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Prediction of sweetpotato starch physiochemical quality and pasting properties using near-infrared reflectance spectroscopy

Guoquan Lu [a,*], Huahong Huang [a], Dapeng Zhang [b]

[a] Department of Agronomy, College of Agriculture and Biotechnology, Zhejiang University, No. 268 Kaixuan Road, Huajiachi Campus, Hangzhou 310029, Zhejiang, China
[b] The International Potato Center, Lima, Peru

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Abstract

A rapid predictive method based on near-infrared reflectance (NIR) spectroscopy (NIRS) was developed to measure sweetpotato starch physiochemical quality and pasting properties. The starch samples were scanned by NIRS and analyzed for quality properties by reference methods, respectively. Results of statistical modeling indicated that NIRS was reasonably accurate in predicting amylose content (AC), amylose percent (AP), total starch content (TSC), protein content (PRC), phosphorus content (PHC), solubility (SOL), swelling power (SP), average granule diameter (AGD), big granule percent (BGP), small granule percent (SGP), crystallinity (CRY), peak viscosity (PKV), hot paste viscosity (HPV), setback (SB), and pasting temperature (P_{temp}) with high coefficients of determination (RSQ = 0.85–0.92) and relatively low standard errors of prediction. The results showed that NIR analysis was sufficiently accurate and effective for rapid evaluation of starch physicochemical properties in sweetpotato. The NIR-based protocol developed in this study can be used for screening large number of starch samples in food enterprises and sweetpotato breeding programs.

Keywords: Sweetpotato; Starch; Physiochemical quality; Pasting property; Near-infrared reflectance spectroscopy

1. Introduction

Sweetpotato (*Ipomoea batatas* (L.) Lam) is among the world's most important, versatile, and under exploited food crops. It can be used as a high nutritional vegetable, and also as industrial materials to process starch, noodle, alcoholic beverage, and many processing snack foods. Sweetpotato storage roots contain approximately 70% starch of the total dry weight (Lu & Sheng, 1990). Sweetpotato quality for many diverse purposes is mainly derived from its starch content and properties. Much work has been done on determination of sweetpotato starch contents, but information on its starch quality remains scarce (Collado, Mabesa, & Corke, 1999; Lu, 2000, 2003). Starch properties of interest includes chemical, physical, pasting and crystallinity. The amylose content of sweetpotato starch is considered to be one of the most important factors influencing the cooking and textural qualities of whole storage root, and quality of sweetpotato starch-based foods (Collado et al., 1999). Starch granule size and distribution affect cooking time, noodle quality and modified starch quality (Collado et al., 1999; Lin, Wheatley, Chen, & Song, 1997). Starch pasting properties influence sweetpotato eating quality and noodle quality, and also are directly responsible for starch industrial uses (Collado et al., 1999).

Many studies on relationships among starch quality parameters indicated that even where correlation coefficients were significant, they might not always be consistent because of the wide diversity of sweetpotato

* Corresponding author. Tel.: +86 571 86971951; fax: +86 571 86971117.
E-mail addresses: lugq10@zju.edu.cn, lugq@mail.hz.zj.cn (G. Lu).

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genotypes, and the complexity of the inheritance of quality parameters (Lu, 2003). Therefore, it is necessary to test every important parameter of sweetpotato starch quality. In sweetpotato quality breeding program, early generation lines of sweetpotatoes are tested for many years and are retained because they possess good agronomic characteristics, but they are often discarded later if analysis shows a deficiency in starch. These traits that are considered important for the end-use objective of the breeding program are usually highly heritable and therefore breeding sweetpotato for desired physicochemical properties is feasible and selection can be started in early generations. However, this feasibility could not be realized unless breeders are supported with rapid and cost-effective methods to screen large number of samples in a timely fashion. In fact, because of the lacking of efficient screening methods, breeders in the current sweetpotato improvement programs can only afford evaluating starch physicochemical properties in advanced generations with a small number of clones. Clones with good agronomic characteristics often have to be discarded in advanced generation because analysis shows they have unsatisfied starch quality.

Traditional assay methods for starch quality parameters may have limitations. AC measured by iodine-blue colorimetry is prone to inter-laboratory variability because of the complexity of the procedure and its reliance on amylose and amylopectin standards for establishing reference curves (Bao, Cai, & Corke, 2001). With the paste viscosity properties performed with an RVA, fewer than 5 samples per hour can be run. Crystallinity measurement also requires X-ray diffraction, a kind of complex and expensive equipment. All these laboratory measurements of starch quality parameters are too laborious, expensive, complex and time-consumptive to efficiently screen many progeny produced in breeding programs and/or rapidly evaluate starch quality in starch and food industry. Therefore, a rapid, simple, resource-saving and accurate test to predict all starch quality parameters would be very useful to sweetpotato breeders and food processors.

The near-infrared reflectance spectroscopy (NIRS) technique is currently used in large-scale routine analysis of some quality traits of many crops (Wu, Shi, & Zhang, 2002) and also in starch analysis. The main advantages of the NIRS technique are that it saves time, economical, and allows the simultaneous estimation of several traits in one measurement. These advantages make it an ideal technique for plant breeding programs (Lu & Sheng, 1990). In rice, Bao et al. (2001) found strong relationships of NIR data with several important starch quality indexes including AC, SB and BD, and believed that NIR analysis is sufficiently accurate for routine screening of large numbers of samples in early generation selection in rice breeding programs. Although NIR analysis in sweetpotato was studied in dry, ground samples (Ishiguro & Yamakawa, 1998; Lu & Sheng, 1990; Wu, Lai, Lee, & Chen, 1995) and also in fresh samples (Katayama, Komaki, & Tamiya, 1996), there is no report on NIR analyses for sweetpotato starch samples.

The present study is focused on the determination of important starch quality characteristics, including starch physiochemical parameters, RVA pasting parameters, and crystallinity properties of sweetpotato starch samples in a large set of sweetpotato varieties. The objective was to develop a rapid and accurate NIR measurement of these quality parameters, and to evaluate its potential application in sweetpotato breeding and sweetpotato starch based food industry.

2. Materials and methods

2.1. Starch sample preparation

A total of 93 sweetpotato genotypes including commercial varieties and advanced breeding lines were selected based on the criteria described by Lu, George, and Zhou (2003). The most important selection criteria is that this set of genotypes should have a broad range of diversity in terms of starch content and starch physicochemical properties in sweetpotato. All genotypes were grown at the experimental farm of Zhejiang University for observational trial in 1999. Out of the 93 genotypes, 21 were selected and planted in other 5 locations for a multiple location trial.

Starches were extracted within one week after harvesting. Starch was isolated as follows: appropriately 5 storage roots were cut into small rectangles that was crushed with 160 ml of running water for 90 s and sieved by 150-μm mesh. Isolated starch was dried at room temperature and was further dried at 100 °C. Dried starch was ground with a model 3010-019 Cyclone grinder (Udy Corp., Fort Collins, CO, USA). All dried starch samples were carefully kept in sealed, dried containers for further use.

2.2. Reference analysis of starch quality characteristics

Amylose content (AC) was analyzed by determining the absorption spectra of iodine–starch complexes at 680 nm using potato amylose as standard (Lu, 2000). Total starch contents were determined by amylase hydrolysis (Reagent kits, Megazyme Co, Ireland) and 3,5-Dinitrosalicylic acid colorimetry (Lu, 2000). Amylose percent (AP) was calculated based on AC and TSC. Protein content (PRC) in sweetpotato starch samples was determined using the Kjeldahl method ($N \times 6.25$), and phosphorus content (PHC) was analyzed by common colorimetry (He, 2000).

Analysis for swelling power (SP) and solubility (SOL) followed the methods of Collado et al. (1999) with some

modifications. 0.15 g (W) of starch samples were weighed and put into small weighed tube (W_1) and added 5 ml distilled water and kept at 25 °C for 5 min, then heated on water bath at 92.5 °C for 30 min after cooling in the iced water for 1 min and kept at 25 °C for 5 min. Starch samples were centrifuged twice at 4200 rpm for 10 min. All supernatant liquor was combined and the solid matter in this liquor was measured as SOL by the same determination method as TSC. The total weight of pasting samples and tube was weighed (W_2). The calculation of swelling power followed the formula: $SP = (W_2 - W_1)/W$.

Sweetpotato granule size and distribution was measured by microscopy Olympus under 400× magnification after dying with iodine–potassium iodine (KI–I) solution. All starch granules were divided into three groups, big granules (>21 μm in diameter), middle granule (11–20 μm) and small granule (<10 μm). The numbers of different size granules were recorded each visual field. Average granule diameter (AGD), big granule percent (BGP), middle granule percent (MGP) and small granule percent (SGP) were calculated following Lu's method (2003).

X-ray diffraction patterns were determined using the wide-angle X-ray scattering technique (WAXS, Philips Co, Netherlands). The crystallinity was computed by integral method (Hoover, 2001).

The paste viscosity properties of sweetpotato peak viscosity (PKV), hot paste viscosity (HPV), cool paste viscosity (CPV) and the difference expressions, breakdown (BD, PKV − HPV), and setback (SB, CPV − PKV) as well as pasting temperature (P_{temp}) were measured on a Rapid Viscosity Analyzer (RVA) model 3-D equipped with Thermal Cycle for Windows, (TCW) (Newport Scientific, Warriewood, NSW, Australia) according to AACC (AACC, 1995) method 61-02 for RVA.

All reference laboratory measurements were duplicated. These data were imported into the NIRS spectral data file, and used to develop calibration models. The 198 samples were sorted by reference data for each constituent, and every third sample was extracted for an external validation group, so all samples were divided into NIR calibration set ($n = 128$) and independent validation set ($n = 70$) (Table 1).

2.3. NIR analysis

NIR spectrometric analyses of sweetpotato starch samples were conducted following the NIR standard procedures, including selection of calibration and validation samples, reference data obtained by routine laboratory analysis, NIR spectral data obtained by scanning samples, selection of optimum equations between spectral data and reference values by calibration, confirmation of optimum equations by validation. Once the prediction equations were established it could be used to rapidly measure new independent samples.

2.3.1. Sample scanning

Sweetpotato starch samples were dried at 50 °C for 3 h to ensure that all samples had similar moisture content before NIR analyses. Spectral data were collected by

Table 1
Statistics of calibration and validation populations of sweetpotato starch quality traits

Starch quality traits	Calibration ($n = 128$)				Prediction ($n = 70$)			
	Mean	SD	Min	Max	Mean	SD	Min	Max
AC (%)	20.43	1.97	14.52	26.33	20.64	1.73	15.45	25.84
AP (%)	23.37	2.40	16.17	30.57	23.47	2.50	15.97	30.97
TSC (%)	89.79	2.14	83.37	96.20	89.88	2.16	83.40	96.36
PRC (%)	0.19	0.07	0.09	0.40	0.18	0.06	0.11	0.39
PHC (mg/100 g)	14.47	2.76	6.14	22.72	14.29	2.82	6.45	22.60
SOL (%)	11.62	2.20	5.02	18.22	11.19	2.13	5.24	18.19
SP (g/g)	23.82	2.04	17.70	29.94	23.52	2.26	16.75	30.29
Granule property								
AGD (μm)	18.98	1.12	15.62	22.35	18.82	1.22	16.16	2.48
BGP (%)	13.69	1.63	8.80	18.59	12.92	1.43	8.94	17.55
MGP (%)	37.44	1.74	32.21	42.67	38.62	1.92	33.22	41.09
SGP (%)	49.12	2.33	42.12	56.11	48.96	2.14	41.23	55.78
CRY (%)	40.87	3.70	29.76	51.98	41.01	4.61	27.17	54.84
RVA property								
PKV (RVU)	424.29	37.72	311.12	537.46	427.42	38.85	310.86	543.98
HPV (RVU)	245.20	26.81	164.77	325.63	242.20	27.09	168.73	323.29
BD (RVU)	173.71	36.61	63.88	283.55	171.91	36.81	61.47	282.33
SB (RVU)	65.14	4.55	51.50	78.78	66.82	4.72	55.92	76.78
P_{temp} (°C)	81.02	2.43	73.71	88.32	81.01	2.31	74.08	87.95

Note: AC, amylose content; AP, amylose percent; TSC, total starch content; PRC, protein content; PHC, phosphorus content; SOL, solubility; SP, swelling power; AGD, average granule diameter; BGP, big granule percent; MGP, middle granule percent; SGP, small granule percent; CRY, crystallinity; PKV, peak viscosity; HPV, hot paste viscosity; BD, breakdown; SB, setback; P_{temp}, paste temperature.

measurement of diffuse reflectance from the starch sample in the NIR region within 1100–2500 nm using a model 5000 monochromator equipped with a transport module (FOSS NIRSystems, Silver Springs, MD, USA). Each sweetpotato starch sample was scanned in duplicate in a small ring quartz window-clad cylindrical cell (NR-7073, internal diameter 35 mm, depth 9 mm). The reflectance spectra were collected continuously over a NIR wavelength region. It was necessary to use full spectral range for scanning because the parameters tested in this study consisted of a large number of physical characters but few chemical constituents. Each spectrum represented the average of 32 scans, and was recorded as $\log(1/R)$ at 2 nm increments. Duplicates of each sample were scanned twice (rotating the ring cup to a different position) to minimize the effects of particle size and sample temperature. The average spectrum of each sample was used for further analysis. The spectroscopic procedures and data recording were done using Win ISI II software (version 1.04, FOSS NIRSystems, Silver Springs, MD, USA).

2.3.2. Calibration and cross-validation

Calibration and validation were conducted following the manual of the Win ISI II software. Samples in the calibration set were used to establish multivariate equations between spectral data and laboratory reference values, and samples in the validation set were used to evaluate calibration equations. The NIRS instrument provides several mathematic treatments for calibration. Combinations of 1st and 2nd derivative, gap, smoothness and scatter correction were used to maximize the calibration results. The optimum equations were developed in this study using modified partial least squares (PLS) regression on the first derivative of reflectance and transmittance spectra (math treatment, $D = 1$, $G = 4$, $S1 = 4$, $S2 = 1$), and scatter correction of standard normal variance and de-trend (SNVD) for starch quality parameters. D is the derivative order number (that is 0 indicates no derivative operation, 1 means 1st derivative and so on); G is gap (the number of data points over which derivation is computed); $S1$ is the number of data points in the 1st smoothing and $S2$ is the number of data points in the 2nd smoothing which is normally set at 1 for no 2nd smoothing. To calculate the relationships between spectral and physicochemical properties of the calibration samples the MPLS regression analysis was performed using the full NIR spectra. This mathematical transformation reduced the original 300-plus and more variables (wavelengths) to a set of up to 16 orthogonal (MPLS) factors. These factors served as regressors in the subsequent calibration step to build up the calibration function, quantifying the relationships between spectral data and laboratory reference data (Shenk & Westerhaus, 1993). To prevent overfitting, this instrument provides cross validation to determine the optimum number of PLS factors. Three cycles of outlier elimination were set up with samples with a '*H*' value (Mahalanobis distance) larger than 4 (spectral outlier) and a '*T*' value larger than 2.5 (sample which did not fit the calibration model) being eliminated (Shenk & Westerhaus, 1993). The accuracy potential of the calibration function was characterized by various NIR performance values, e.g. the standard error of calibration (SEC) or the standard error of cross validation (SECV). The best calibration equations for this type data were judged by the highest calibration RSQ (or statistic 1-variance ratio (1-VR) as an estimate of the coefficient of determination) and the lowest SEC or SECV (Wu et al., 2002).

2.3.3. Validation

Only application of cross-validation to validate calibration equations might not be sufficient. The subsequent validation of the initial calibration function using samples independent from the calibration set led to further NIR performance values for each constituent. The standard error of prediction (SEP) and the RSQ (determination coefficients, or squared coefficient of correlation) could well describe the NIR analytical error when analyzing samples of unknown quantitative composition (Lu & Sheng, 1990).

3. Results

3.1. Spectral characteristics and variability of quality parameters among starch samples

Sweetpotato flour and starch samples resulted different spectra, especially in the long wavelength region (Fig. 1), suggesting that specific equations need to be developed for the measurement of starch quality parameters. However, the spectra were similar among the starch samples from different sweetpotato genotypes, as well as among samples from different locations (Figs. 2 and 3). This result shows that a general calibration equation can be developed using a combination of starch samples from different genotypes and different locations (Lu, 2003).

The summary statistics for each starch quality parameter of the sweetpotato starch samples revealed a wide ranges of variation for most of the parameters, which suggested that the samples used in this study is a reasonable representative of the overall diversity in sweetpotato, thus ensured that the calibration and validation sets were properly selected (Table 1).

3.2. Starch physiochemical property

The statistical results of calibration and validation for the starch quality parameters are summarized in

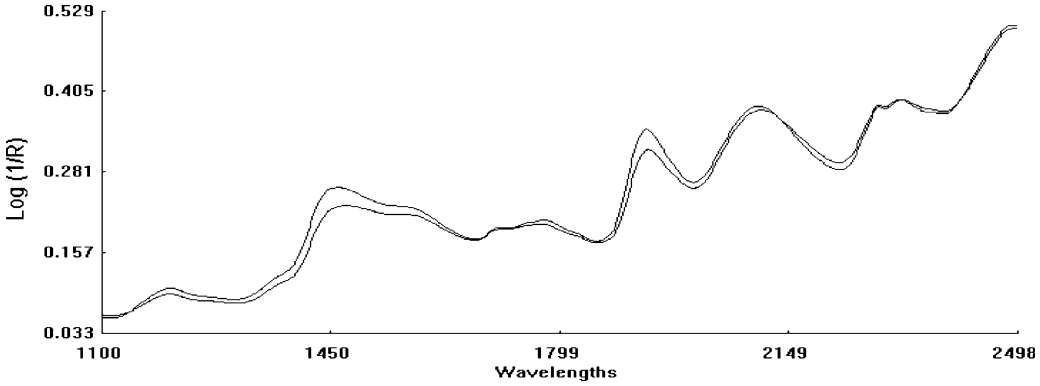

Fig. 1. NIR spectrum of sweetpotato flour and starch (CV: Xushu18; Starch: deep line; Flour: light line).

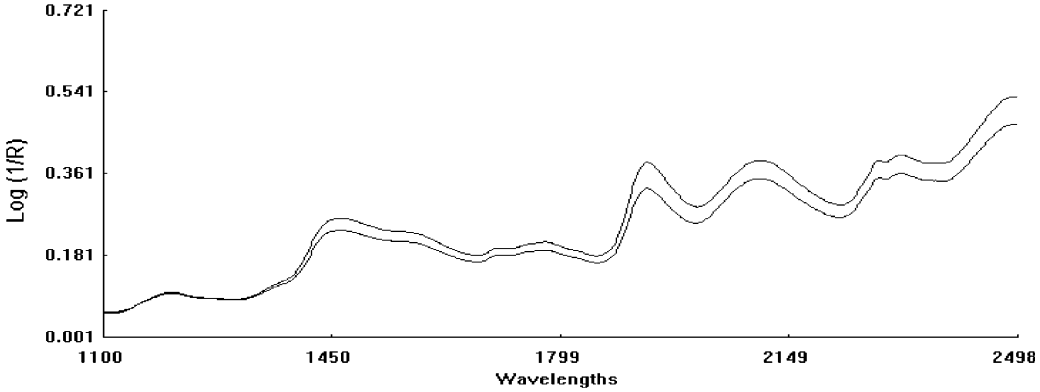

Fig. 2. NIR spectra of sweetpotato starch from different genotypes (cv. Xu18: upper line; Zhe13: bottom line).

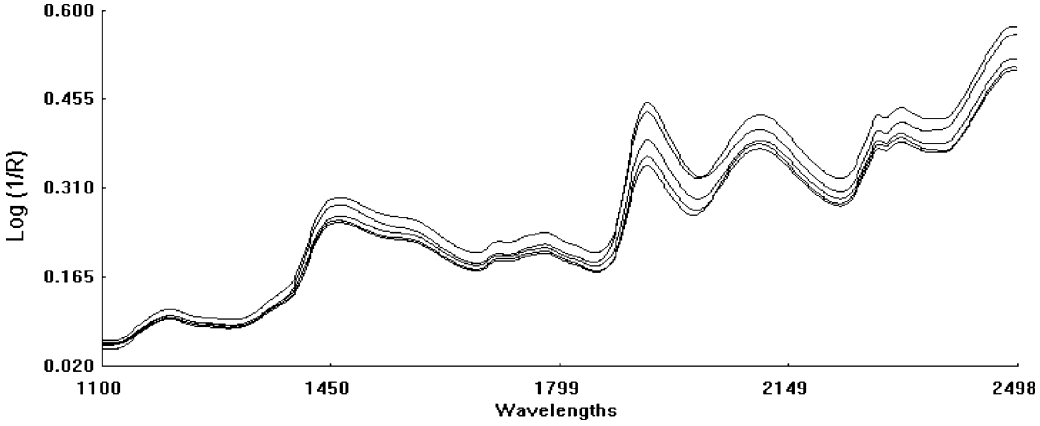

Fig. 3. NIR spectra of sweetpotato starch from different grown locations (cv. Xu18, from up to down: Xianju, Xiaoshan, Quzhou, Yiwu and Yuhuan).

Table 2. Bao et al. (2001) reported the prediction of apparent amylose content (AAC) of rice starch by NIRS was accurate and applicable (SEP = 1.39%, R2 = 0.91). Ishiguro and Yamakawa (1998) established a prediction equation for AC of sweetpotato starch with a SEP of 1.11% and a correlation coefficient (r) of 0.85. Similarly accurate results for AC of sweetpotato starch (SEP = 0.98%, RSQ = 0.90) and for AP (SEP = 0.88%, RSQ = 0.91) were also obtained in this study (Table 2). AP is another more precise parameter to express amylose percent among total starch content. Which one should be used in sweetpotato starch evaluation depends on the research purpose. Both of them are very similar. Just like sweetpotato flour starch content (Lu & Sheng, 1990), TSC in starch samples also could be determined by NIRS with a SEP of 1.77% and a RSQ of 0.86. TSC is significantly affected not only by genotypes but also by starch isolation and extraction (Lin

Table 2
Calibration and validation of quality traits of sweetpotato starch

Starch quality traits	Calibration		Prediction	
	SEC	RSQ	SEP	RSQ
AC (%)	0.832	0.912	0.982	0.897
AP (%)	0.647	0.924	0.882	0.911
TSC (%)	1.274	0.915	1.772	0.857
PRC (%)	0.028	0.881	0.042	0.862
PHC (mg/100 g)	0.853	0.941	1.528	0.889
SOL (%)	0.653	0.917	0.936	0.893
SP (g/g)	0.767	0.886	0.937	0.852
Granule property				
AGD (μm)	0.917	0.872	1.012	0.869
BGP (%)	0.842	0.908	0.924	0.855
MGP (%)	0.705	0.836	1.065	0.614
SGP (%)	0.815	0.881	1.399	0.848
CRY (%)	1.795	0.897	1.936	0.875
RVA property				
PKV (RVU)	8.411	0.922	13.106	0.909
HPV (RVU)	9.761	0.919	10.164	0.852
BD (RVU)	7.753	0.906	10.669	0.815
SB (RVU)	1.522	0.948	1.815	0.917
P_{temp} (°C)	1.918	0.911	1.908	0.876

Note: AC, amylose content; AP, amylose percent; TSC, total starch content; PRC, protein content; PHC, phosphorus content; SOL, solubility; SP, swelling power; AGD, average granule diameter; BGP, big granule percent; MGP, middle granule percent; SGP, small granule percent; CRY, crystallinity; PKV, peak viscosity; HPV, hot paste viscosity; BD, breakdown; SB, setback; P_{temp}, paste temperature.

et al., 1997). Therefore, the same starch extraction method was used for all starch samples in this study in order to identify varietal difference. PRC in sweetpotato starch was relatively low with a mean of 0.19%. It could be estimated by NIRS with acceptable accuracy (SEP = 0.04%, RSQ = 0.86). The reason for that is likely due to its wide range; another reason is that because the NIR region of the electromagnetic spectrum consists primarily of absorption information on NH (protein), OH (water) and CH (fat or oil). PHC is very important starch quality parameter. Sweetpotato starch contains about 14 mg/100 g PHC with a range from 6.14 to 22.72 mg/100 g. A successful result was obtained for PHC by NIRS with a SEP of 1.53 mg/100 g and a RSQ of 0.89. SOL and SP affect noodle quality and starch processing properties. Both could be measured by NIRS with acceptable RSQ of over 0.85. Except AC, up to know this might be the first report on the other physiochemical parameters of sweetpotato starch by NIRS. The above results indicated that NIRS could be used to estimate sweetpotato physiochemical properties with enough accuracy for the quality-breeding program.

3.3. Starch granule property

Except MGP that gave poor results with a relatively low RSQ of 0.61, all other granule parameters including AGD, BGP, SGP and even CRY achieved better prediction with higher RSQ (over 0.85) (Table 2). Because of the very low RSQ for MGP, this calibration was not suitable to estimate MGP. Luckily, once BGP and SGP were determined MGP could be easily calculated. These indicated that NIRS could be predicted sweetpotato starch granule parameters with relatively good precision.

3.4. Starch RVA property

The first attempt to get information correlated to rice RVA pasting data by NIRS (Delwiche, McKenzie, & Webb, 1996) was only partially successful (RSQ < 0.74). Bao et al. (2001) conducted similar work. In their study, although the PV and HPV of RVA profiles were poorly predicted, BD and SB achieved better prediction with low SEP (<20.8 RVU) and higher RSQ (>0.76). In our study, except BD, which was partially successful with a little low RSQ (0.82), PKV, HPV, SB and even P_{temp} could be determined by NIRS with acceptable accuracy (RSQ > 0.85) (Table 2). Interestingly, SB, which was identified as the most important RVA parameter for sweetpotato (Lu, 2003) gave a very good prediction result with a low SEP (1.82 RVU) and the highest RSQ (0.92). Therefore, it can be believed that predictions of main RVA parameters by NIR are sufficiently accurate to be applied in sweetpotato quality breeding, especially for early selection phases of sweetpotato breeding.

4. Discussion

Most starch quality parameters, such as AC, AGD, CRY, SB, and so on, could be measured easily and

accurately in a diverse group of sweetpotato varieties using NIRS. Other quality parameters, including MGP and BD with a lower RSQ (0.61–0.84), although fit less well in the calibration model, were still able to be assessed by NIRS. This group of parameters can at least be classified samples into qualitative groups in the initial screening stage of sweetpotato breeding.

In general, the traits that could be successfully predicted by NIRS are generally more important in a sweetpotato quality-breeding program than those that could not be well predicted in this study. NIR screening for these starch quality parameters can offer enough information to select or discard a breeding line. However, because NIRS is a secondary technique relying on calibration against a reference analysis, and the quality of the calibration process is critical, for accurate testing of advanced breeding lines, instrumental testing with RVA and some other methods will be still required for confirmation of differences in quality parameters.

Precision and reliability of NIR calibration and prediction may be affected by many factors, such as sample representativeness, genetic variability for traits, accuracy of reference data, and so on. The genetic variability available for some traits was the most limiting factor in achieving high RSQ values. In our study, there were 105 samples obtained from 21 genotypes grown in 5 different locations, if calibration equations were developed only by these samples the precision of calibration for starch quality parameters was reduced because of poor sample representativeness and narrow range of quality parameters. For example, the RSQ of AC was reduced from 0.91 to 0.87 in this calibration equation, and SEP was increased from 0.832% to 1.135%. Similar results were obtained for other quality traits (data not showed). On the other hand, if 8 genotypes with high AC (>25%) from 93 genotypes selected were excluded in calibration set, the results of NIR calibration for AC significantly become worse. The RSQ of AC was reduced from 0.91 to 0.84; SEP was increased from 0.832% to 1.337%. The reason for that is that calibration samples with middle AC accounted for a large amount of the variability.

Accuracy of reference data is also very important factor that directly contribute to the precision of NIRS determination. In our study, the equations for some parameters did not show satisfactory determination coefficients. The reason why there was difficulty in developing successful equations for these quality parameters is possibly explained by hard to give good reference data. Therefore, for developing satisfactory NIRS calibration, the reference method should be further improved.

Application of NIRS to estimate main quality parameters in sweetpotato quality breeding, in particular, in screening for high dry matter and high starch content, and low amylose content, has been successfully attempted by several scientists (Ishiguro & Yamakawa, 1998; Katayama et al., 1996; Lu & Sheng, 1990). In this study, most important starch quality parameters of sweetpotato starch samples have been determined with acceptable precision by NIRS. It is well known that starch quality analysis by routine methods is very costly, strenuosity, time consumption and has many other disadvantages. Comparing to routine lab analysis methods, NIRS has the many advantages:

(1) Sample preparation and measurement is simple and rapid, sophisticated treatments or techniques are no need on measurements.
(2) Simultaneous determination of multiple traits with the development of these calibrations.
(3) It is more flexible because this method can be applied for the measurements of all kinds of sample types.
(4) Materials can be shipped and reused after measurements because of non-destructibility. Not a part of population but a whole population can be analyzed.
(5) It is economical because reagents and/or manpower are no need.
(6) It is a real clean and environmental friendly analytical system because no wastes emerge.

It is these causes that make NIRS develop so fast. As sweetpotato is an asexual propagation crop, all traits were kept relatively stable from one generation to another. Therefore, it can be expected that NIRS will become a very suitable, practical and useful technique for breeders in screening early generations of sweetpotatoes.

In summary, the measurement of most quality parameters of sweetpotato starch can be accomplished with NIRS with an RSQ of 0.85 and reasonable SEP. This level of precision is sufficient to allow breeders to screen new breeding lines for high starch quality and also to allow food enterprises to determine the various use of sweetpotato starch. In order to improve calibrations new sweetpotato starch samples with wide range of starch quality parameters should be added to this calibration population in future work. Further research will also be necessary to improve the accuracy of other starch quality parameters and also to transfer these calibrations to other instruments.

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