Processing and Processed Products

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Introduction

A major trend affecting food consumption patterns in the U.S. in the 1980's was the increasing consumer demand for high quality, nutritious food products requiring minimal home preparation. In part, this trend was driven by the changing nature of employment in which the two-income household and the household of a single worker/parent replaced the conventional breadwinner-homemaker combination prevalent through the first six decades of this century. The sweetpotato is available mainly in the fresh market form which requires significant home preparation time or as canned sweetpotato, a form with limited potential as a recipe ingredient. A frozen patty product and several frozen sweetpotato-containing entrees are available commercially in some markets. These products account for a very minor part of the sweetpotato production. The lack of a diversity of convenient products may have contributed to the decline in per capita consumption of sweetpotato from about 26 pounds per year in the 1930's to slightly more than 5 pounds per year in 1988.

During the past 50 years, The National Sweetpotato Collaborators Group has been actively engaged in research on new and improved products. For a variety of reasons, with the exception of the products mentioned above, this research has not resulted in successfully marketed products. The goal of this report is to summarize research concerned with processing and products conducted by the Collaborators Group. This report will emphasize research conducted since the last report in 1970, with reference to the two preceding publications (*17,79*)[1].

Preprocessing

Cultivars. The Collaborators Group has developed and conducted a well designed and effective program to evaluate cultivars for desirable baking and canning characteristics. The program has been effective because it provides for the testing of promising cultivars for several years in diverse locations. The formalized scoring protocol used by the Collaborators Group evaluates cultivars for fresh market appeal (size, appearance, and baking quality) as well as suitability for canning (86). Individual breeding programs have also selected sweetpotato for industrial uses characterized by high yield and dry matter, and low susceptibility to diseases and insects, but with no concern for exterior appearance (*25,47*). Hamilton et al. (*26*) described selection criteria amenable to rapid screening for industrial uses.

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[1]*Italic* numbers in parentheses refer to Literature Cited, page 81.

Increasingly, sweetpotato researchers have begun to question also whether sweetness and strong flavor--traditional positive selection attributes--may be limiting wider acceptance (*46,55*), particularly with regard to obvious processed food applications such as chips and french fries. Some breeding programs are actively screening cultivars with low flavor impact and low sweetness for suitability as french fries, chips, and mashed products. Several reports have been published relative to this type of cultivar (*52,53,54*). Cultivars most suitable for chipping and frying should be high in dry matter and low in reducing sugars, amylolytic enzyme activity, polyphenol oxidase, and phenolics. Finally, since size and/or shape are not processing quality factors so long as the majority of the roots are larger than the canner size, cultivar, and cultural practices can be optimized for high total yield.

Harvesting and Storage. Harvesting and storage are discussed more fully in another chapter of this report. Our present focus is on the manner in which harvesting techniques and postharvest practices impact upon the properties of the processed product. At present, the majority of the sweetpotatoes in the U.S. are hand-harvested because the degree of bruising and skinning experienced with mechanical harvesters is not acceptable for that proportion of the crop directed to the fresh market. If significant industrial and/or processing utilization is to occur, mechanical harvesting will be a necessity. The constraints to harvesting that exist for fresh market quality are not a factor for roots intended for processing and/or industrial use because exterior appearance is not an important consideration. Thus, existing mechanical harvesters may be suitable if the entire harvested crop was processed.

The manner in which sweetpotatoes are handled following harvest can have a significant effect on processed products made from them. Unless sweetpotatoes are processed within a few days of harvest, metabolic changes may occur which affect the appearance, texture, and flavor of the processed product. Curing of sweetpotato results in an increase in sugars and a decrease in starch and alcohol-insoluble solids (*16,27,67,81,96*). Changes occurring during storage after curing are cultivar-dependent. Some cultivars exhibit an increase in sugars and a decline in starch and alcohol-insoluble solids. In others, the starch content increased and sugar content decreased during the first part of the storage period, with these trends being reversed during the latter part of the storage period (*67,81*).

The postharvest holding conditions of sweetpotatoes also affect processing properties due to levels of amylolytic enzymes present in the roots. Alpha-amylase activity increases during storage (*20,100*), while beta-amylase activity decreases slightly (*8,100*). When the sweetpotato is heated, little starch hydrolysis occurs until the starch gelatinization temperature is reached. When gelatinization begins, alpha-amylase rapidly degrades starch to lower molecular weight dextrins. Concurrently, beta-amylase hydrolyses starch and starch fragments into maltose. Alpha-amylase activity persists longer than beta-amylase activity in the heated material because the alpha-amylase is more heat-stable (*44*). The degree of starch degradation and maltose formation is dependent upon the enzyme activities and the temperature program. Thus, for a given cultivar heat processed

in the same way, cured, stored roots will be sweeter and less starchy than just-harvested roots because increased alpha-amylase activity results in increased starch degradation and maltose formation. An exception to this generalization is a group of clones reported to contain no beta-amylase (*53*).

Processing

After sweetpotatoes are received at the processing facility, the roots are cleaned with a high-pressure water spray to remove adhering soil and organic matter. Some applications have held the roots in hot water as a step prior to further processing. Preheating reduces enzymatic discoloration and drives off intercellular gases which, if not removed, may prevent attainment of the desired container vacuum level, thereby placing a strain on container integrity (*21,77*). Others have found that preheating the unpeeled roots is not necessary, and that container integrity can be assured if hot syrup is used and the filled cans are exhausted in a steam chamber prior to sealing and retorting (*21*).

Peeling. Peel removal is the next step in the processing operation. The peel can be removed by lye peeling, a combination of lye and steam peeling, steam peeling alone, or abrasive peeling. Product quality and use considerations govern the peeling method selection. Lye peeling is the most common method used. The cleaned roots are conveyed into the lye bath, held for the required time, and then transferred into a rotary washer where the loosened peel and adhering softened tissue are removed by a high-pressure water spray. Depending upon the size and condition of the raw product, boiling sodium hydroxide at concentrations of 10-20 percent and bath residence times of 6-10 minutes are used (*27,104*). In some operations, higher lye concentrations and a scrubber system are often used to reduce the volume of waste requiring treatment (*23*). Peeling losses, dependent upon the bath residence time, the size of the raw product, and the lye concentration, range from 20-40 percent of the raw product. Increased bath residence times increase peeling loss but decrease the amount of hand trimming required, and result in less enzymatic darkening because the cambial region is removed (*79*).

High-pressure steam peeling is also employed by sweetpotato processors because the process can be automated and will result in less peeling loss than lye peeling. Two problems occurring during high-pressure steam peeling are explosion of large, broken roots and formation of small longitudinal tunnels resembling insect damage. Burkhardt et al. (*9*) developed a steam peeler that overcame these problems. Harris and Barber (*32*) demonstrated that depth and uniformity of peeling can be controlled by the steam pressure and the speed of diffusion. They also reported that the optimum peeling depth was 1.6-1.8 mm for best color of whole roots. However, color, flavor, and textural qualities of puree were not lowered by a peel that removed only the cork layer of 0.1-0.3 mm. An improved steam peeling process was described by Smith et al. (*88*) in which a high-pressure steam application for 80 seconds was followed by injection of cold water into the chamber during the exhaust step, resulting in an attractive product with very little enzymatic discoloration and low peeling loss. Harris and Smith (*34,35*) patented the thermal blast process in which the product was enclosed for a brief period in a heated chamber pressurized with heated steam, followed by a nearly instantaneous release of pressure. When the pressure was released, the super-heated liquid water immediately beneath the surface flashed into vapor and blasted the peel away from the product. Abrasive or hand-peeling was necessary for sweetpotatoes served raw, as on a salad bar, because the ring of disrupted tissue resulting from heat penetration during lye or steam peeling detracted from product appearance and textural properties. For most applications, however, lye or steam peeling is most suitable.

Effects of Processing on Nutritional Quality

Lanier and Sistrunk (*48*) found that canning caused significant loss of ascorbic acid, pantothenic acid, niacin, and riboflavin. Total carotenoids were not diminished by canning. Lee and Ammerman (*49*) reported that retorting caused significant isomerization and loss of beta-carotene. Canned sweetpotato loses amino acids due to leaching into the syrup (*58*). Purcell and Walter (*71*) found that 26 percent of the nitrogen was leached into the syrup of canned sweetpotato and that significant destruction of lysine and methionine occurred during canning and drum-drying. Walter et al. (*96*) reported that available lysine decreased in sweetpotato flour prepared by drum-drying as compared to flour prepared by forced-air drying at 60°C.

Canned Products

Sweetpotatoes intended for canning must be size-graded prior to packing in cans. This step is accomplished by mechanical sorting. Since the styles of canned products range from whole roots (canners) to cut root chunks, processors can utilize a wide range of root sizes. However, within each type, similar sized product is most attractive.

Prior to filling, some processors blanch the material in water at 77°C for 1-3 minutes to inactivate enzymes. After blanching, the cans are filled with sweetpotato and then with hot syrup (20-40 percent sucrose). Cans larger than No. 303 should be exhausted long enough for the "cold spot" to reach 77°C. The cans are then sealed, retorted until the lethal value of the heating is equivalent to 4-5 minutes at 121°C (*21*), cooled with water, and boxed. No. 303 cans are not exhausted, but should then be sealed in a steam-flow can sealer and processed as described.

Four types of canned sweetpotato are processed commercially. In order of decreasing quantity, they are: cuts and halves in syrup; whole, small roots in syrup; vaccuum packed; and mashed, solid packs (*2*). Statistics show that a steady decline in production of each type of product has occurred for the past 15 years. Bouwkamp (*6*) suggested that the decline can be attributed to cultural and economic factors which may equal or exceed the importance of technical limitations in development of a successful processing industry. Edmond and

Ammerman (*21*) stated that any increase in consumption of sweetpotato would come from the use of processed products. With the reported decline in consumption of canned sweetpotatoes, it seems apparent that the processed products of the future must be products other than the present canned types.

Various attempts have been made to develop new products. However, often the attempt has been to copy products that are prepared from other commodities. Products of the white potato are examples. While this approach is a reasonable one, the sweetpotato may not lend itself readily to preparation of certain products or to be able to compete economically with the white potato. A few of the new products have enjoyed some degree of success at the market place.

Firmness. Preprocessing factors such as cultivar differences, growing conditions, chronological age, and post-harvest history can influence product firmness. The procedures used by the Collaborators Group evaluate all selections for the high degree of firmness required for the canned product. Studies with many selections and cultivars have shown that firmness was cultivar-dependent (*45,60*). Irrigation has been reported to cause a decrease in firmness (*15*), to result in no change (*29*), or to increase firmness (*45*). Sweetpotatoes harvested later in the growing season tend to be less firm than those harvested earlier (*45,78*). This tendency was ascribed to the chronological age of the roots, since roots from plots planted early were less firm than roots from late planted plots when both plots were harvested at the same time (*78*). Postharvest handling also affects firmness. It has been reported that roots held for more than a few days following harvest resulted in roots less firm than those processed soon after harvest (*4,14,72*). Cheng and Ammerman (*10*) reported that sweetpotatoes canned immediately after harvest or after curing for 10 days were similar in firmness and were firmer than sweetpotatoes canned after 10 days of curing plus 10 days of storage.

Because sweetpotatoes canned soon after harvest are firmer than the canned product made from stored roots, the canning industry is geared to processing only freshly harvested roots, thus limiting the canning season to the harvesting period. Members of the Collaborators Group have conducted research into ways to increase firmness of cured and stored sweetpotatoes. The decrease in firmness is likely due to a complex interaction of physical and chemical factors. Although changes in starch during curing seem to be too slight to cause the differences in texture, increases in amylolytic enzyme activity during this period may affect starch content during processing and, thus, cause some of the observed softening. Ahmed and Scott (*1*) reported that increased softening of canned sweetpotato was related to decreases in pectic materials. Baumgardner and Scott (*5*) found that the pectic substances of the processed material were associated with canned product firmness. Increased firmness of the canned product made from stored sweetpotato has been accomplished by addition of calcium (*82,104*), calcium and pectin (*50,72,102*), and citric acid as an acidulant (*87*).

Color. A bright orange color is essential for consumer acceptance of canned sweetpotatoes. This attribute is a key factor in evaluation of selections by the Collaborators. The orange color is due mainly to beta-carotene (*59,65,69,70*) and is cultivar-dependent. Additionally, the amount of phenolics and the activity of polyphenol oxidase (PPO) present in the roots before processing may significantly affect the color of the canned product (*22,77,80*). Discoloration results from oxidation of phenolic components catalyzed by PPO, and appears as a brown or gray color that masks the preferred bright orange color. Phenolics can also form a gray colored complex with Fe^{+3}, also causing diminution of the orange color.

Phenolics are localized mainly within 2-3 mm of the root surface, and the PPO is localized in roughly the same area (*74,77,80*). Consequently, heat penetration from the peeling treatment must be avoided, or be of such intensity that the PPO enzyme is inactivated (*101*). If tissue in the heated zone is disrupted and the enzyme remains active, a brown or gray discoloration of the exterior surface of the peeled root may result. To avoid this problem, preheating of the root prior to lye peeling has been used (*76,77*). Discoloration was avoided in a high-pressure steam peeler in which cold water was introduced during the exhaust cycle, because the cooling effect of the injected water limited heat penetration to a ring of about 1 mm below the peeled surface (*88*). Most of the heat-disrupted tissue was removed by the post-steam chamber treatment. Discoloration can be avoided also if tissue removed extends beyond the cambial area. This is frequently the practice where lye peeling is used.

Several other factors can affect the color of canned sweetpotato. Uncoated tin-plated cans, used for many years, resulted in exceptionally bright products because the tin was oxidized and solubilized by the liquor and formed a yellow-orange complex with phenolics (*83*). However, considerable detinning often occurred, and the detinned areas assumed an unattractive black appearance. Smittle and Scott (*90*) reported that can corrosion was due to PPO activity and nitrate concentration. They suggested that discoloration could be avoided if cultivars low in PPO activity and nitrate levels were selected. Since enameled cans are now used exclusively, detinning is no longer a problem.

Additives can reduce or eliminate discoloration in canned sweetpotato. Twigg et al. (*94*) found that ethylene diaminetetraacetic acid (EDTA), stannous chloride, citric acid, and ascorbic acid were efficacious as color improvement agents. Citric acid solution used as a soak agent prior to processing has also reduced discoloration (*87*). The mode of action of these additives is believed to be chelation of metallic ions (EDTA, citric acid, ascorbic acid), formation of a complex with phenolics (stannous chloride), lowering of pH (citric acid, ascorbic acid), and reduction of oxidized, polymerized phenolics (ascorbic acid).

Syrup content can affect sweetpotato appearance. In general, sweetpotato canned in syrup that contained 40-50 percent sucrose were more attractive than that canned in syrup of lower sucrose content (*6,104*).

From the above discussion, it is clear that as a result of research conducted by the Collaborators, firm bright orange, canned sweetpotatoes can be produced from freshly harvested, uncured as well as cured, stored sweetpotatoes. Application of this technology awaits implementation by the processing industry.

Other Processed Products

Pureed and Dehydrated Products. Sweetpotatoes for processing into pureed or dehydrated forms are affected by many of the same factors described above, up to and including the peeling operation and, thus, are handled in a similar manner as roots which are to be canned whole or in chunks. After peeling, the roots are subjected to a variety of processing treatments dependent upon the product.

Production of high quality purees for canning, freezing, and dehydration has been the goal of research conducted by several Collaborators. Harris and Barber (33) described a process in which whole roots or pieces were cooked in a sucrose solution prior to pulping. Others have cooked sweetpotatoes by baking, boiling in water, and/or steaming prior to pureeing (*43,89,103*). In regard to sensory and nutritional quality, freezing is less destructive to the finished puree than canning. However, Silva et al. (*84*) reported that pies made from canned puree were more acceptable than those made from frozen puree, probably because of caramelization reactions of the canned products. Smith et al. (*89*) described an aseptic canning process which eliminated long heat processing times (*31*) associated with conventional canning and resulted in a shelf-stable, high quality puree. Szyperski et al. (*91*) developed a process for production of purees with consistent textural properties, regardless of raw product postharvest handling practices. The most successful commercial application for the puree is as an infant food.

Cooked sweetpotato can be prepared into a puree or mash. Puree can be used to prepare numerous foods such as baby food, pies, patties, and flakes. Also, puree can be used as an ingredient in a variety of baked goods.

Turner and Danner (*93*) investigated consumer acceptance of an improved frozen puree. Commercial and school cafeterias gave the product a very high rating. Harris and Barber (*33*) determined that the frozen puree could be used to produce excellent quality pies or souffles.

Researchers at the Mississippi experiment station investigated the use of field-run roots for production of puree. Santos (*73*) filled puree into plastic casings and froze it to form one-pound rolls. Continuing the study, McMillen (*57*) reported that good quality mashed sweetpotato could be prepared from either 'Jewel' or 'Centennial' roots that had been cured and stored for four months. Smith et al. (*89*) used flash sterilization to treat puree prior to aseptic packaging. This process produced puree of improved quality when compared to that of frozen puree.

Partial dehydration of blanched, raw sweetpotato strips and french fry pieces improved the textural properties and flavor when these materials were cooked in hot oil (*42,98*). Collins and Washam-Hutsell (*13*) described a process for production of sweetpotato leather snack food.

Precooked, dehydrated sweetpotato flakes consist of particles of approximately 1.6-6.4 mm diameter prepared from thin sheets of drum-dried puree (*6*). Being subject to oxidative deterioration, flakes should be packaged in containers of very low transfer rates for water vapor and oxygen. The package of flakes should be filled with an atmosphere containing less than 2 percent oxygen. For use, flakes are rehydrated and used in a variety of foods.

Considerable research has been conducted to improve the quality of flakes since the patent for production of flakes was first issued (*18*). Purcell (*69*) found that the amounts of individual carotenoids in flakes remained stable during production. Loss of carotenoids from flakes during storage was reduced by addition of antioxidants, packaging under a nitrogen atmosphere, and storing at low temperatures. Hoover (*36*) used phosphates to improve color of flakes. Storage conditions of the roots prior to processing were found to influence quality and production of flakes (*3,39,41*). Quality of flakes was improved when roots were held at 14.4°C for 6-24 weeks.

Flavor, texture, and appearance of flakes was improved as the amount of soluble solids was increased by amylolytic enzyme hydrolysis of starch (*19,20, 38,40,97*). Originally, a commercial enzyme preparation was used. Later, advantage was taken of the endogenous amylase system present in sweetpotato. Rapid heating of comminuted tissue up to 78.9-80.6°C by steam injection and holding at these temperatures for 30 minutes or less produced excellent quality flakes from fresh and cured roots.

Szsyperski et al. (*91*) found that a controlled alpha-amylase process was useful for producing consistent puree, independent of age of the roots or seasonal variation. McArdle and Bouwkamp (*56*) reported that rapid heating of mashes to 80°C yielded the maximum level of major, unconverted carbohydrate fractions.

Patties. Frozen patties represent one of the recent successful products made from the sweetpotato (*6*). Originally, patties were prepared from freshly harvested roots. However, due to the short harvest season, only a limited quantity of patties could be produced. Pak (*64*) developed a frozen patty suitable for restaurant handling from puree that was prepared from cured, stored roots. Use of a modified starch as an ingredient permitted development of a golden-brown crust color without use of batter and breading. Patties made from 'Travis' were as acceptable as patties made from 'Centennial' or 'Jewel' (*86*). The patties from cured roots proved to be more acceptable than the patties from uncured roots (*85*).

Using specified amounts of selected ingredients and rapid heating of the comminuted sweetpotato pulp by steam injection, Hoover et al. (*43*) prepared acceptable patties from freshly harvested or cured, stored roots of 'Jewel' and 'Centennial'. Walter and Hoover (*97*) stated that the starch content after cooking was positively correlated with consumer acceptance, and was the most important factor in preparation of a patty of consistent quality from fresh and stored roots. By use of scanning electron microscopy, the authors showed that most of the cells of the tissue had been ruptured and that the cooked patty was held together by an amorphous matrix of added ingredients and cellular contents.

Chips and French Fries. Many efforts have been made to produce a high quality chip from sweetpotato (*42*), but several problems have hindered development. The main problems have been discoloration, lack or loss of crispness, and high oil uptake. Thus, research has been directed toward minimizing the impact of these factors on quality.

Hoover and Miller (*42*) showed that high quality chips could be made by optimizing a combination of treatments applied to raw chips prior to deep frying.

The authors reported that blanching the raw chips of cured, stored roots in water with 0.5-0.75 percent sodium pyrophosphate, dehydrating to 50 percent moisture, and deep frying at 143-154°C for 3.5 to 2.5 minutes, respectively, produced chips of excellent quality. Picha (*68*) showed that the color of chips was positively related to reducing sugars. Therefore, freshly harvested roots should produce the most preferred color since such roots contain less sugar than stored roots. Martin (*52*) used sweetpotato selections of low sweetness levels to produce chips of excellent color. Wiley and Bouwkamp, as reported by Hannigan (*30*), developed a method of using a solvent to extract 90-100 percent of the sugar from slices before the product was fried, thereby producing a pleasantly colored chip. Bozorgmehr (*7*) found that unsalted chips from 'Red Jewel' showed less decrease in Hunter color 'b' values (yellowness) and carotenoid content when packaged under a nitrogen atmosphere as compared to air. Chips with 1 percent salt showed greater deterioration than unsalted chips. The mean oil content of the chips was 51.5 percent. Toledo (*92*) reported on a chip prepared from puree and tapioca starch. The mixture was dried on a drum dryer as a thin sheet. Pieces were deep fried for approximately 30 seconds at 135° C to yield a bright yellow-orange chip of excellent quality.

Walter and Hoover (*98*) discussed previous research on development of a french fry-type product by other workers, including some of the problems encountered. These authors prepared samples from fresh and cured, stored roots. Strips were blanched, partially dehydrated, frozen, and later fried in peanut oil. Good quality fries were prepared from 'Jewel' and 'Centennial' roots stored less than 24 weeks. Schwartz et al. (*75*) tested the blanched, frozen product that was stored up to 12 months. Extended storage caused a loss of vitamin C and an apparent increase in carotene. Dehydration destroyed some vitamin C. For the fried product, no storage-induced changes in organoleptic quality were noted.

Flour. Puree of cooked sweetpotato can be dried and prepared as flour of excellent quality. Such flour may be used as an ingredient in a variety of baked goods. Because of its enzyme levels and beta-carotene content, flour is subject to deterioration unless it is packaged properly. Limited research has been conducted on flour.

Flour was assayed by Walter et al. (*96*) for amino acid content, nonprotein nitrogen, and available lysine. Protein efficiency ratios (PER) for protein of the flour ranged from 2.2 to 1.3, depending upon cultivar and dehydration treatment. While amino acid analyses indicated little difference in levels of lysine, a bioavailability assay for lysine correlated well with PER values. Gurkin (*24*) studied the effect of different storage conditions on rate of deterioration of 'Red Jewel' flour. After six weeks of storage, beta-carotene content was found to be 4.4 percent lower in flour stored under a 2 percent oxygen-98 percent nitrogen atmosphere than in flour stored under a 100 percent nitrogen atmosphere. Beta-carotene content seemed to increase as the storage time was extended. However, the pigment was apparently more readily extracted in the older flour. Hunter color 'b' values (yellowness) decreased slightly during the storage period. Generally, breakfast muffins with sweetpotato flour were preferred by a sensory panel to muffins made with puree.

Collins and Abdul Aziz (*11*) tested the effect of sweetpotato flour (and puree) as an ingredient on quality of yeast-raised doughnuts. Several chemical and physical properties and six organoleptic attributes of the doughnuts were tested, but overall quality was not significantly lowered by addition of sweetpotato.

Foliage as Greens. Extensive investigations on the nutritional value of sweetpotato foliage as edible greens are being conducted at the G.W. Carver Experiment Station at Tuskegee University. Pace et al. (*62*) evaluated greens of 'Jewel' and 'Carver' for proximate composition as affected by cultivar, harvest date, crop year, and processing. Overall nutrient content for both cultivars was similar except for lipids and ash. Protein decreased in both blanched and canned greens as the season progressed. Nutrients remained constant from year to year. Pace et al. (*63*) reported that calcium and iron increased and zinc decreased in the foliage as the plant aged. On the wet basis, a 100 g serving provided from 13-27 percent of the calcium and 3-17 percent of the iron required in the Recommended Dietary Allowances for adult males. Availability of iron increased as the foliage aged (*64*). Sensory testing for acceptance of the greens remains to be investigated.

Frozen Products. At present, only frozen patties and frozen pieces are available commercially. Collins et al. (*12*) evaluated frozen products consisting of puree, sugar, cinnamon, and one of four ingredients added for flavor. Samples most preferred had pineapple, ham, or a combination of both ingredients. Scores indicated a "like moderately" to "like very much" reaction by the panel. Hunter 'L' and 'b' color values were decreased slightly, and the Hunter 'a' value was increased during frozen storage to 135 days. Several of the products listed above also could be provided in the frozen form: french fries, puree, patties, and greens. Hoover (*37*) used phosphates as a color preserver in precooked, frozen sweetpotato products.

Specialty Products. A baked, ready-to-eat sweetpotato has potential as a commercial product, provided that such a product possesses the attributes essential for appeal to consumers. Working toward developing a baked sweetpotato, several workers conducted related research. Walter et al. (*100*) studied effects of amylolytic enzyme activity on "moistness" and carbohydrate changes of baked roots. Scores for moistness and other attributes were determined and correlated. Picha (*66*) developed a chromatographic procedure to measure sugars of baked and raw sweetpotato. Major sugars found were maltose, sucrose, glucose, and fructose. Walter (*95*) reported that given sufficient time after harvest, baked, cured roots were indistinguishable from baked, uncured roots.

A "fruit leather" of supple, leathery texture was prepared from baked roots (*13*). The product containing 5.9 percent moisture and 0.48-0.58 water activity did not support microbiological growth. Dietary fiber was 4.1 percent (DWB), color was orange, pH was 4.8, and caloric content was 17.3 kJ/g.

Martin (*51*) removed sugars and other flavorants from sliced and shredded sweetpotato by a short water soak procedure. The slices and shreds were then boiled in water and presented as mashed, fried, and rice substitute dishes. Consumers rated these products highly acceptable.

Future Products. Sweetpotato products must possess a number of characteristics if they are to gain consumer acceptance. Consumers of today are considered more sophisticated than consumers of the past. They are gainfully employed, manage households, and do all the other activities expected of them. Such demands on time leave less time for preparing the family meal. Consequently, today's shoppers are looking for products that are compatible with their busy schedules. The demand is high and is increasing for products that are ready to eat, requiring heating only, particularly heating by microwaves. Also, the products must possess excellent quality. After all, future sweetpotato products will be competing against some excellent products currently on the market. The price of the item may be secondary, since many shoppers purchase foods that they want, provided they are of satisfactory quality and require little preparation.

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