



Crystallinity, thermal and pasting properties of starches from different potato cultivars grown in Brazil



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ABSTRACT

Starches from different potato cultivars were characterized as amylose and phosphorus content, crystallinity, thermal and paste properties. Statistical analysis of amylose content showed difference between starches samples and the cultivars Asterix and BRS Clara showed higher contents than others. Phosphorus content ranged from 633 to 966.7 mg kg⁻¹. The X-ray diffraction analysis showed that the crystallization of potato starches can be classified as B-type X-ray pattern, presenting crystallinity index ranging from 20.02% to 21.59%. Regarding thermal properties, the onset temperature did not show statistical difference between starch samples, in gelatinization and retrogradation analysis. As expected there was a significant decrease in peak temperature and enthalpy after the retrogradation of starches. For the pasting properties results showed significant difference in all cultivars. Pearson correlation coefficients showed that amylose content was negatively correlated to the onset, peak and final temperature of gelatinization, final temperature of retrogradation and pasting temperature. Phosphorus content was positively correlated to crystallinity index, peak viscosity and breakdown. Starches extracted from potato varieties showed different characteristics which can be useful to food and related industries that make use of potato starch, allowing wide options of use in various sectors of industrial application in Brazil.

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1. Introduction

Potato (*Solanum tuberosum*) is one of the most important crops in the feeding the world population. It is in fourth in world production, after rice, wheat and maize, presenting nearly 36.7 million tons harvested in 2013. In the same year was harvest in Brazil 3.57 million tons of potatoes [1]. However, it is estimated that less than 50% of potatoes grown worldwide are consumed fresh. Industrial uses of potatoes include products like frozen fries, flakes, snacks, flour and starch [2].

Potatoes are planted in almost all Brazilian states although commercial cultivation is practiced predominantly in the South and Southeast where soil and climatic conditions are more favorable and the cultivation is strongest. More recently, the commercial cultivation has advanced to the states of Goiás and Bahia, Midwest and Northeast regions of Brazil respectively, which have plateaus with soil and climate conditions highly favorable to culture [3].

The potato stands out as tuber culture of greater economic importance to Brazil, being the country self-sufficient in the production of the same, though the consumption being only of the tuber *in nature*. Due to it, the country depends on the import of potato starch, because although there are great areas of cultivation, there is no processing of these tubers for extraction and marketing of starch. Starch is composed exclusively of glucose residues linked by only two types of bonds: α -1,4 and α -1,6 glycoside linkages. Amylose and amylopectin make up 98–99% of the dry weight of native granules, with the remainder comprising small amounts of lipids, minerals, and phosphorus in the form of phosphate esters. Amylopectin in the granule is present in the semi-crystalline structure, while amylose is located in amorphous. Starch granules possess different X-ray patterns, displaying A, B and C-type, depending on their amylopectin branch chain-length [4,5].

Starch varies greatly in form and functionality between and within botanical species, and even from the same plant cultivar grown under different conditions. This variability provides starches of diverse properties [6]. Starch contributes greatly to the textural properties of many foods and has many industrial applications as a thickener, colloidal stabilizer, gelling agent, bulking agent, water retention agent and adhesive [6].

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Most starch consumed by humans has undergone some form of processing, which usually involves heating in the presence of moisture under shear, and then cooling. During heat treatment, the starch granules are gelatinized, losing their crystallinity and structural organization. On cooling, the disaggregated starch molecules firstly form a gel and then retrograde gradually into semi crystalline aggregates that differ in form from the native granules. Understanding the steps that occur during gelatinization and retrogradation of a particular starch are key steps to better predict the functional properties of processed starch from knowledge of the structure of native granules [5].

The different pasting properties of starch from different cultivars may be due to the difference in granular size, phosphorous content and amylose content of starch granules. Considering pasting properties potato starches has the highest pasting viscosity, this characteristics is largely attributed to starch-bound phosphate [7]. The presence of phosphate groups in starch increases the hydration capacity of starch pastes after gelatinization, resulting in a correlation between the starch phosphate content and the starch viscosity changes and the gel-forming capacity [8]. Potato starches has higher concentration of phosphate than the starches from others botanical sources [9].

The relationship between the structural characteristics and functional properties of starches has received much attention, since it is important to understanding how the functional properties of starch are affected by its structural features. This information could provide the basis for further manipulation of appropriate quality attributes [10] and understand starch behavior and utilization [7]. The cooking, textural and rheological properties of potatoes are related to the physicochemical, morphological, thermal and rheological properties of their starches [11].

Considering the importance of the potato as a world source of starch, the fact that Brazil is the second largest producer of cassava starch with large companies involved with this process, and the yield potential of potato starch in the country, this study aimed to determine the crystallinity, thermal and pasting properties of starches which were isolated from six potato cultivars grown in Brazil in order to obtain information about their properties targeting future applications.

2. Material and methods

2.1. Raw materials used

The potato cultivars were grown in the Pouso Alegre city, Minas Gerais state, Brazil. The cultivars used were: Asterix, Atlantic, BRS Clara, Ágata, Mustang and Fontane. The extractions were performed by physical method with three repetitions by cultivar [12]. The moisture, lipids and protein content of the starches were determined following the AOAC [13].

2.2. Amylose content

Amylose content was determined according to ISO-6674 method [14]. The amylose content was calculated from standard curves of amylose and the results were expressed as percentage of amylose.

2.3. Phosphorus content

Phosphorus content was determined according to Malavolta et al. [15]. The phosphorus content in the digestion was measured as inorganic phosphorus, using the vanado-molybdate method to calculate the phosphorus content of starch (absorbance read at 420 nm).

2.4. X-ray analysis

Crystallinity were determined as follows, the starches were kept in a desiccator containing saturated solution of BaCl₂ (25 °C, aw=0.9) for 10 days for moisture balance. The X-ray diffraction patterns of the starches were then determined using a Wide Angle Goniometer unit (RINT2000, Rigaku, Tokyo, Japan), with Cu K α radiation (λ = 0.1542 nm). The scanning speed was 1°/min at 50 kV and 100 mA. The relative crystallinity was quantitatively estimated based on the relationship between the peak and total areas following the method of Nara and Komiya [16] using the Origin software (version 7.5, Microcal Inc., Northampton, MA, USA).

2.5. Thermal properties (DSC)

The thermal properties of potato starches were analyzed using a differential scanning calorimeter (DSC) Pyris 1 (Perkin Elmer, USA). Starch samples (about 2.5 mg, dry basis) were weighed into aluminum pans, mixed with distilled water (7.5 μ L) and sealed. The sealed pans were kept at room temperature for 2 h for balance and heated at a rate of 10 °C min⁻¹ from 25 °C to 100 °C. An empty pan was used as reference. After running the samples in DSC, they were refrigerated at 4 °C for 14 days and analyzed again under the same conditions to determine the thermal properties of retrograded starches. Gelatinization temperature (onset, peak and final) and enthalpy change of native and retrograded starches were determined using the Pyris 1 software from Perkin Elmer, USA [17].

2.6. Pasting properties

Pasting properties of potato starches were determined using a Rapid Visco Analyzer (Model RVA 4, Newport Scientific Pty. Ltd., Warriewood, Australia), using starch suspensions (2.5 g of starch in 25 mL of water), corrected for the basis of 14% of moisture. The program used was Standard 1 and viscosity was expressed as RVU. Obtaining results for peak viscosity, breakdown, final viscosity, retrogradation and pasting temperature.

2.7. Statistical analysis

Analysis of variance (ANOVA) and Tukey's test were used to conduct the statistical analysis of results. Significant differences were reported for $p < 0.05$. Pearson correlation coefficients were determined to evaluate relationship between variables.

3. Results and discussion

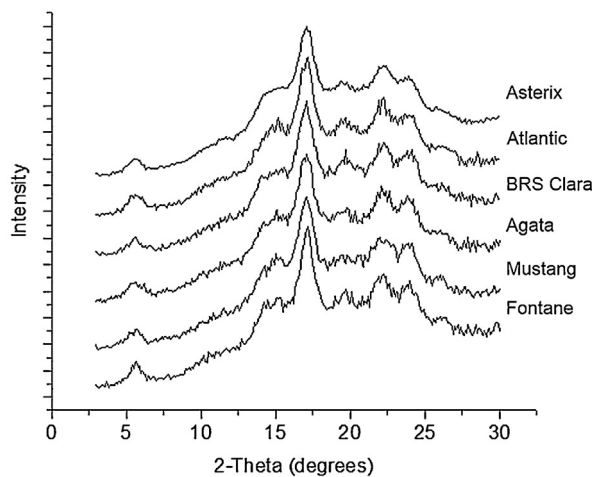
Table 1 shows the chemical composition of potato starches. Protein content ranged from 0.19 to 0.31%. Lipids content of potato starches showed low values ranging from 0.04% (Atlantic) to 0.14% (Mustang). The amylose content of potato starches presented low variation. Asterix cultivar had the highest amylose content (23.43%) while Mustang cultivar had the lowest value (16.10%). Amylose and amylopectin contents affect starch granule architecture in pasting properties, textural attributes and application for processed food. Similar results were found by Buléon et al. [18] and Noda et al. [19]. Results from Asterix cultivar confirmed previous reported results in which the phosphorus content was negatively correlated with the amylose content in potato starch [7,20]. Phosphorus content of potato starches ranged from 633 mg kg⁻¹ (Asterix) to 966.7 mg kg⁻¹ (Atlantic). The range of the phosphorus content was similar to that reported by Noda et al. [7], Noda et al. [19], Veselovsky [21], Wiesenborn et al. [22] and Kim et al. [23].

X-ray patterns of potato starches from different potato cultivars are presented in Fig. 1. All samples showed a typical B-type X-ray pattern, with major peaks at 5.6, 15, 17, 18 and 23 in 2θ .

Table 1
Protein, lipids, amylose and phosphorus content of potato starches.

Samples	Protein (%)	Lipids (%)	Amylose (%)	Phosphorus (mg kg ⁻¹)
Asterix	0.31 ± 0.01 ^b	0.09 ± 0.01 ^b	23.47 ± 1.17 ^c	633 ± 57.7 ^a
Atlantic	0.25 ± 0.04 ^{ab}	0.04 ± 0.01 ^a	20.33 ± 0.63 ^{abc}	966.7 ± 132.4 ^d
BRS Clara	0.26 ± 0.05 ^{ab}	0.11 ± 0.01 ^{bc}	23.33 ± 3.33 ^c	933 ± 100.0 ^c
Ágata	0.20 ± 0.01 ^{ab}	0.10 ± 0.02 ^{bc}	17.50 ± 1.11 ^{ab}	733 ± 152 ^b
Mustang	0.28 ± 0.04 ^{ab}	0.14 ± 0.01 ^c	16.10 ± 0.21 ^a	700 ± 100.0 ^b
Fontane	0.19 ± 0.02 ^a	0.07 ± 0.01 ^{ab}	20.97 ± 0.79 ^{bc}	900 ± 100.0 ^c

Means in the same column with different letters are significantly different ($p < 0.05$).

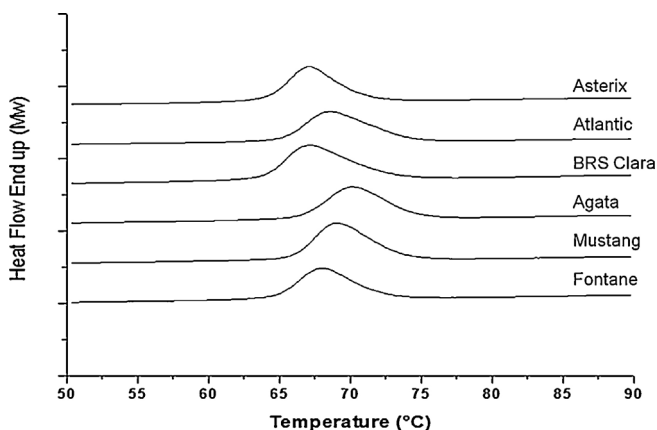
**Crystallinity index (%)**

Asterix	Atlantic	BRS Clara	Ágata	Mustang	Fontane
20.00±0.17 ^a	21.00±0.23 ^{ab}	20.50±0.09 ^{ab}	21.00±0.13 ^{ab}	20.50±0.46 ^{ab}	22.00±0.09 ^b

Fig. 1. X-ray diffraction patterns and crystallinity index of investigated potato starches. Means in the same line with different letters are significantly different ($p < 0.05$).

These results agree with those related by Zobel [24,25], Jane et al. [26], Buléon et al. [18], Protserov et al. [27]. The polymerization degree of the branched chains of amylopectin is related to the type of polymorphism [28] and in B-type starches typically exhibit large portion of long-chain ($DP > 37$). The crystallinity index of the potato starches ranged from 20.02% to 21.59%.

Data of thermal properties of potato starches are summarized in Table 2, and DSC gelatinization curves are shown in Fig. 2. The peak and final temperature and gelatinization enthalpies showed significant difference between potato starches samples, whereas no significant difference was found in onset temperature. The results

**Fig. 2.** DSC curves of investigated potato starches.

obtained were similar to those presented by Kaur et al. [11] who evaluating some properties of potatoes starches found that the endothermic peaks for different potato cultivars ranged from 59.96 to 68.89 °C, the temperature of peak ranged from 63.37 to 64.58 °C, and the final temperature ranged from 67.4 to 68.9 °C. But the range of enthalpy of gelatinization observed by these authors was lower than obtained in this research.

Starch from cultivars Asterix and BRS Clara showed higher amylose content than other (Table 1), and Asterix showed lower onset and peak temperature and lower enthalpy change of gelatinization. This fact could be due to these starches have more short chain length and lesser crystalline regions. The cultivar Mustang showed different behavior, low amylose content and low enthalpy change of gelatinization, and high onset temperature. Amylose content is one of the main factors that affect the physicochemical properties of starch, and higher amylose content may lead to a higher gelatinization temperature, lower peak viscosity and breakdown [29].

When starch is heated in the presence of enough water its crystalline organization decomposes to form amorphous regions. This molecular disordering is called gelatinization. Differential scanning calorimetric (DSC) identifies melting and crystallization events as well as glass transition temperatures. DSC provides a simple method for measuring the heat energy required for starch gelatinization [30].

The extension of crystalline perfection is reflected at the gelatinization temperature range and the change of enthalpy obtained by DSC [31]. Starches from different potato cultivars showed small range of gelatinization temperature and also showed high variation

Table 2
Thermal properties of gelatinization and retrogradation (DSC) of potato starches.

Gelatinization properties						
Samples	T_{onset} (°C)	T_{peak} (°C)	T_{final} (°C)	ΔT (°C)	ΔH (J g ⁻¹)	
Asterix	64.64 ± 0.04 ^a	67.32 ± 0.12 ^a	71.13 ± 0.11 ^a	6.49 ± 0.05 ^a	15.54 ± 0.16 ^a	
Atlantic	65.57 ± 0.08 ^a	68.74 ± 0.00 ^c	74.26 ± 0.06 ^{bc}	8.94 ± 0.44 ^b	17.74 ± 0.13 ^b	
BRS Clara	64.65 ± 0.03 ^a	67.74 ± 0.00 ^b	73.44 ± 0.10 ^{bc}	8.70 ± 0.17 ^b	16.45 ± 0.48 ^{ab}	
Ágata	66.66 ± 0.40 ^a	70.17 ± 0.35 ^d	74.80 ± 0.05 ^c	7.94 ± 0.41 ^{ab}	17.80 ± 0.50 ^b	
Mustang	66.29 ± 0.18 ^a	69.08 ± 0.24 ^c	73.32 ± 0.21 ^b	7.01 ± 0.30 ^a	16.30 ± 0.04 ^a	
Fontane	65.13 ± 0.09 ^a	68.16 ± 0.11 ^b	72.55 ± 0.18 ^{ab}	7.43 ± 0.28 ^{ab}	17.85 ± 0.49 ^b	
Retrogradation properties						
Samples	T_{onset} (°C)	T_{peak} (°C)	T_{final} (°C)	ΔT (°C)	ΔH (J g ⁻¹)	R (%)
Asterix	42.46 ± 0.45 ^a	53.11 ± 0.11 ^a	63.74 ± 0.67 ^a	21.28 ± 1.12 ^a	5.34 ± 0.04 ^a	35.44 ± 2.04 ^a
Atlantic	41.71 ± 0.56 ^a	54.04 ± 0.95 ^a	66.40 ± 0.37 ^{abc}	24.70 ± 0.93 ^{bc}	6.41 ± 0.03 ^b	36.22 ± 0.23 ^a
BRS Clara	41.55 ± 0.59 ^a	53.28 ± 0.11 ^a	67.33 ± 0.38 ^{bc}	25.78 ± 0.98 ^{bc}	6.98 ± 0.11 ^c	41.28 ± 0.30 ^{bc}
Ágata	42.89 ± 0.66 ^a	54.62 ± 0.12 ^a	66.00 ± 0.73 ^{abc}	23.11 ± 0.06 ^{ab}	6.39 ± 0.10 ^b	35.38 ± 0.17 ^a
Mustang	41.11 ± 0.10 ^a	53.31 ± 0.37 ^a	68.37 ± 0.01 ^c	27.26 ± 0.11 ^c	6.70 ± 0.23 ^c	42.66 ± 0.94 ^c
Fontane	41.53 ± 0.36 ^a	53.45 ± 0.59 ^a	64.82 ± 0.62 ^{ab}	23.30 ± 0.98 ^{ab}	6.64 ± 0.05 ^c	37.21 ± 1.31 ^{ab}

T , temperature; $\Delta T = T_{\text{final}} - T_{\text{onset}}$; ΔH , enthalpy change of gelatinization and retrogradation; R , retrogradation range. Means in the same column with different letters are significantly different ($p < 0.05$).

Table 3
Pasting properties of investigated potato starches (Rapid Visco Analyzer).

Sample	Peak viscosity (RVU)	Breakdown (RVU)	Final viscosity (RVU)	Setback (%)	Pasting temp. (°C)
Asterix	593.55 ± 0.53 ^a	258.31 ± 2.00 ^a	396.97 ± 2.77 ^d	61.73 ± 0.24 ^c	70.98 ± 0.04 ^a
Atlantic	1004.14 ± 22.09 ^d	677.81 ± 17.43 ^d	367.31 ± 0.06 ^c	40.98 ± 4.59 ^a	71.93 ± 0.04 ^a
BRS Clara	795.18 ± 14.84 ^c	502.13 ± 17.20 ^c	346.61 ± 1.65 ^b	53.56 ± 4.01 ^{bc}	71.08 ± 0.11 ^a
Ágata	645.28 ± 8.54 ^b	310.92 ± 11.49 ^b	393.38 ± 0.41 ^d	59.02 ± 3.36 ^{bc}	73.50 ± 0.07 ^b
Mustang	812.76 ± 4.48 ^c	520.21 ± 4.71 ^c	333.20 ± 1.18 ^a	40.65 ± 1.41 ^a	71.80 ± 0.07 ^a
Fontane	827.25 ± 8.84 ^c	530.37 ± 8.25 ^c	346.99 ± 3.12 ^b	50.10 ± 2.53 ^{ab}	71.05 ± 0.14 ^a

RVU, rapid visco units; temp., temperature. Means in the same column with different letters are significantly different ($p < 0.05$).

of enthalpy change, suggesting a greater perfection and homogeneity of the crystals. On cooling, the disaggregated starch molecules first form a gel and then retrograde gradually into semi-crystalline aggregates that differ in form from native granules. The recrystallization, which occurs during long storage period, is attributed to amylopectin fractions [32].

The analysis of the thermal properties of retrograded starches showed reduction of the onset, peak and final temperatures when compared with those obtained for native starches (Table 2). This reduction occurs because of an improper alignment of the chains of amylopectin during the re-associating, causing formation less ordered and less stable crystal structures than those existing in the native starch. In this way less energy is required to melt the crystals [32,33].

The potato starches showed high values of retrogradation range (Table 2), which may suggest that these starches exhibit higher proportion of very long branched chains of the amylopectin. According to Rocha et al. [34], there is a relationship between higher proportions of branched chains of amylopectin with high rates of retrogradation.

The pasting characteristics play an important role in the selection of a variety for use in the industry as a thickener and binder. The pasting properties of potato starches are presented in Table 3. The peak viscosity, breakdown, final viscosity and setback of potato starches varied greatly, while similar pasting temperature were observed.

The Ágata cultivar present significant difference of pasting temperature for other, with highest value (73.50 °C), however, lower values were found by Liu et al. [35]. The starch of the cultivar Atlantic showed highest peak viscosity (1004.14 RVU), while starch of cultivar Asterix showed lowest peak viscosity (593.55 RVU). Asterix cultivar also showed lowest breakdown (258.31 RVU) while Atlantic had higher value (677.81 RVU). The inverse behavior was

observed in setback, so the Asterix had the highest value while Atlantic had the lowest (Table 3). These results are according to correlation between higher amylose content and lower phosphorus content (Tables 1 and 4), which lead to lower peak viscosity and breakdown, but higher setback in potato starches, due to network of amylose content [20,36].

Gelatinization occurs when native starch is heated in the presence of sufficient moisture. The granules absorb water and swell, and the crystalline organization is irreversibly disrupted. Amylose molecules begin to leach from the granules as they are disrupted under shear and the viscosity of the resulting paste increases to a maximum, which corresponds to the point when the number of swollen but still intact starch granules is at a maximum. The maximum is followed by a decrease in paste viscosity, as the granules rupture and starch molecules are dispersed in the aqueous phase [5].

The viscosity of breaking permits evaluating the stability of the product at high temperatures under mechanical stirring and is directly related to the peak of viscosity [37]. The peak height at a given concentration reflects the ability of the granules to swell freely prior to physical breakdown. Starches that are capable of swelling to a high degree are also less resistant to breakage during cooking showing significant decrease in viscosity after reaching the peak [38,39]. In the cultivars Asterix, Atlantic and Ágata was observed significant decrease in viscosity after reaching the peak, presenting values of breakdown almost half of the values of peak viscosity, showing that these starches are less resistant to cooking.

Pearson correlation coefficients amongst starch properties are shown in Table 4. Protein content was negatively correlated to the enthalpy change of gelatinization ($r = -0.65$, $p < 0.01$) and crystallinity index ($r = -0.56$, $p < 0.05$). Lipids content was positively correlated to the final temperature of gelatinization ($r = 0.49$, $p < 0.05$) and retrogradation range ($r = 0.67$, $p < 0.01$). Amylose

Table 4
Pearson correlation between physicochemical and starch properties of potato starches.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. Protein	1.00																		
2. Lipids		1.00																	
3. Amylose			1.00																
4. Phosphorus				1.00															
5. T_{onset}					1.00														
6. T_{peak}						1.00													
7. T_{final}							1.00												
8. ΔH								1.00											
9. T_{onset} retro									1.00										
10. T_{peak} retro										1.00									
11. T_{final} retro											1.00								
12. ΔH retro												1.00							
13. Retro (%)													1.00						
14. Crystallinity														1.00					
15. PV															1.00				
16. BD																1.00			
17. FV																	1.00		
18. SB																		1.00	
19. PT																			1.00

Only significantly correlated variables and coefficients are shown. T_0 , T_p , T_c and ΔH , onset, peak and conclusion temperature and enthalpy change; retro, retrogradation; PV, BD, FV, SB and PT, peak viscosity, breakdown, final viscosity, setback and pasting temperature.

* $p < 0.05$.

† $p < 0.01$.

ψ $p < 0.001$.

content was negatively correlated to the onset, peak and final temperature of gelatinization, final temperature of retrogradation and pasting temperature. It is widely accepted that high amylose is the major factor contributing to low peak viscosity, since the extent of starch swelling is presumed to be interrupted by an increase in the amylose content [29,40–42]. However, Wiesenborn et al. [22] and Ganga and Corke [43] reported that the amylose content did not have an effect on the peak viscosity for potato starch. In this study, there was no correlation between the viscosity peak and breakdown for the potato starch as also observed by Karim et al. [20] and Noda et al. [7].

Phosphorus content was positively correlated to crystallinity index ($r = 0.47$, $p < 0.05$), peak viscosity ($r = 0.58$, $p < 0.05$) and breakdown ($r = 0.57$, $p < 0.05$) confirming that the phosphorus content affect pasting properties in potato starch [7,20,44]. Nutting [45] reported that when potato starch is pasted its phosphate groups ionize leaving the starch with a negative charge, resulting in the slight Coulombic repulsion that opens up the branched amylopectin molecules and increases their solvation. Compared with an electrically neutral starch this increased solvation results in larger pasted granules and a higher starch paste viscosity [45]. No correlation between setback and phosphorus content was observed in this study as also observed by Lu et al. [44]. However this correlation was observed by Noda et al. [7]. Analysis of phosphorus content is assumed to be useful for predicting the pasting properties in potato starch [7] and have directly correlates to the pasting properties of starch [44].

Generally, the thermal properties of starch studied by DSC are mainly based on the crystallinity of the amylopectin in starch granule. High phosphorus content is usually associated with a larger amount of amylopectin, rather than directly correlating to transition enthalpy of starch. However, the phosphorus content did not have an impact on this study, which agrees with previous reports [23,46–48].

Enthalpy of gelatinization (ΔH_{gel}) gives an overall measure of crystallinity (quality and quantity) and is an indicator of the loss of molecular order within the granule. The amount of double-helical order in native starches should be strongly correlated to the amylopectin content and granule crystallinity increases with amylopectin content [49]. In this study, the enthalpy change was positively correlated with the crystallinity index ($r = 0.69$, $p < 0.01$) and also correlated with pasting temperature ($r = 0.058$, $p < 0.05$) and peak temperature of retrogradation ($r = 0.72$, $p < 0.01$). Whereas the enthalpy change of retrogradation was positively correlated with retrogradation range ($r = 0.63$, $p < 0.01$), crystallinity index ($r = 0.51$, $p < 0.05$), peak viscosity ($r = 0.55$, $p < 0.05$) and breakdown ($r = 0.63$, $p < 0.001$), and negatively correlated with final viscosity ($r = -0.77$, $p < 0.001$) and setback ($r = -0.52$, $p < 0.05$). Generally, gelatinization temperature and enthalpy change are positively correlated to the stability crystalline structures [50], but this correlation was not observed in this study. Crystallinity index showed correlation with pasting properties, being positively correlated to peak viscosity and breakdown, and negatively correlated to final viscosity and setback.

4. Conclusion

The growing starch markets have led to food industries to a constant demand for starches with specific properties that meet the demands of applicability. In this way have increased the studies on native starches that can have characteristics of commercial interests. This study showed that starch extracted from important potato cultivars grown in Brazil differed in the physical, chemical and rheological properties. All samples showed a typical B-type X-ray pattern. The phosphorus content of the starches had a more

pronounced effect than the amylose in paste properties. Starches extracted from Asterix, Ágata and Atlantic cultivars showed low hot paste stability with stirring. Starches from different potato cultivars showed small range of gelatinization temperature and also showed high variation of enthalpy. The potato cultivars showed potential as a source of native starches in Brazil.

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