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Effect of Root Ages on the Quality of Low Cyanide Cassava Flour from Kasetsart 50

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ABSTRACT

Cassava flour is a food product used in many diets, that is derived from fresh edible roots of cassava, preferentially from low-cyanide sweet cassava. Despite the high cyanogenic content in fresh roots, the bitter cassava can be also used to produce flour if the fresh roots are of good quality and are processed properly. In this study, the quality of cassava flour produced by a simple process from variety Kasetsart 50 (KU50), the bitter cassava which was extensively grown in Thailand for industrial use was investigated. Flour qualities obtained were dependent on the root quality. Roots with different ages (6, 8, 10 and 12 months old) exhibited different chemical compositions and cyanide contents, which consequently produced flour containing different levels of cyanide content. Fresh roots with high cyanide content produced flour with high cyanide content. Moreover, flour prepared from fresh roots at various ages exhibited significant differences in paste viscosity. These differences were greater than that seen for extracted starches from fresh roots alone, implying the role of other non-starch components in fresh roots on determining the paste viscosity of flour. Furthermore, composite blending of flour with various paste properties was proposed to minimize the paste viscosity variation, and remedy inconsistent quality of cassava flour-based products.

Key words: cassava flour, root age, cyanide, paste viscosity

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is an important subsistence crop in many tropical areas including Asia, Africa and Latin America with a number of uses for its edible starch-storage roots. The roots are typically employed as an important staple food that can be processed into a wide variety of products such as *gari*, *lafun*, *fufu*, *farinhain* and *casabe*. Cassava flour is another cassava-based product that is used in many diets and serves as a substitute wheat flour in bakery and noodle products (Loreto, 1992). To produce flour, fresh roots are cut, sliced or pounded into small pieces and then sun-dried. The dried products are subsequently milled to produce flour.

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The actual processing practice, however, varies depending on the geographical origin, available root quality, and the desired flour quality and the end application.

The influence of processing on flour quality has been extensively investigated. For instance, for flour quality including chemical composition, cyanide content, microbiological quality, paste viscosity profile and cooking quality have been elucidated the effect of chipping method (size and equipment), drying method (sun drying vs. oven drying and drying temperature), fermentation process (natural or culture addition), and milling method (hammer mill vs. pin mill vs. roller mill and the particle size) (Padmaja, 1995; Fernadez *et al*., 1996; Jones *et al*., 1996). Cassava varieties are, in general, classified into two classes by a high and low cyanide content present in fresh roots as “bitter” and “sweet” type, respectively. Also, the physicochemical properties of processed flour is in part determinded by the variety of cassava used (Rattanachon, 2003). Mostly, the sweet cassava is preferred for making cassava flour since it tends to produce flour with low cyanide content. However, the bitter cassava roots, typically provide a higher starch yield, and if processed appropriately can also be used to produce low-cyanide flour. To properly process the bitter cassava, the roots are grated into the mash and then subjected to pressing to reduce the content of cyanogenic compounds.

Many previous studies have demonstrated that the organoleptic properties of cooked roots and physico-chemical characteristics of extracted starch are affected by the age of harvested roots and environmental conditions during plant and root development, such as the amount of rainfall and soil temperature (Moorthy and Ramanujam, 1986; Asaoka *et al*., 1991, 1992; Defloor *et al*., 1998a, b; Sriroth *et al*., 1999a, b; Santisopasri *et al*., 2001). These factors can presumably influence the quality of flour and, hence, the final products made from cassava flour.

The objective of this work was to evaluate the effect of root quality as a function of harvest time on the flour quality especially the chemical composition, cyanide content and the paste viscosity of flour obtained from cassava variety Kasetsart50 (KU), the bitter cassava which was widely grown for industrial use in Thailand due to its higher starch yield and lower price.

MATERIALS AND METHOD

Cassava root plantation: Cassava variety Kasetsart 50 (KU50), the most widely grown cassava variety in Thailand, was planted at Nakornratchasrima province in April 2002 at the beginning or rainy season. Fresh roots were harvested at 6, 8, 10 and 12 months after planing and processed into cassava flour within 24 hrs.

Cassava flour production: Fresh roots were peeled, washed thoroughly and then grated. The mash was then pressed with a hydraulic press and dried in a hot air oven at 50°C for 48 hrs. The dried sample was hammer-milled to fine powder and passed through a 100-mesh sieve.

Cassava starch production: Cassava starch was extracted from fresh roots within 24 hrs after root harvest, using water as the extracting medium. Peeled roots were washed and grounded with water and then filtered. The starch slurry was settled to let starch precipitate and the cake was collected for further drying at 50°C. The dried sample was milled and passed through a 100-mesh sieve.

Analysis of chemical composition: The chemical composition of fresh roots, flour and starch including moisture, fat, starch, protein, ash, crude fiber (dietary and crude fiber) was determined according to recommendations of the Association of Official Analytical Chemists (AOAC, 1995).

Determination of cyanide content: The cyanide contents in fresh roots and flour were determined by the enzymatic method using linamarase (EC 3.2.1.21, BDH Laboratories Supplies, UK) enzyme and the total cyanide content, reported as mgHCN equivalent. kg^{-1} dry sample, was quantified by chloramine T and pyridine-pyralozone reagents, using potassium cyanide as a standard (O'Brien *et al*., 1991).

Paste viscosity characterization: The paste properties of flour and starch were evaluated by a Rapid Visco Analyzer (RVA4, Newport Scientific, Australia), using 3g samples (14% moisture content) with 25g of distilled water. The samples were started at 50°C 1 min then heated from 50 to 95°C with a heating rate increase of 12 °C/min and then maintained at 95°C for 2.5 min. The hot paste was subsequently cooled to 50°C with a cooling rate of 12°C/min and then held for 2 min (Standard program No. 1). The recorded values included pasting temperature (°C), peak viscosity (the maximum viscosity, RVU), trough viscosity (the hot paste viscosity at 95°C, RVU), final viscosity (the cold paste viscosity at 50°C, RVU), breakdown (the difference between peak and trough viscosity, RVU) and setback from trough (the difference between final and trough viscosity, RVU).

RESULTS AND DISCUSSION

The chemical composition of fresh cassava roots varied somewhat by time harvest (Table 1). Roots which were very young (i.e. 6 months) and old (i.e. 12 months) had the lowest starch content, but also had a greater portion of water-soluble non starch component, which was mainly sugars (i.e. sucrose, glucose and fructose, 4-5% dry basis). This presumably might be regulated by an environmental factor during plant growth and root development. Environmental changes in growing conditions subjected the plants to the water stress (8 to 10 months; the amount of precipitate = 0 and 39 mm, respectively), led to physiological adjustment of plants. The plants, were lather released from the water stress conditions (at 11 months in this study; the amount of precipitate = 104 mm), could recover quickly by forming new leaves, the energy for this process was likely obtained by utilizing reserved starch. The net effect was a reduction in starch content. In addition, the effect of root age was evident on the total cyanide content as the roots with 6 and 8 months old contained very high amounts of cyanogenic compounds. This might presumably also be due to the environmental conditions during plant and root development, especially at 8 months after being subjected to drought (Sriroth *et al*., 1999a, b; Santisopasri *et al*., 2001). Fresh roots with high cyanide content produced flour with high cyanide content (Table 2). Cassava variety Kasetsart 50 (KU) is the most widely grown variety in Thailand for the industrial purposes especially for cassava chip & pellet and starch production, but roots are rarely used to produce flour, because of its very high cyanide content. However, with fresh roots of good quality and proper processing, flour with low cyanide content, that complies with the FAO/WHO food safety

Table 1 Chemical composition of fresh cassava roots (variety KU 50) at different harvest times.

Root age (months)	Chemical composition (% dry basis)					Total cyanide content (mg $HCN.kg^{-1}$ dried sample)
	Starch	Fat	Protein	Crude fiber	Ash	
6	80.21± 0.35^{b}	0.14 ± 0.07^{ns}	2.81 ± 0.02^{a}	2.54 ± 0.05^{a}	2.72 ± 0.07^{a}	1,427.2 ± 481.6^{a}
8	84.51 ± 0.14^{a}	0.21 ± 0.03^{ns}	2.30 ± 0.02^{b}	1.93 ± 0.02^{b}	1.98 ± 0.01^{c}	1,259.5 ± 186.8^{a}
10	83.87 ± 0.12^{a}	0.14 ± 0.07^{ns}	1.83 ± 0.02^{c}	1.79 ± 0.02^{c}	2.41 ± 0.04^{b}	799.9 ± 94.4^{ab}
12	80.73 ± 0.28^{b}	0.08 ± 0.01^{ns}	1.41 ± 0.01^{d}	2.59 ± 0.04^{b}	2.52 ± 0.08^{b}	533.7± 49.1^{b}

^{abc} Values with different letters in the same column are significantly different at $p < 0.05$.

^{ns} Not significant.

standard (less than 10 mg HCN.kg^{-1} dried weight) could be achieved. Flour obtained from fresh roots at the age of 6 and 12 months also contained a slightly lower starch content. It was interesting to note that by using this processing protocol, some of other components including protein, crude fiber and ash were lost in discharged water during mash pressing.

Cassava flour prepared from fresh roots with different ages exhibited significantly different profiles of paste viscosity determined by a Rapid Visco Analyzer (Figure 1). Flour produced from roots at 6 months old provided the highest peak viscosity whereas that from 10-month roots had the lowest value (peak viscosity = 311 and 284 RVU, respectively; Table 3). Moreover, flour from the 10-month roots exhibited the lowest values of trough and final viscosity (59 and 89 RVU, respectively). Variation in the paste characteristics of flour might affect the quality of resulting products.

To further investigate the reasons that

Table 2 Chemical composition of cassava flour produced from fresh roots (variety KU 50) harvested at different times.

Root age (months)	Chemical composition (% dry basis)					Total cyanide content (mg HCN.kg^{-1} dried sample)
	Starch	Fat	Protein	Crude fiber	Ash	
6	89.84 ± 0.09 ^{b}	0.17 ± 0.04 ^{b}	0.77 ± 0.01 ^{b}	2.08 ± 0.16 ^{a}	0.91 ± 0.08 ^{b}	18.8 ± 4.1 ^{a}
8	91.10 ± 1.10 ^{ab}	0.25 ± 0.02 ^{a}	0.80 ± 0.02 ^{b}	2.04 ± 0.10 ^{a}	1.10 ± 0.06 ^{a}	15.5 ± 0.9 ^{a}
10	91.47 ± 0.10 ^{a}	0.16 ± 0.02 ^{b}	1.10 ± 0.01 ^{a}	1.52 ± 0.05 ^{b}	1.12 ± 0.02 ^{a}	0.7 ± 0.0 ^{b}
12	90.90 ± 0.12 ^{ab}	0.06 ± 0.00 ^{c}	0.54 ± 0.05 ^{c}	1.49 ± 0.03 ^{b}	1.24 ± 0.02 ^{a}	1.3 ± 0.1 ^{b}

^{abc} Values with different letters in the same column are significantly different at $p < 0.05$.

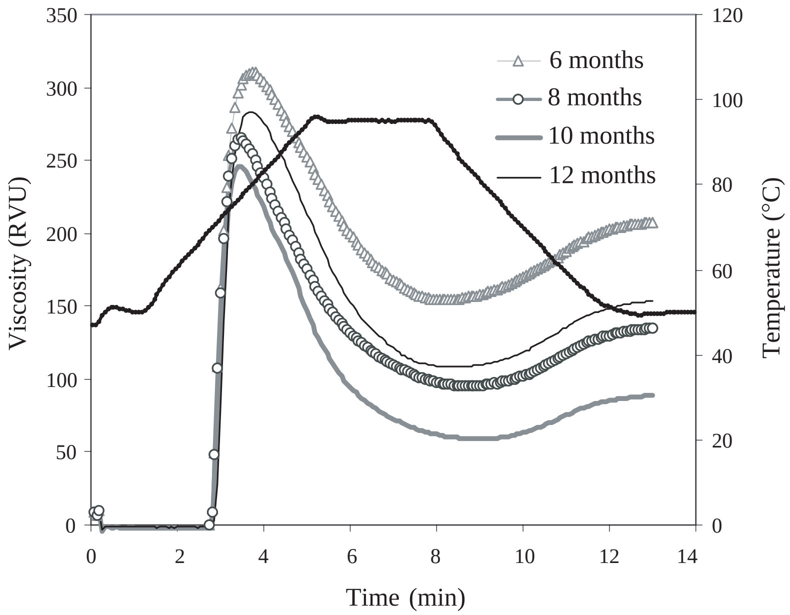

Figure 1 Paste viscosity profile of cassava flour produced from fresh roots (variety KU 50) at different times of harvest.

Table 3 Paste viscosity characteristics of cassava flour and starch produced from fresh roots (variety KU50) with different harvest times.

Sample	Paste characteristics					
	Pasting temperature (°C)	Peak viscosity (RVU)	Trough viscosity (RVU)	Breakdown (RVU)	Final viscosity (RVU)	Setback from trough (RVU)
Flour of roots at						
6 months	69.94±0.10 ^{d}	311±4 ^{a}	154±3 ^{a}	157±3 ^{b}	208±4 ^{a}	54±6 ^{a}
8 months	70.15±0.41 ^{c}	266±5 ^{bc}	95±8 ^{b}	171±5 ^{ab}	135±8 ^{b}	40±1 ^{b}
10 months	70.71±0.05 ^{b}	246±13 ^{c}	59±13 ^{c}	187±2 ^{a}	89±15 ^{c}	30±2 ^{c}
12 months	71.58±0.03 ^{a}	284±5 ^{b}	108±13 ^{b}	176±9 ^{a}	153±15 ^{b}	45±3 ^{b}
Difference range*	1.64	65	95	30	119	24
Starch of roots at						
6 months	70.14±0.42 ^{ns}	426±7 ^{b}	144±4 ^{c}	282±9 ^{b}	249±6 ^{ab}	105±7 ^{a}
8 months	68.73±1.42 ^{ns}	454±13 ^{a}	149±7 ^{c}	305±7 ^{a}	242±10 ^{b}	93±3 ^{b}
10 months	68.78±0.47 ^{ns}	437±5 ^{b}	170±2 ^{a}	267±6 ^{c}	259±11 ^{a}	89±10 ^{b}
12 months	69.54±0.53 ^{ns}	432±4 ^{b}	157±1 ^{b}	275±3 ^{bc}	227±5 ^{c}	70±5 ^{c}
Difference range*	1.41	28	26	38	32	35

^{abc} Values with different letters in the same column are significantly different at $p < 0.05$.

* Difference rage = Maximum value – Minimum value

ns Not signficant.

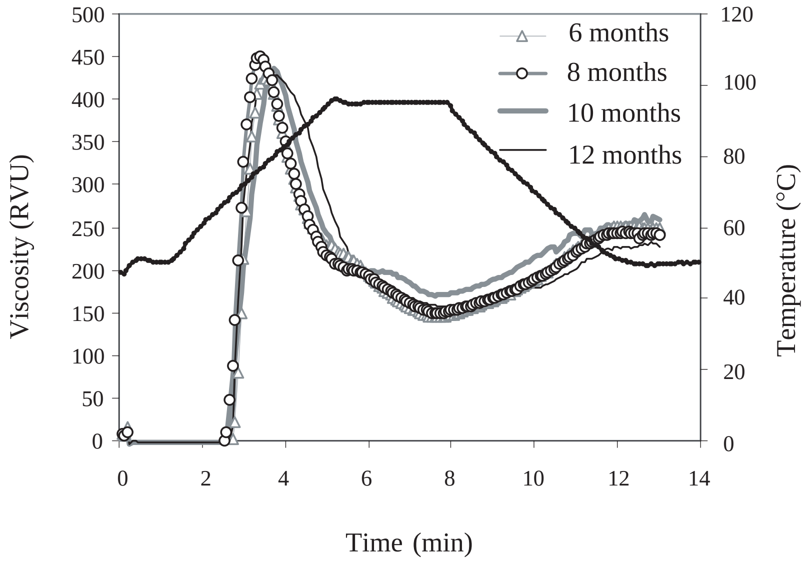

Figure 2 Paste viscosity profile of cassava starch produced from fresh roots (variety KU 50) at different times of harvest.

might induce variation in flour quality, the starch was also extracted from fresh roots at the same harvest intevals, i.e. 6, 8, 10 and 12 months. Extracted starches of all root ages were very pure with the starch content greater than 95% (dry basis), and the contents of other components (fat, crude fiber, ash and protein) were very low (less than 0.1%, dry basis). The paste viscosity of starch was then characterized by an RVA (Figure 2). In general, all cassava starches exhibited higher paste viscosities than flour (Table 3). The starch from 8-month roots demonstrated the highest viscosity peak whereas the viscosity peak of starches from other root ages were lower and not significantly different (Table 3). Similar to flour, extracted starches from roots with different ages revealed different paste viscosity parameters. However, the different degrees of variation in paste viscosity of flour and starch were evident (Table 3). The ranges of viscosity difference among flour samples were higher than starches. The differences of peak, through and final viscosity of flour were 65, 95 and 119 RVU, respectively whereas for starch were 28, 26 and 32 RVU, respectively (Table 3). Consequently, the variation in flour viscosity could not be explained exclusively by the viscosity variation in starches, which were present in fresh roots and were the major component in flour. It could presumably be explained by the influence of other non-starch components present in roots in a combination with flour processing that might induce some changes in properties of flour or starch in flour. Further studies should be continued to elucidate causes of this viscosity variation.

It is likely that variation in the paste characteristics of flour will produce products with inconsistent quality. To minimize that problem, a composite blend of flour with various paste properties was conducted. Flour samples with low (F_1) and high (F_2) paste viscosity were blended at different ratios on dried weight basis. The viscosity of composite blends were clearly dependent on the properties of native flour composition (Figure 3). With the addition of high-viscosity flour (F_2), the viscosity of low-viscosity flour (F_1) increased. The greater the ratio of high-viscosity flour (F_2) applied, the higher the viscosity of the composite flour obtained (Table 4).

By this technique, the variation of flour properties could be minimized. Further more, the properties could be adjusted to be more appropriate with the quality of finish products, which are type- and consumer- dependent.

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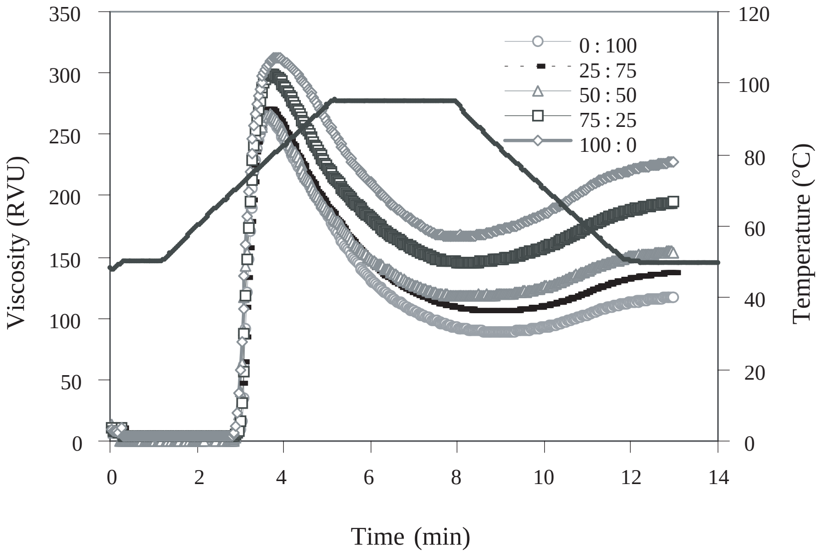

Figure 3 Paste viscosity profiles of low- and high-viscosity composite blends of cassava flour.

Table 4 Paste viscosity characteristics of cassava flour composite blends mixed as different ratios of low- and high-viscosity flour.

Ratio of composite blends between low - and high - viscosity flour	Paste characteristics					
	Pasting temperature (°C)	Peak viscosity (RVU)	Trough viscosity (RVU)	Breakdown (RVU)	Final viscosity (RVU)	Setback from trough (RVU)
100 : 0	72.90±0.20 [ns]	264±1 [d]	89±1 [e]	176±1 [a]	118±1 [e]	29±2 [d]
75 : 25	72.15±1.34 [ns]	272±4 [c]	106±1 [d]	166±1 [b]	138±1 [d]	32±3 [cd]
50 : 50	71.93±0.53 [ns]	267±2 [cd]	118±1 [c]	150±1 [d]	154±4 [c]	36±4 [c]
25 : 75	72.63±0.18 [ns]	300±1 [b]	145±2 [b]	154±2 [c]	195±1 [b]	49±3 [b]
0 : 100	72.05±1.13 [ns]	313±2 [a]	166±1 [a]	146±3 [d]	227±1 [a]	61±1 [a]

[abcde] Values with different letters in the same column are significantly different at $p < 0.05$.

[ns] Not signficant.

LITERATURE CITED

Asaoka, M., J.M.V. Blanshard, J.E. Rickard. 1991. Seasonal effects on the physico-chemical properties of starch from four cultivars of cassava. **Starch/Starke** 43: 455-459.

Asaoka, M., Blanshard, J.M.V., Rickard, J.E. 1992. Effects of cultivar and growth season on the gelatinisation properties of cassava (*Manihot esculenta*) starch. **J Sci Food Agri**. 59: 53-58.

Association of Official Analytical Chemists (AOAC).1995. **Official Methods of Analysis**. 16th ed., The Association of Official Analytical Chemists, Virginia.

Defloor, I., R. Swennen, M. okanga and J.A. Delcour. 1998a. Moisture stress during growth affects the breadmaking and gelatinisation properties of cassava (*Manihot esculenta* Crantz) flour. **J Sci Food Agri**. 76: 233-238.

Defloor, I., I.Dehing and J.A. Delcour. 1998b. Physico-chemical properties of cassava starch. **Starch/Starke** 50: 58-64.

Fernandez, A., J. Wenham, D. Dufour and C. C. Wheatley. 1996. The influence of variety and processing on the physicochemical and functional properties of cassava starch and flour. *In* D. Dufour, O'Brien, G. M., Best, R. (eds.). **Cassava Flour and Starch: Progress in Research and Development. International Center for Tropical Agriculture (CIAT)**, Cali, Columbia. 409 p.

Jones, D. M., D. S. Trim and C. C. Wheatley. 1996. Improving processing technologies for high-quality cassava flour. *In* D. Dufour, G. M. O' Brien, R. Best, (eds.). **Cassava Flour and Starch: Progress in Research and Development. International Center for Tropical Agriculture (CIAT)**, Cali, Columbia. 409 p.

Loreto, A. B. 1992. Cassava flour processing: ViSCA's Experience. *In* **Product Development for Root and Tuber Crops**. Vol. I-Asia. Proceedings of the International Workshop, held April 22-May 1, 1991, at Leyte, Philippines. Eds. G. Scott, S. Wiersema, and P. I. Ferguson, International Potato Center (CIP), Lima, Peru. 384 p.

Moorthy, S.N. and T. Ramanujam. 1986. Variation in properties of starch in cassava varieties in relation to age of the crop. **Starch/Starke**. 38: 58-61.

O'Brien, G.M., A.J. Taylor and N.H. Pouler. 1991. Improved enzymatic assay for cyanogen in fresh and processed cassava. **J Sci Food Agri.** 56: 277-289.

Padmaja, G. 1995. Cyanide detoxification in cassava for food and feed uses**. Critical Rev in Food Sci. and Nutri**. 35(4): 299-339.

Rattanachon, W. 2003. **Comparative of genetics and physico-chemical properties of cassava (*Manihot esculenta* Crantz) between bitter and sweet type**. M. S. Thesis. Kasetsart University. Bangkok.

Santisopasri, V., K. Kurotjanawong, S. Chotineeranat, K. Piyachomkwan, K. Sriroth and C. G. Oates. 2001. Impact of water stress on yield and quality of cassava starch. **Industrial Crops and Products** 13(2): 115-129.

Sriroth, K., K. Piyachomkwan, V. Santisopasri and C. G. Oates. 1999a. Environmental conditions during root development: indicator of cassava starch quality. **Euphytica** 120(1): 95-101.

Sriroth, K., V. Santisopasri, C. Petchalanuwat, K. Piyachomkwan, K. Kurotjanawong and C. G. Oates. 1999b. Cassava starch granule structure-function properties: Influence of time and conditions at harvest on four varieties of cassava starch. **Carbohydrate Polymers**. 38(2): 161-170.