003).

3.2 Morphology of the starch granules

The Figure 2 shows the particles through image captured by scanning electron microscope (SEM), showing beads with sizes and different shapes, wherein there is a predominance of the ellipsoidal shape with irregular diameters ranging between axes 10 and 100 micrometers and smooth surface, which, according to Barbosa (2013), demonstrates integrity granules. Utrilla-Coello et al. (2014) studying Enano starch of banana, Morado, Valery and Male found that the major axes obtained similar variation to the Mysore starch, between 10 and 80 micrometers. The particle size amounted area and perimeter averages of 277.67 µm2 and 141.33 micrometers respectively (Figure 2). It was counted about 53 particles.

3.3 Thermal starch property

The curve Differential Scanning Calorimetry (DSC) is set in the Figure 3. The initial temperature (T_0), peak temperature (T_p) and end temperature (T_e) of the endotherm peak of gelatinization was 67.54 °C, 75.18 °C and 87.56 °C, respectively.

The enthalpy founded was 12.38 J/g. The gelatinization time is represented by $T_e - T_0$ temperature range, which was 20.02 °C. Note, according to the obtained results (Figure 3), that only an endothermic peak was obtained during the analysis of starch, which suggests, according Yoo & Jane (2002), that no amylose complexed with lipids. Similar results of the temperature and enthalpy were found in varieties like Nanicão Silver Anã, Morado and Male (Leonel et al., 2011; Utrilla-Coello et al., 2014). These results may be closely associated with the amylose levels found that ranged from 19-37%.

3.4 Degree of molecular organization of starch

The infrared spectrometry by Fourier Transform (FT-IR) has been used to estimate the amount of crystalline and amorphous domain of the starch structure, for evaluating the intensity of the absorbance at 1047 and 1022 cm^{-1}, respectively (Capron et al., 2007).

To make the rate of absorbance of the spectrum between the bands 1047 and 1022 cm-1 with the Mysore banana starch (*Musa* AAB - Mysore) find the value 0.92, that indicates a predominance of crystalline order of the molecules in the pellet.

This predominance of crystalline area below the amorphous area of the bead is much higher compared to the proportion found in green banana starch granules from other species as Williams and Red Banana of China (Musa coccinea), whose rates of these absorbance were close to 0.60 and 0.55, respectively (Jiang et al., 2015).

3.5 Gelation study

The Figure 4 clearly shows the results obtained in the study of gelation capacity of the Mysore banana starch. There was a variation according to the change in concentration of the samples.

At a concentration of 2%, the starch presented liquid estate and in the 4%, notorious viscosity. With 6%, the viscosity has

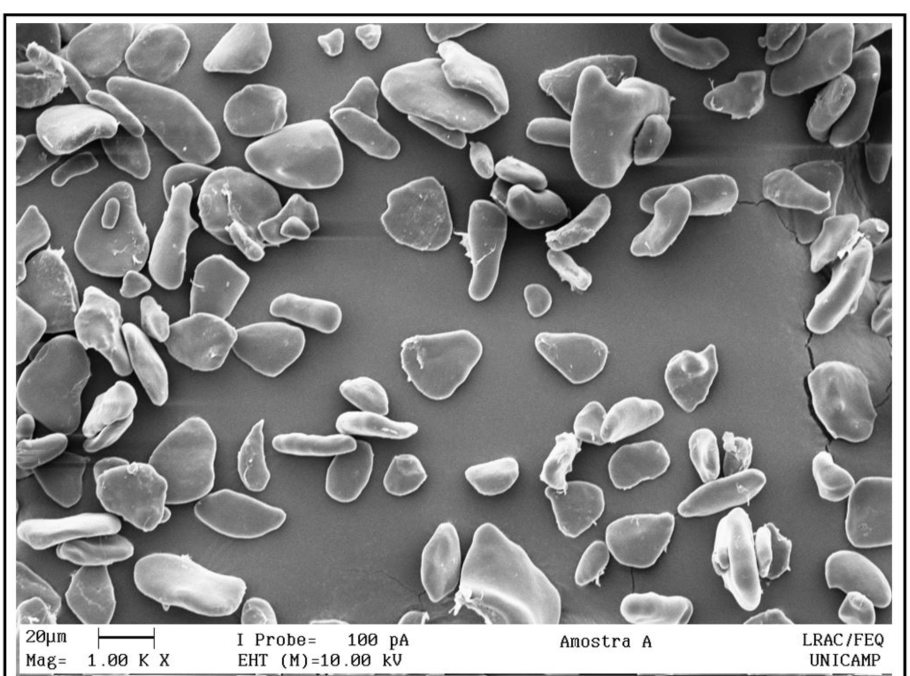

Figure 2. Morphology of the starch granules by SEM.

become firmer. Already at a concentration of 8% the starch shows a gelling state formation, which determines this percentage as the minimum concentration of gelation, because the sample of the inverted tube did not reach to slide in it (Figure 4b).

In the concentration range from 10 to 14% the starch proved to be completely steady, surpassing the gel point. Results of the minimum concentration of the gelation between 6 and 10% can be found in several studies with the starches extracted from unconventional sources (Farias et al., 2013; Cavalcanti et al., 2011).

3.6 Paste properties

The results obtained by Rapid Visco Analyser (RVA) in the starch can be seen on Table 2. The breakdown viscosity (breakdown) got higher result when compared to other native starches studied by Ascheri et al. (2010), Leonel et al. (2011), Oliveira et al. (2009) e Mota et al. (2000), indicating less resistance of gelatinized granules to mechanical fragmentation under shear.

It's perceptible a marked loss of the viscosity during the heating and shear process (Figure 5). At setback value it is observed that the banana starch has fewer tendencies to downgrading compared to other starches (Leonel et al., 2011; Ascheri et al., 2010). The paste temperature obtained by RVA was 79.1 °C, value that shows the approximate temperature range found by Leonel et al. (2011), which was 60-73 °C in banana starches. This value is consistent with the peak temperature shown in the DSC (75.18 °C) and shows a high resistance to expansion and rupture.

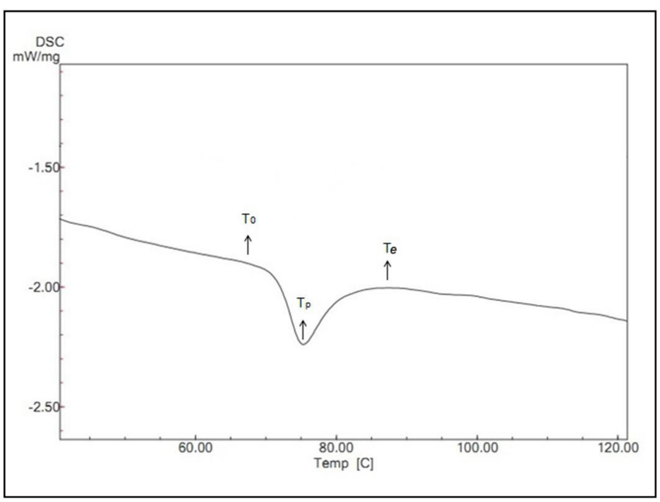

Figure 3. DSC curve for the banana starch.

3.7 Syneresis

It was observed that the starch gel showed syneresis after 24 hours of refrigerated storage and that syneresis increased to 48 hours. However, after 48 h, the syneresis percentage was decreasing, ranging from 10.51% ± 0.51 to 2.80 ± 0.54% (360 h), amounting to a loss of water of total 33.46%.

Low results of syneresis after a certain storage time, according to Muccillo (2009), may indicate that the starch is less prone to downgrading. This characteristic is enhanced where there is the result of the setback obtained in the RVA analysis. Low water contents released by starch gel as obtained in this study (33.46%) may indicate a higher possibility of applying starch or other refrigerated products which is undesirable syneresis (sauces, etc.).

3.8 Swelling and solubility

As there was a temperature rise from 70 °C, there was an increase in the swelling of starch granules (Figure 1a). The swelling continued gradually to 90 °C, which is consistent with the results found in the DSC analysis.

Table 2. Property of the paste (VAR) of Mysore banana starch.

Parameters	Results
Temperature paste (°C)	79.1 ± 0.8
Maximum viscosity (mv)	5,455.3 ± 45.9
Time Maximum viscosity (min)	4.5 ± 0.2
Minimum viscosity (cP)	3,034.0 ± 150.9
Breakdown (cP)	2,421.3 ± 114.8
Final viscosity (cP)	3,985.0 ± 84.3
Setback (cP)	951.0 ± 66.9

Triplicate average ± standard deviation.

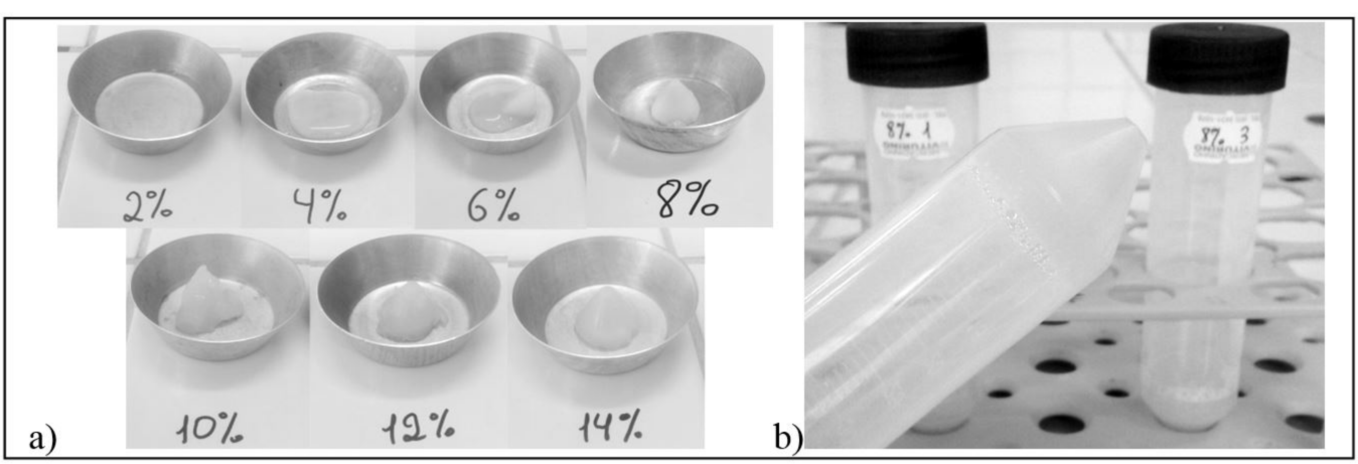

Figure 4. The starch samples with different concentrations (a); Minimum concentration of gelling obtained (b).

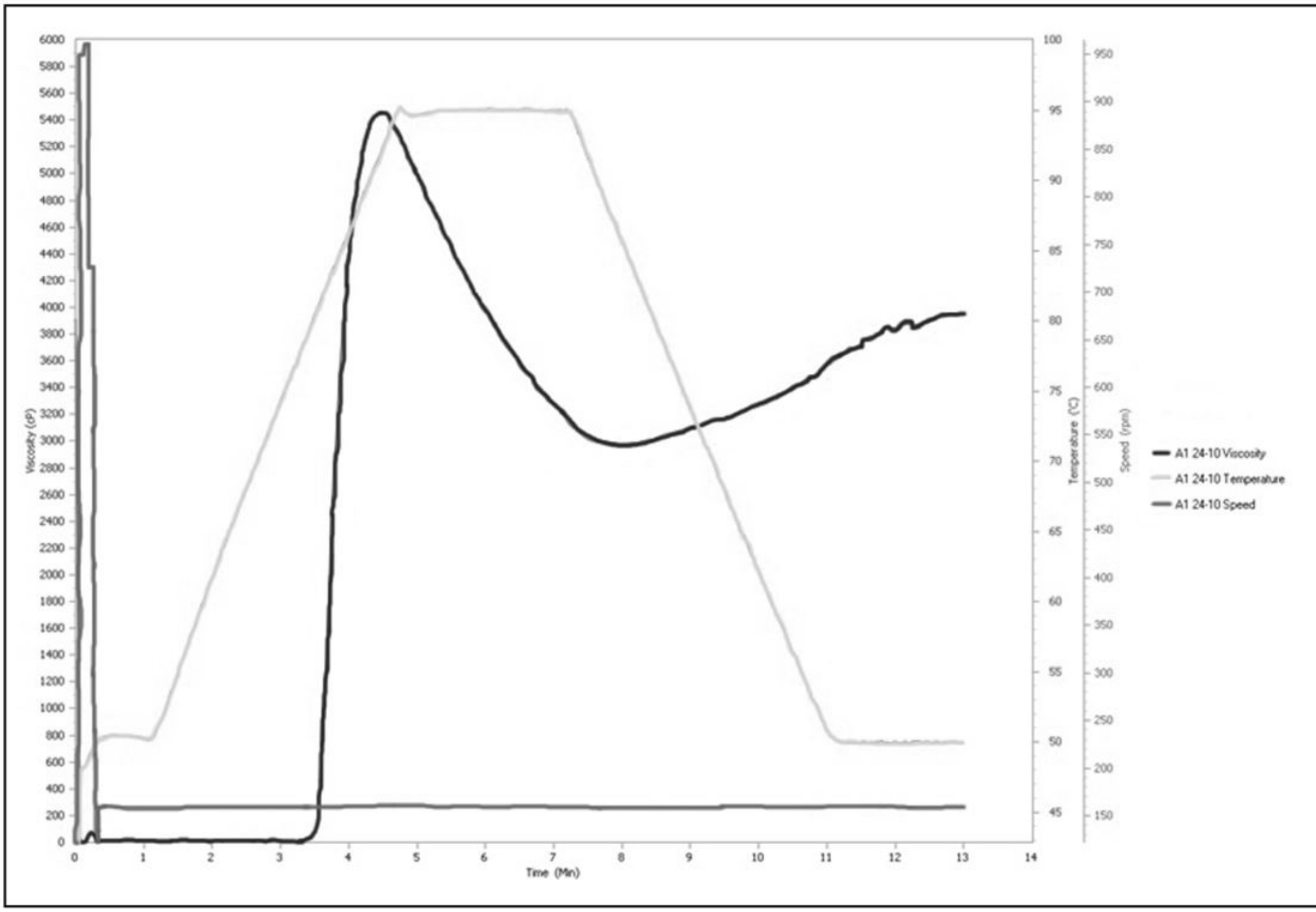

Figure 5. Viscosity profile of paste of Mysore banana starch.

An exponential increase in swelling can be noticed between 70-80 °C temperature range that is associated with the DSC peak temperature (75.18 °C) and of the paste of the RVA (79.1 °C).

Regardless to solubility, it was observed that there was an increase this property or swelling of the granules (60-70 °C) (Figure 1b). However, after 70 °C there was a reduction of solubility, probably due to disruption of the granule structure and leaching of compounds in the granules.

According to Sajilata et al. (2006), starches with reduced in the solubility can be directed to certain industrial applications, it offers good crispness and low water retention and fat.

The variation of the pH between 3 and 9 caused little effect on the solubility and swelling power of the starch (Figure 1c). However, from pH 9, there was an increase in these properties until pH 12. This was probably due to deprotonation of the hydroxyl groups of the starch molecules, leading to expulsion thereof and allowing greater water penetration in the granule (increased swelling and solubility).

3.9 Absorption capacity of the water and oil

In the water absorption capacity (WAC), a starch obtained a value of absorption of 1.19 g water / g starch. In the oil absorption capacity (OAC) gave a similar value when compared to water, 1.18 g oil / g starch. According to Resio et al. (2000), these characteristics can define the industrial interest of the starches in the formulation of food products.

3.10 Clarity folder

The higher the transmittance the higher the light of the folder, which indicates lower opacity and absorbance values. With the passage of the storage time the starch gels exhibited a decrease in transmittance and, consequently, greater opacity. Visually, starch gels can be considered moderately transparent compared to starch gels obtained by Silva et al. (2006), what makes their utilization is intermediary between the application in salad dressings or toppings of sweet pies, for example.

4 Conclusions

Mysore banana starch yield was low; however, this starch showed good features physicochemical and functional properties. It showed good power of swelling, which shows the potential for its use in products that require water retention, such as meat products and jellies.

The low percentage of water loss during storage and low setback obtained by folder profile study show that the starch is less prone to downgrading and syneresis, quite considerable factor when it comes to the development of products that need to be kept under refrigeration.

References

American Association Cereal Chemists – AACC. (2010). *Approved methods of analysis* (11th ed.). Saint Paul: AACC. Retrieved from http://methods.aaccnet.org/toc.aspx

Adebowale, K. O., Afolabi, T. A., & Oluowolabi, B. I. (2006). Functional, physicochemical and retrogradation properties of sword bean (*Canavalia gladiata*) acetylated and oxidized starches. *Carbohydrate Polymers*, 65(1), 93-101. http://dx.doi.org/10.1016/j.carbpol.2005.12.032.

Ascheri, D. P. R., Moura, W. S., Ascheri, J. L. R., & Carvalho, C. W. P. (2010). Caracterização física e físico-química de rizomas e amido do lírio-do-brejo (*Hedychium coronarium*). *Pesquisa Agropecuária Tropical*, 40(2), 159-166.

Association of Official Analytical Chemists – AOAC. (2005). *Official Methods of analysis of Association of Official Chemists* (13th ed.). Washington: AOAC.

Barbosa, M. C. (2013). *Efeito da adição de proteína nas propriedades físicas e reológicas dos géis obtidos a partir de amido da semente de jaca (Artocarpus integrifólia)* (Ph.D. thesis). Universidade Estadual do Sudoeste da Bahia, Itapetinga.

Beuchat, L. B. (1977). Functional and electro phonetic characteristics of succinylated peanut flour proteins. *Journal of Agricultural and Food Chemistry*, 25(2), 258-261. http://dx.doi.org/10.1021/jf60210a044.

Capron, I., Robert, P., Colonna, P., Brogly, M., & Planchot, V. (2007). Starch in rubbery and glassy states by FTIR spectroscopy. *Carbohydrate Polymers*, 68(2), 249-259. http://dx.doi.org/10.1016/j.carbpol.2006.12.015.

Cardenette, G. H. L. (2006). *Produtos derivados de banana verde (Musa spp) e sua influencia na tolerância à glicose e na fermentação colônica* (Ph.D. thesis). Universidade de São Paulo, São Paulo.

Carvalho, A. V., Seccadio, L. L., Mourão, M. Jr., & Nascimento, W. M. O. (2011). Qualidade pós-colheita de cultivares de bananeira do grupo 'maçã', na região de Belém – PA. *Revista Brasileira de Fruticultura*, 33(4), 1095-1102. http://dx.doi.org/10.1590/S0100-29452011000400007.

Cavalcanti, M. T., Silva, V. C., Costa, T. S., Florencio, I. M., & Florentino, E. R. (2011). Obtenção do amido do endocarpo da manga para diversificação produtiva na indústria de alimentos. *Revista Verde de Agroecologia e Desenvolvimento Sustentável*, 6(5), 80-83.

De La Torre-Gutiérrez, L., Chel-Guerrero, L. S., & Betancur-Ancona, D. (2008). Functional properties of square banana (*Musa balbisiana*) starch. *Food Chemistry*, 106(3), 1138-1144. http://dx.doi.org/10.1016/j.foodchem.2007.07.044.

Ditchfield, C. (2004). *Estudo do processamento contínuo do purê de banana* (Master's thesis). Universidade de São Paulo, São Paulo.

Farias, A. M., dos Reis, S. O., Farias, W. M., & de Carvalho, R. V. (2013). Extração e caracterização de amido de manga. In *Anais do XVII Encontro Latino Americano de Iniciação Científica, XIII Encontro Latino Americano de Pós-Graduação e III Encontro de Iniciação à Docência*, São José dos Campos.

Goldstein, J. L., & Swain, T. (1963). Changes in tannis in ripening fruits. *Phytochemistry*, 2(4), 371-383. http://dx.doi.org/10.1016/S0031-9422(00)84860-8.

Jambrak, A. R., Herceg, Z., Šubarić, D., Babić, J., Brnčić, M., Brnčić, S. R., Bosiljkov, T., Čvek, D., Tripalo, B., & Gelo, J. (2010). Ultrasound effect on physical properties of corn starch. *Carbohydrate Polymers*, 79(1), 91-100. http://dx.doi.org/10.1016/j.carbpol.2009.07.051.

Jiang, H., Zhang, Y., Hong, Y., Bi, Y., Gu, Z., Cheng, L., Li, Z., & Li, C. (2015). Digestibility and changes to structural characteristics of green banana starch during in vitro digestion. *Food Hydrocolloids*, 49, 192-199. http://dx.doi.org/10.1016/j.foodhyd.2015.03.023.

Lawal, O. S., & Adebowale, K. O. (2005). Physicochemical characteristics and thermal properties of chemically modified jack bean (*Canavalia ensiformis*) starch. *Carbohydrate Polymers*, 60(3), 331-341. http://dx.doi.org/10.1016/j.carbpol.2005.01.011.

Leonel, M., & Cereda, M. P. (2002). Caracterização físico-química de algumas tuberosas amiláceas. *Ciência e Tecnologia de Alimentos*, 22(1), 65-69. http://dx.doi.org/10.1590/S0101-20612002000100012.

Leonel, M., Carmo, E. L. C., Leonel, S., Franco, C. M. L., & Campanha, R. B. (2011). Extração e caracterização de diferentes genótipos de bananeira. *Revista Brasileira de Fruticultura*, 33(spe1), 599-605. http://dx.doi.org/10.1590/S0100-29452011000500082.

Martínez, C., Cuevas, F., & Medina, L. M. (1989). *Evaluación de lacalidad culinaria y molineradel arroz: guia de estúdio* (6th ed.). Cali: Centro Internacional de Agricultura Tropical.

Matsuura, F. C. A. U., Costa, J. I. P., & Folegatti, M. I. S. (2004). Marketing de banana: preferências do consumidor quanto aos atributos de qualidade dos frutos. *Revista Brasileira de Fruticultura*, 26(1), 48-52. http://dx.doi.org/10.1590/S0100-29452004000100014.

Miller, G. L. (1959). Use of dinitrosalicylle acid for determination of reducing sugar. *Analytical Chemistry*, 11(3), 426-428. http://dx.doi.org/10.1021/ac60147a030.

Moraes, O. M. G., & Chaves, M. B. (1988). Método espectrofotométrico para a determinação de amido em produtos cárneos. In *Anais do Encontro Nacional de Analistas de Alimentos*, Belo Horizonte.

Mota, R. V., Lajolo, F. M., & Cordenunsi, B. R. (1997). Composição em carboidratos de alguns cultivares de banana (*Musa* spp.) durante o amadurecimento. *Ciência e Tecnologia de Alimentos*, 17(2), 94-97. http://dx.doi.org/10.1590/S0101-20611997000200005.

Mota, R. V., Lajolo, F. M., Ciacco, C., & Cordenunsi, B. R. (2000). Composition and functional properties of banana flour from different varieties. *Stärke*, 52(2-3), 63-68. http://dx.doi.org/10.1002/(SICI)1521-379X(200004)52:2/3<63::AID-STAR63>3.0.CO;2-V.

Muccillo, R. C. S. T. (2009). *Caracterização e avaliação de amido nativo e modificado de pinhão mediante provas funcionais e térmicas* (Ph.D. thesis). Universidade Federal do Rio Grande do Sul, Porto Alegre.

Núnez-Santiago, M. C., Bello-Pérez, L. A., & Tecante, A. (2004). Sweeling-solubity characteristics, granule size distribution and rheological behaviour of banana (*Musa paradisiaca*) starch. *Carbohydrate Polymers*, 56(1), 65-75. http://dx.doi.org/10.1016/j.carbpol.2003.12.003.

Oliveira, T. M., Pirozi, M. R., Borges, J. T. S., Germani, R., & Fontes, M. P. F. (2009). Caracterização do amido de grão-de-bico (*Cicer arietinum* L.). *Boletim de Pesquisa do Centro de Pesquisa e Processamento de Alimentos da Fundação da Universidade Federal do Paraná*, 27(1), 27-42.

Pino, V. H. D., & Lajolo, F. M. (2003). Efecto inhibitorio de los taninos Del frijol carioca (*Phaseolus vulgaris* L.), sobre la digestibilidade de la paseolina por dos sistemas multienzimaticos. *Ciência e Tecnologia de Alimentos*, 23(1), 49-53. http://dx.doi.org/10.1590/S0101-20612003000100011.

Resio, A. N. C., Tolaba, M. P., & Suarez, C. (2000). Algumas propriedades físicas y térmicas Del almidón de amaranto. *Food Science & Technology International*, 6(5), 371-378. http://dx.doi.org/10.1177/108201320000600503.

Sajilata, M. G., Singhal, R. S., & Kulkarni, P. R. (2006). Resistant starch: a review. *Comprehensive Reviews in Food Science and Food Safety*, 5(1), 1-17. http://dx.doi.org/10.1111/j.1541-4337.2006.tb00076.x.

Silva, F. A. S., & Azevedo, C. A. V. (2009). Principal components analysis in the software assistat-statistical attendance. In *Proceedings of the 7th World Congress on Computers in Agriculture*, Reno.

Silva, G. O., Takizawa, F. F., Pedrosa, R. A., Franco, C. M. L., Leonel, M., Sarmento, S. B. S., & Demiate, I. M. (2006). Características físico-químicas de amidos modificados de grau alimentício comercializados no Brasil. *Ciência e Tecnologia de Alimentos*, 1(26), 188-197. http://dx.doi.org/10.1590/S0101-20612006000100030.

Singh, N., Sandhu, K. S., & Kaur, M. (2004). Characterization of starches separated from Indian chickpea (*Cicer arietinum* L.) cultivars. *Journal of Food Engineering*, 63(4), 441-449. http://dx.doi.org/10.1016/j.jfoodeng.2003.09.003.

Utrilla-Coello, R. G., Rodríguez-Huezo, M. E., Carrillo-Navas, H., Hernández-Jaimes, C., Vernon-Carter, E. J., & Alvarez-Ramirez, J. (2014). In vitro digestibility, physicochemical, thermal and rheological properties of banana starches. *Carbohydrate Polymers*, 101, 154-162. PMid:24299760. http://dx.doi.org/10.1016/j.carbpol.2013.09.019.

Waliszewski, K. N., Aparicio, M. A., Bello-Pérez, L. A., & Monroy, J. A. (2003). Changes of banana starch by chemical and physical modification. *Carbohydrate Polymers*, 52(3), 237-242. http://dx.doi.org/10.1016/S0144-8617(02)00270-9.

Yoo, S. H., & Jane, J. I. (2002). Structural and physical characteristics of waxy and other wheat starches. *Carbohydrate Polymers*, 49(3), 297-305. http://dx.doi.org/10.1016/S0144-8617(01)00338-1.