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Pulp Recovery from North American Pawpaw Fruit [*Asimina triloba* (L.) Dunal]

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Abstract

The North American Pawpaw [*Asimina triloba* (L.) Dunal] is a tree fruit that is native to the eastern United States, and commercial demand for the fruit is increasing. Pawpaw fruit have a short harvest season, bruise easily, and have a short shelf life, presenting challenges to storing, shipping, and marketing the fruit. Storing the pulp as a frozen processed product would eliminate the postharvest issues that impede fresh fruit sales, and make pawpaw fruit products available year-round. In 2010 and 2011, a series of experiments were conducted with the objectives to determine if a commonly available sauce maker could be effective for processing pawpaw pulp, and to compare processing efficiency of four commercially available pawpaw cultivars. Fruit weights, percent seed, and pulp extraction recovery from ripe fruit of four commonly available pawpaw cultivars ('Mitchell', 'PA-Golden', 'Sunflower', and 'Susquehanna') were examined. These cultivars were selected based on varietal fruit size, and texture differences. 'Sunflower' and 'Susquehanna' had larger fruit, fewer seeds, and a higher percentage of fresh weight recovered as processed pulp, compared to the smaller fruited 'Mitchell'. An average of 50% of fruit fresh weight was recovered as processed pulp using hand-processing, and an average of 45% of fruit fresh weight was recovered as processed pulp using the mechanized method with superior cultivars.

The North American Pawpaw [*Asimina triloba* (L.) Dunal] is a tree fruit native to most of the eastern United States, and is being grown on a small scale commercially, with its popularity on the rise. Pawpaw is the only member of the Annonaceae (Custard Apple) family adapted to a temperate climate (Pomper and Layne, 2005). Pawpaws produce a fruit with creamy yellow-orange flesh and a unique flavor resembling a blend of mango, banana, and pineapple. The fruit are high in antioxidants, vitamins, minerals, amino acids, and essential fatty acids (Peterson et al., 1982). Ripe pawpaw flesh firmness ranges from avocado-like to custard-like in texture. The fruit ripen during a 4-6 week period of mid-August through early October, varying slightly by cultivar and growing location. Pawpaw fruit bruises easily and has a short shelf life of 2-3 days at room temperature, or 2-3 weeks under refrigeration at 4°C (McGrath and Karahadian, 1994; Layne, 1996, Archbold et al., 2003). Fruit can be picked slightly under-ripe, or firm-ripe, to increase shelf life, but fruit that is picked prematurely will not ripen properly with favorable flavor profiles or soluble solids levels.

Demand for pawpaw production on a larger commercial scale is increasing, but postharvest handling, storage, and shipping problems due to the short shelf life and ease of bruising are impediments to commercial development of pawpaw as a fruit crop on a larger scale (Popenoe 1916, 1917; Peterson, 1991). Pawpaw fruit currently are generally sold on a local scale at farmers' markets, small grocers, produce markets, and Community Supported Agriculture outlets (CSAs); and shipping for long-distance distribution is difficult. Marketing frozen fruit pulp as a value-added product could be a solution to the problem of perishability, expand the geographic availability of pawpaw fruit, and make pawpaw products available year-

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round. Frozen pureed pawpaw pulp can be used in a number of value-added products, including ice cream, yogurt, smoothies, baked goods, wine, jams, jellies, and chutney. Ripe pawpaw fruit sell for approximately $3-4 per pound ($6.60-8.80 per kg) at retail markets in Kentucky. Frozen pureed pawpaw pulp is sold by several online vendors for $6-10 per pound ($13.20-22.00 per kg). Pawpaw fruit pulp extraction is labor-intensive and made difficult by the row of large inedible seeds contained in the fruit, and valuable pulp may be lost through ineffective extraction methods. In the past, pawpaw pulp has been processed by hand using a variety of methods, including pushing peeled fruit through a colander or mesh screen, or squeezing through a mesh bag, to remove seeds. These methods have proven to be time- and labor- intensive, and valuable pulp is lost through ineffective extraction methods.

There are approximately 50 pawpaw cultivars that are commercially available from nurseries (Pomper et al., 2009). These cultivars vary in fruit size, with the pawpaw cultivars 'Mitchell' and 'PA-Golden' being small fruited cultivars, and with texture differences that have been previously observed; 'Susquehanna' tends to have a firm flesh when grown in Kentucky and 'PA-Golden' has soft flesh in Kentucky trials (unpublished data). Fruit size, percent seed, and fruit texture could all influence pulp recovery rates. Persimmon enthusiasts have developed a successful processing approach using a modified sauce maker to separate seeds from pulp and macerate the pulp from American persimmon (personal communication, Jerry Lehman). This method could also be effective in pawpaw pulp extraction. The objectives of this study were to determine if a commonly available sauce maker could be effective for processing pawpaw pulp, and compare processing efficiency of four commercially available pawpaw cultivars.

Materials and Methods

A method of mechanically extracting pawpaw pulp was developed at Kentucky State University, based on one developed by Indiana nut and persimmon grower Jerry Lehman for persimmon processing (pers. comm.). A Roma Food Strainer and Sauce Maker (Weston Supply, Strongsville, Ohio) was purchased, along with a grape spiral and pumpkin-squash screen. The grape spiral was modified to remove large pawpaw seeds by filing off the last two spirals. Ripe pawpaw fruit are then cut in half, and the flesh and seed scooped out of the skin with a spoon or ice cream scoop by hand. The flesh containing seeds is then fed through the hopper on top of the Roma processor, and as the pulp moves through the device via a hand crank or attachable motor, the seeds are removed by the modified grape spiral, and the pulp pushed through the pumpkin/squash screen. This method yields a more highly textured, chunky product, which can be used intact, or, if desired, be further pureed in a food processor or blender if a smooth, homogenized texture is required.

To determine the efficiency of mechanically processing pawpaw pulp using the modified Roma Food Processor method, ripe pawpaw fruit were hand-harvested from orchards in September at the Kentucky State University Research and Demonstration Farm (Frankfort, Ky.). In 2010, three sets of ten ripe fruit each of four commonly available pawpaw cultivars ('Mitchell', 'PA-Golden', 'Sunflower', and 'Susquehanna') were selected. In 2011, 'PA-Golden' was not included in the study. Temperatures and precipitation were measured by the Kentucky Mesonet site located at the KSU Research Farm. The orchards were not irrigated. Trees were fertilized with urea at 6 oz. (170 g) N per tree in March of each year and minimally pruned to remove only broken, rubbing, or overhanging limbs in February-March of each year. These cultivars were chosen based on varietal fruit size, ('Mitchell' being a small fruited cultivar), and textural differences; ('Susquehanna' tends to have a firm flesh and 'PA-Golden' has soft watery flesh).

Fresh weights of whole fruit were recorded before pulp extraction. The fruit were cut in half and pulp and seed were removed with a spoon and fed through the modified Roma Sauce Maker with a grape spiral and squash/pumpkin screen to separate seeds from pulp and macerate the pulp, in three replicates of ten fruit each. The pulp/seed mixture was run through the strainer three times to obtain as much processed pulp as possible.

The finished processed pulp of each cultivar was weighed and percent of whole fruit fresh weight that was obtained as processed pulp was calculated. Fruit were also processed with the formerly used hand processing method and percent pulp recovered using this method was calculated for comparison. Percent seed was determined by weighing whole fruit, removing the seeds, and measuring the weights of clean seeds.

Means separation and correlation were calculated using the statistical program CoStat (CoHort Software, Monterey, Calif.). Data from each year were analyzed separately. Analysis of variance was performed using Student-Newman-Keuls means separation at a significance level of $P \leq 0.05$. Correlation was calculated using the values for fruit weight and percentage of pulp recovered.

Results and Discussion

In 2010, 'Susquehanna' had the largest fruit (264 g), followed by 'Sunflower' (203 g), 'PA-Golden' (117 g); and 'Mitchell' (66 g) had the smallest fruit. In 2011, 'Sunflower' (284 g) and 'Susquehanna' (266 g) had larger fruit than 'Mitchell' (84 g) (Table 1).

Processed pulp recovery rate varied significantly among cultivars, with 'Sunflower' and 'Susquehanna' having a greater percentage of pulp recovered from fruit using mechanical processing than 'Mitchell' in both years of the study. In 2010, total rainfall was 40 inches (1016 mm), 4 inches (102 mm) below the normal annual rainfall of 44 inches (1118 mm). In 2011, total rainfall was 67 inches (1702 mm), 22 inches (560 mm) above normal (www.kymesonet.org). There was a trend for fruit grown under high rainfall conditions in 2011 to have a higher pulp recovery rate. In 2010, when the total rainfall was 4 inches (102 mm) below normal, processed pulp recovery rate varied significantly among cultivars, with 'Susquehanna' (44%) and 'Sunflower' (41%) having a greater percentage of pulp recovered from fruit compared to 'Mitchell' (24%), and 'PA Golden' not significantly different from the other three cultivars, with 33% of the fresh weight recovered as processed pulp. In 2011, when the total rainfall was 22 inches above normal, processed pulp recovery rate also varied significantly among cultivars, with 'Susquehanna' (49%) and 'Sunflower' (44%) having a greater percentage of pulp recovered from fruit compared to 'Mitchell' (28%). In

Table 1. Average fruit weights, percent pulp recovered after mechanical processing (percentage of fresh weight of whole fruit), and percent seed by weight of four commercially available pawpaw cultivars over two years.

Cultivar	Fruit weight (g)[z]		Proportion pulp recovered (by weight) (%)		Proportion seed (by weight) (%)	
	2010	2011	2010	2011	2010	2011
Mitchell	66 d[y]	84 b	24 b	28 b	13 a	12 a
Sunflower	203 b	284 a	41 a	44 a	8 b	8 b
Susquehanna	264 a	266 a	44 a	49 a	4 c	5 c
PA-Golden	117 c	--[x]	33 ab	--	8 b	--
Significance	***	**	*	***	***	***

[z] values represent mean of three replicates of ten fruit each.

[y] Statistical analysis performed using CoStat statistical software, Student-Newman-Keuls means separation at a significance level of P 0.05.

[x] -- indicates data were not collected.

both years of the study, 60-80% more pulp was recovered from the larger fruited cultivars 'Sunflower' and 'Susquehanna' than from the smaller fruited cultivar 'Mitchell'. There was a significant positive correlation between fruit weight and percent pulp recovered ($R^2 = 0.76$).

Larger-fruited cultivars also had a lower percentage of seed, with 'Susquehanna' and 'Sunflower' having significantly less seed by weight than 'Mitchell' (Table 1). 'PA Golden' had a medium fruit size and low seed content. Low seed content aids in ease and efficiency of processing, making larger fruited selections a superior choice for pawpaw pulp extraction and processing. Firm texture did not appear to be an impediment to efficient processing. The firmest-appearing fleshed cultivar, 'Susquehanna', had the highest percent pulp recovery, and the softest-appearing fleshed cultivar, 'PA Golden', had intermediate pulp recovery.

Previously, pawpaw pulp was processed entirely by hand by cutting fruit in half, scooping out the flesh and seeds with a spoon, and either squeezing it by hand through mesh bags, or pressing it through mesh screens or colanders using a spoon. This method was labor- and time- intensive. In previous years, an average of 50% of fruit fresh weight was recovered as processed pulp using the hand-processing method with five fruit of mixed cultivars (unpublished data), and an average of 45% of fruit fresh weight recovered as processed pulp using the mechanized method and superior cultivars ('Sunflower' and 'Susquehanna') in this study. The greatly reduced time and labor inputs required for mechanical processing offset the slightly reduced pulp yield.

There are several unique challenges that must be addressed in developing new methods for pawpaw fruit processing. Pawpaw skin is bitter and care must be taken when processing fruit that no skin or skin residue is included in the processed pulp. The seeds are large, inedible, and have emetic properties (Vines, 1960); therefore processors must be careful not to contaminate processed pulp with ground seeds. Damage due to bruising and fruit cracking can lead to off-flavors and also present food safety concerns due to potential microbial contaminants in the fruit. All of these challenges must be addressed in developing an efficient method for processing pawpaw fruit. The mechanized method described here addresses these issues by excluding the skin from processing, preventing any bitter contamination; and utilizing some manual labor in the process to ensure no bruised, cracked, or discolored fruits are used in processing, while having enough mechanization to expedite processing and making it time- and labor-efficient.

Larger pawpaw fruit are most suitable for efficient processing due to having a higher processed pulp recovery rate and low percent seed by weight. A high rate of processed pulp was recovered from the large-fruited cultivars 'Susquehanna' and 'Sunflower', whereas a low proportion of pulp was recovered from the small-fruited cultivar 'Mitchell'.

Acknowledgments

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About the cover: 'Bays' cherimoyas *continued from page 68*

highest of fruits in natural production of ethylene. As a result, it can pass from hard, rubbery and inedible to overripe in a day or two, which made marketing problematic, especially in the years before rapid, temperature-controlled transportation.

Nonetheless, cherimoyas trees were fairly common in home gardens such as the Brown family's, and Anthony and his twin brother, Jonathan, grew up savoring the fruits. They planted their first block at age 16 in 1967, when commercial groves were few. Boosted by the growing demand for exotic fruits in the 1970s and 1980s, the venture flourished, and the family became California's largest cherimoya grower and packer. Joined by other family members, they shipped cherimoyas from as many as 40 other growers, and by the late 1980s and 1990s their company, California Tropics, claimed four-fifths of the cherimoya market. They also were major growers of three other exotic subtropical fruits, passion fruit, feijoas and sapotes. In 2004 the family split their holdings among the siblings and stopped packing for others, but they still farm about 100 of the state's roughly 250 acres of cherimoyas.

The great majority of the state's cherimoyas are grown nearby in coastal areas of Santa Barbara and Ventura counties, which are virtually free from the hard frosts that could greatly damage the trees. But under local conditions the pistils of cherimoya flowers dry out before they can be naturally pollinated, so every afternoon from May to September Brown and his workers gather pollen and hand-pollinate the flowers just after they open.

Although cherimoya cultivars differ considerably in season, appearance, and flavor, this information is not often available. Brown harvests four varieties, from November to June. 'Bays' is early in season, round and very smooth, with a delicate flavor. 'Fino de Jete', from Spain, is mid- to late-season, medium to large, heart-shaped, pale, and fine-textured. Brown developed two of his varieties by crossing others in the early 1970s. 'Lisa', a hybrid of 'Bays' and 'McPherson', is early to mid-season, pale green, low-seeded, with fine texture, and very good flavor; despite its name, which means "smooth" in Spanish; deep thumbprint-like markings cover its skin. 'Bonita', a cross of 'Booth' and 'Pierce', is mid- to late-season, conical to heart-shaped, white-speckled, with firm flesh and rich flavor.

These four varieties are well adapted to the coastal climate, but there are others, equally delicious, more suited to districts further inland or in northern San Diego County, the state's other major growing area. These include 'Booth', which is late, medium to large, with distinctive bumps, speckled skin, lots of seeds, and a particularly strong, rich flavor. 'Pierce', mid- to late-season, heart-shaped to conical, with pale greenish skin, can be extremely sweet, but it tends to develop sugar spots that consumers misconstrue as blemishes. 'McPherson', which originated in Orange in 1933, although it is often misnamed 'Spain'. It has a marvelously intense, well-balanced flavor, but it is prone to splitting.

(Photograph and text: David Karp)