Participatory process improvement for small scale sweetpotato flour production in East Java, Indonesia.

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Abstract: Socio-economic and agronomic potential for small scale sweetpotato flour production has previously been identified in East Java, Indonesia. Better control of browning during processing and improved conversion rate were two technical problems that required solutions before marketable flour could be commercially produced. Local women processors participated in household level processing experiments to improve flour whiteness and conversion rate. Treatments tested were size reduction (shredding vs. slicing), root peeling versus use of whole roots, and soaking in water/sulfite solution. All treatments produced flour darker than wheat flour at the α =.5 level. Shredded, peeled roots gave the whitest flour but lowest conversion rates and highest processing costs (all significantly darker than wheat flour at the α =.5 level). To produce marketable flour, further improvements to shredding/peeling treatments are needed, and use of roots from high-yielding and high-dry-matter-content varieties, currently under evaluation in Indonesia, is proposed and planned.

Key words: sweetpotato flour, processing, browning, conversion rate, marketability, profitability, participatory research.

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Introduction

Sweet Potato (SP) is an important secondary crop in Indonesia, providing good yields to small farmers and fitting well into rice based cropping systems. East Java produces 10-20% of the sweet potato in Indonesia. Only 16% of SP is consumed by the producers: 73.8% of production is for the market (Heriyanto, 1993). SP production in this area provides cash income from fresh root sales (for direct consumption or snack food production), fodder for cattle, plus the organic fertilizer from cattle partially fed on sweet potato vines. To ensure reasonable yields, local farmers invest significant amount of material and labor inputs into sweet potato production. However, fluctuating prices may cause financial losses (in 1995 prices ranged between US$0.07 ^{1} to US$0.017kg^{-1} or lower. Market diversification offers potential to increase farmer income. Indrasari (1995) found that acceptable food products could be produced from SP flour made using the process of Suismono (1995), but that due to high fresh root prices, the flour could not be produced at an economic cost.. In East Java, low fresh root prices and a long dry season increase the feasibility of an SP flour enterprise based on natural drying. Peters and Wheatley (1997) and Heriyanto et al (1997) have identified the economic and social potential of small scale processing of SP roots into flour for rural income generation in East Java. SP flour would be marketed as a low cost alternative to imported wheat flour, especially for snack food and noodle producers. Small flour production and use trials were made using local varieties (Peters and Wheatley, 1997). For the production of flour to be commercially viable, flour whiteness needed to be improved while better conversion rates were fundamental for improving process economics and enterprise profitability. This paper reports results of technical research with potential processors to determine the optimum process for the production of high quality, marketable flour in East Java, conducted in Kenongo village (Malang district), where the previous study had identified economic, agronomic and sociological potential for sweetpotato flour processing enterprises.

Much technical research on SP flour carried out in developing country institutions has focused on product formulation using SP flour (Palomar 1992, Amante 1993, Indrasari et al, 1995) rather than on efficient, low-cost, small scale processes to produce the flour. Martin (1984) evaluated 26 varieties, and different size reduction and drying methods, for flour production. He found that significant differences between varieties in flour quality and yield. Latex production and polyphenolic oxidation adversely affected the color of flour, and the products made from it. Slices were easier to handle, but more difficult to dry and mill. Flour color darkened on boiling, although this could be prevented through use of sodium bisulphite. A later paper (Martin 1985) reports the use of a soaking/leaching period before drying of slices or grates, as a treatment to reduce the development of brown color and off tastes during drying, storage and use of the flour.

Martin (1984) reported SP flour yields of 17-38%, depending on variety. From Indonesia, Suismono (1995) found that flour produced by natural drying of shredded SP gave acceptable quality and yield of flour (24% yield using white fleshed variety Lampeneng) combined with low processing costs. A range of process options (peeling, use of press to dewater prior to drying, and soaking shreds in water containing sulphite to prevent browning) were also evaluated under laboratory conditions. Suismono (1995) found that good quality flour could be produced without peeling, resulting in improved flour yields. Indrasari et al (1995) investigated the acceptability of SP flour to small scale home industry producers of wheat flour based snack foods and noodles in West Java, finding that acceptable products could be made at substitution levels ranging from 5 to 30% for different products. However, the price of fresh SP roots in West Java was too high for processing to be attractive to farmers

This research adopted a participatory approach, and involved women interested in sweet potato flour processing. The advantages of this approach were many fold: 1) for future pilot production, the women would have been familiar with the process of making flour, 2) it allowed interested, motivated, and innovative women an opportunity to contribute to the search for the best processing procedures, 3) the potential constraints of household-level processing could be addressed as they emerged during this trial, and 4) realistic results applicable to on-farm processing could be taken into consideration for future production. The goal of the research was to improve, under farm household level processing conditions, SP flour whiteness and conversion rates, previously identified (Peters and Wheatley, 1997) as the major constraints in East Java. A SP processing trial was conducted to meet the following objectives.

1. to determine a practical and effective method for controlling the browning reaction during processing.
2. to identify the best combination of process operations for maximizing flour yield, while producing flour of marketable quality.
3. to investigate SP flour marketability and profitability, based on the trial results.

Materials and Methods

Trial design

The trial was designed to test the following hypotheses concerning whiteness and conversion rates.

H1: Shredding, through faster drying, results in whiter flour than slicing, although flour yield may be lower due to greater losses during processing.

H2: Peeling leads to whiter flour but a poorer conversion rate than use of whole, unpeeled roots.

H3: Soaking sweet potato shreds or slices in sulfite solution, instead of water, improves the whiteness of flour.

To test these hypotheses, eight treatments were designed to test the effects of :

1) shredding (h), plus dewatering using a manual press, versus slicing (s) (pressing not possible)
2) peeling (p) versus use of whole, unpeeled roots (u),
3) soaking in Na meta bisulfite solution (n) versus soaking in water (w).

The eight treatments were:

1. hpw: shredded/peeled/water
2. huw: shredded/unpeeled/water
3. spw: sliced/peeled/water
4. suw: sliced/unpeeled/water
5. hpn: shredded/peeled/sulfite
6. hun: shredded/unpeeled/sulfite
7. spn: sliced/peeled/sulfite
8. sun: sliced/unpeeled/sulfite

The trial was carried out by eight landless women who usually engage in seasonal agricultural labor, under the coordination of two research assistants. Every day, each woman processed a different treatment and the rotation ensured that each woman processed all eight treatments[2]. Each treatment was standardized by using 5 kg of fresh, weevil-free, roots. Once selected, the occasional weevil-infested roots were not replaced. Selected roots were washed, peeled (if necessary), shredded or sliced, soaked for 1h in water (or 0.2%w:v sodium meta bisulfite solution). Shredded treatments only were dewatered using a manual press before being spread out on bamboo trays to dry. Dried chips were milled using local pin mill with 0.5 mm screen. Any starch remaining in buckets after soaking was dried and added to the relevant treatment before milling.

Trial equipment

The equipment used included: 8 handheld peelers, 1 manual shredding machine, 1 home-made slicer, 2 locally-made presses, 16 drying bamboo trays (two for each woman), 24 plastic buckets (3 for each woman), and a pin mill. The shredder was loaned by the Research Institute for Legume and Tuber crops (RILET), while the bamboo trays, slicer[3], and presses were locally constructed from bamboo. Since there was only one shredder, one slicer, and two presses[4], the processing schedule was staggered to avoid more than one woman needing the same piece of equipment at the same time.

Problems surfaced with these low-input equipment during the first day and were solved by the participants with low-input solutions. Some shreds fell through the cracks of the bamboo trays. A shortage of drying racks forced some of the bamboo trays to lie on the ground, resulting in loss to chickens. Dried shreds were lost during collection from the bamboo trays, due to the uneven tray surface. Use of newspaper placed on the bamboo trays did not hinder drying, but prevented losses through cracks and during collection of dried shreds. More drying racks were constructed. The data from the first day (day 0) were not used in the analyses of results.

Flour whiteness and quality testing.

Sweetpotato flour whiteness was determined at Research Institute for Rice (Sukamandi, W. Java) using a Kett Whiteness Tester Model C-100. Results were compared with locally purchased wheat flour. Flour quality was evaluated by participating women on a scale based on their perception of flour color (i.e., whiteness), texture, and marketability. The scale ranged from 3 (high quality) to 8 (low quality).

Data collection

Data collected included: 1) processing time for each processing step for each woman, 2) weight of peeled skin to determine weight loss through peeling, 3) weight of dried shreds or slices, 4) flour weight/treatment/day, 5) sun-drying time, and 6) the women's perception of the color, texture, and marketability of flour from each treatment. Based on these data, the results sections reports on : a) conversion rates, b) whiteness and quality of the flour, and c) processing time and costs.

Results

Conversion rates

The root:flour conversion rate of each treatment was calculated on the basis of root:shreds (slices) conversion rates and adjusted for the average conversion rates between shreds and flour. This calculation was necessary because there was left-over flour in the mill between two millings, but it was impractical to clean the mill after each use. The root:flour conversion rate was accurate on an aggregate level for all treatments of each day, but not accurate for each treatment. Thus, the average root:flour conversion rate from 8 replications (from 8 days) of each treatment was calculated as follows:

daily root:shred = aggregated shreds weight from 8 treatments/5 (kg of roots)

daily root:flour = aggregated flour weight from 8 treatments/5 (kg of roots)

daily shred:flour = daily shred:flour/daily root:shred

average root:shred = aggregated daily shreds weight of each treatment/8 (days)

average shred:flour = aggregated daily shred:flour from 8 days/8 (days)

average root:flour (of each treatment) = average root:shred * average shred:flour

The average root:flour conversion rates of the treatments ranged from 23.04% (hpn) to 26.54% (sun). The conversion rates of treatments sun and suw--sliced and unpeeled were significantly higher than all the other treatments while treatments hpc and hpw—shredded and peeled were significantly lower than all the rest (at $\alpha = .05$ level). There was no significant difference between conversion rates of the sliced/peeled treatments or grated/unpeeled treatments (Table 1).

Flour whiteness and quality

All treatments produced darker flour than wheat flour. Nevertheless, the peeled treatments were all significantly whiter than the unpeeled treatments, regardless of whether they were soaked in water or sulfite solution. Moreover, the shredded/peeled treatments produced significantly whiter flour than the rest (Table 2). The flour quality scores obtained from participants ranged from 4.9 to 6.4, indicating medium to low quality (Table 2). Consistent with the laboratory results, the flours produced from shredded/peeled treatments were regarded by the participants as of the highest quality.

Processing time and cost

As expected, peeling was significantly more time-consuming than use of unpeeled roots. Peeling also gave higher processing costs. However, the processing times for the four different peeled treatments did not differ significantly. Processing costs ranged from Rp 55 to Rp 91 per kilo of fresh root, or Rp 222 to Rp 366 per kilo of flour, based on 25% conversion rate (Table 3). Processing time was also examined to see whether processing efficiency was influenced by participant age. While processing time varied between people (Table 4), but was unrelated to age: the time taken by the oldest person (age=60), was not significantly different from the others, including the youngest participant (age=23).

Three hypotheses

1. Slices vs. shreds: slicing did not consistently produce whiter flour (Table 2), even though the whiteness of flour from sliced roots was, on average, lower than that of the shredded treatments (Table 5). However, slicing in combination with use of whole roots, resulted in significantly better conversion rates than all the other treatments (Table 1), even though slicing alone did not consistently yield higher conversion rates than shredding, except for peeled roots (Table 5).

2. Peeled vs unpeeled, whole roots: peeling produced significantly whiter flour than whole roots (Table 2), and the average whiteness of the peeled treatments was considerably higher than that of the whole root treatments (Table 6). The flour of peeled/shredded treatments was significantly whiter than the peeled/sliced treatments. Peeling/shredding treatments lead, at the same time, lead to significantly poorer conversion rates than all the other treatments. Peeling, combined with slicing, however, was not significantly different from unpeeling/shredding.

3. Soaking in water vs. sulfite solution: there was no significant difference in whiteness between the water and sulfite treatments (Table 2). The average scores of these two treatments also indicate

little difference in whiteness or flour quality (Table 7). Thus, the data refute the hypothesis that sulfite at this concentration may improve the whiteness of flour.

Discussion and Conclusions

The participating women repeatedly stated that the time involved in processing was not an important consideration since they often are unemployed. Their primary concerns were flour marketability and profitability. None of the treatments resulted in flour as white as wheat flour (i.e. low marketability). Thus, improving whiteness is essential before sweetpotato flour may be marketable, which means improvements over peeling/shredding combinations. This incidentally, but not surprisingly, coincides with the women's perception of the quality and marketability of the flour: the two flour samples from peeled/shredded treatments were considered the highest quality (Table 2).

This combination, however, produced conversion rates that were significantly lower than any other treatment combination. In addition, the processing time for the peeled/shredded combination was also significantly higher than for the unpeeled treatments (Table 3). Nevertheless, marketability must take precedence over profitability for obvious reasons. The combination of peel/shred/water gave 23.6% conversion to flour (Table 1), and the estimated processing cost of this treatment combination, at a 25% conversion rate, is Rp 347/kg flour (Table 3). Adjusted for 23.6% conversion, the cost would be Rp 368 for this processing method.

This problem, however, may be alleviated by using high-yielding and high-dry-matter (DM)-content varieties, while addressing the issue of raw material costs at the same time (cost of SP fresh roots). Table 8 shows that sweetpotato production trials in Malang, using four new white-fleshed varieties, yielded up to 30 ton/ha with fresh root DM content reaching 39.4% (Mok, 1996). At this level of DM content, sweetpotato can be expected to render 30% of root:flour conversion or better, which would reduce processing cost and increase profitability (Figure 1). Moreover, there is a trade-off between yield and DM content (i.e., potential root:flour conversion rate) for profitability (Table 8). Table 9 shows that the variety *AB94001.8*, which yielded 30 t/ha with DM content of 37.8%, would produce the greatest profit of Rp 2,856,000 per hectare, assuming that all the roots are processed into flour and sold at Rp 650 kg^{-1}, indicating the importance of selecting for high yielding varieties for sweetpotato flour processing.

Participants' reactions and suggestions

Upon completion of the trial, the women were anxious to experiment what they had thought would produce whitest flour. An extra day of trial was granted, allowing the women to improvise and employ their own methods. The following is a summary of their reactions to the eight treatments used in the trial, and a summary of their improvised methods.

- Peeling is essential for producing white flour and it is acceptable.
- A hand-held peeler is not necessarily easier or faster than a knife, but it is safer, especially when the women are tired from peeling.
- The shredding machine, borrowed from RILET, leaves chunks unshredded which require further laborious hand grating. This makes shredding a more difficult task than slicing. The women gave suggestions on how to improve this machine to fit their needs.
- A well-constructed press would be useful to reducing water content of shreds before drying. Hand-pressing is acceptable until a better press become available and affordable.
- Spreading slices on the bamboo trays for drying takes greater effort as the slices tend to stick together, thus spreading shreds is preferred.
- The recommended processing procedures by the participants is: peel, shred, wash three times with clean water, spread to sun dry, and mill. It was believed that repeated washing would produce the whitest flour.

Even though this recommended method would be laborious, processing time is not a great concern of the participants. Martin (1985) also proposed three sequential washes with clean water as the best method for producing high quality flour. The womens' major concern was to produc e a product that would sell. Economically, feasibility must take into consideration labor costs; however, with little alternative income sources, their perception of profitability is based on the difference between the raw material costs and the market prices of the flour. This means continuing to improve on the peel/shred method, even if labor intensive, and to select for and diffuse high yielding and high DM content varieties.

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[1] Exchange rate: US$1=Rp2,300.
[2] Due to some confusion on the second day of trial, one more day was added to repeat the second day to ensure accuracy.
[3] The women preferred the simple and small home-made wooden slicer to the large metal slicing machine from RILET because they thought this machine was too dangerous.
[4] At first there was only one press, so the processing was based on only one press available.