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Development and transfer of processing technologies for fruity food products from sweet potato

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ABSTRACT

In an attempt to increase the economic value of sweet potato *(Ipomoea batatas),* the starchy roots have been processed into fruity-food products. The formulated fruity sweet potato products have similar appearances, tastes, and nutrient contents, but had higher vitamin A levels when compared with other processed fruit and vegetable products. The developed products were rated high in sensory scores and consumer acceptability tests. The formulations, nutrient compositions, and factors which affect product quality are presented. Technology transfer has been carried out through seminars, workshops, trainings, and demonstrations. Technologies for the catsup and the beverage have already been adopted by farmers' cooperatives and catsup/food processing companies in the Philippines. Factors that could accelerate transfer of the technologies to the private sector are discussed.

INTRODUCTION

In many countries, sweet potato (*Ipomoea batatas)*—SP, is an important food crop with various good attributes such as high yield, wide ecological adaptability, low input requirements, and shorter growing period than other root crops. More importantly, SP is a starchy commodity containing vitamins, particularly vitamin A, and minerals comparable to those of various fruits (Truong 1989). This was the basis for development of several fruity food products, namely: (1) dried sweet-sour SP, (2) SP catsup, (3) SP jam, (4) SP beverage, and (5) SP leather, towards increasing the economic value of the crop. The processing of SP into products with similar taste and appearance as processed fruit items has been proven to be cost-effective to make them competitive with fruits.

The technologies for processing the first 4 of the 5 products have been transferred to the private sector. Large-scale production of these products would benefit the following target clientele: (1) farmers—who will get better markets for their fresh SP by participating in an integrated system for production, processing, and marketing to increase the value of their produce; (2) food processors who take advantage of the relative cheapness and nonseasonal production of SP compared to fruits, and being a nutrient-rich raw material; and (3) consumers—that will be offered low-priced and nutritious products. The paper reports the development of processing technologies for fruity-food products from SP and examines the factors contributing to the transfer of the technologies to the private sector.

METHODOLOGY

PRODUCT DEVELOPMENT

Materials. The fresh roots of Visayas State College of Agriculture (VISCA) cultivars of SP (i.e., VSP series 1–7) BNAS-51, UPL-SP 5, and various accessions were obtained from the experimental fields of VISCA, Baybay, Leyte, Philippines. Native SP cultivars were purchased from the public markets of Baybay, Ormoc, Tacloban, and Cebu City and of various cities and towns in Luzon, Philippines. Other ingredients such as sugar, ascorbic acid, citric acid, agar, etc., were of food grade. The artificial food flavors and the extracted juice/pulp of ripe papaya, mango, pineapple, guava, and Philippine lemon, Kalamansi, were used as flavoring agents in product formulation.

Commercial products of dried fruits, banana, tomato catsup, fruit jams/jellies, fruit juice/drinks, and fruit leather which were either locally made or imported were compared with the developed products.

Methods of preparation. For the dried sweet-sour SP, the fresh roots were washed, peeled, and sliced into 0.3 cm thick slices, cooked, soaked in syrup containing citric acid, dried at 60–65°C, and packed in plastic bags (Truong et al. 1988). For processing of other fruity-products, the peeled roots of SP were chopped into chunks, steam cooked, and blended with water into a slurry that was used to prepare SP beverage, SP jam, SP catsup, and SP leather following the procedures described by Truong and Fementira (1989, 1990), Truong et al. (1990), and Truong et al. (1991a, 1991b).

Sensory Evaluation. Samples of the fruity-sweet potato products were assessed by a trained laboratory taste panel of 8–12 members selected from the personnel of the Department of Agricultural Chemistry and Food Science, VISCA. The samples were placed in appropriate containers, coded, and served at room temperature.

The panelists, rated the acceptability of the products on a hedonic scale of 9 points with 9: like extremely and 1: dislike extremely. The aroma of the samples was scored on a 7-point scale with 7: very distinct fruit aroma, and 1: very distinct sweet potato aroma. Gel consistency of SP jam was assessed on a 5- point scale of intensity with 5: very good, and 1: very poor. The degree of sweetness and sourness blend of SP catsup was evaluated on a 5-point scale with 5: predominantly sweet and 1: predominantly sour.

Consumer acceptability tests. The accepted formula of the fruity-food products which were identified in the sensory evaluation were subjected to consumer acceptability test. Unless otherwise stated, 4 groups of consumers: elementary school pupils, high school students, college students, and adults were randomly selected in VISCA and/or Tacloban City to assess the products. For SP catsup, the consumer panel had 200 respondents comprising housewives, professionals, technicians, etc., from randomly selected households and offices in Tacloban City.

TECHNOLOGY TRANSFER

A strategy of technology transfer was developed for the all the products. The first step was the dissemination of information to the public through scientific reports, announcements in newspapers, seminars, and investment fora held in various provinces in the Philippines. Displays of actual products were carried out in science and technology fairs organized by government and nongovernment organizations.

The 3 modes of technology transfer adopted were: (a) Direct extension—the SP catsup technology was extended to entrepreneurs and farmers through practical trainings and demonstrations. Recently, the dried sweet-sour SP was also transferred through the same mode; (b) Exclusive contract—initially, the technology for dried SP was transferred, on an exclusive basis for 5 yr, to a group of businessmen who were establishing a food processing enterprise; and (c) Non-exclusive contract—a non-exclusive basis for the transfer of the patented SP beverage technology to a big food beverage company was adopted. The decision on the appropriate mode of technology transfer depended on the following factors: (i) originality of the technology, (ii) capability of the potential users, and (iii) technology level, i.e, its suitability for village level, small, or large scale.

RESULTS AND DISCUSSION

PRODUCT DEVELOPMENT

Dried sweet-sour sweet potato (SP). The product has a sweet and sour taste of dried fruits. It was originally named Delicious SP (Truong et al. 1988). The cooked SP slices soaked in 60° Brix syrup containing 0.8–0% citric acid produced the most acceptable product. The Delicious-SP prepared from VSP-1, which is a "moist" type SP with low dry matter and starch content, had the highest sensory scores due to its attractive orange color and soft texture.

The dried sweet-sour SP contained 13033 I.U. of vitamin A /100 g which is higher than that of dried mango and dried apricot (Truong 1989).

Sweet potato catsup. A formula of SP catsup consisting of 32.3% (w/w) SP, 42% water, 2.9% vinegar, 11.3% sugar, 1.0% salt, 0.3% spices, and food colors was developed. Various SP cultivars having cooked flesh color ranging from yellow to orange and "moist" texture can be used for catsup making. Organoleptic rating of SP catsup was slightly higher than commercial banana catsup; but they both had comparable viscosity, total soluble solids, pH, and SP castup contained vitamin A intermediate between that of banana and tomato catsup. In consumer acceptability tests, SP catsup was rated equal to the leading brand of banana and tomato catsup in terms of color, flavor, consistency, and general acceptability. The SP catsup which was stored for 4 months at ambient temperature had sensory scores comparable to that of freshly prepared samples. The details on user acceptance and economic analysis of SP catsup have been reported by Truong et al. (1990).

Sweet potato jam. The formula containing 20.7% (w/w) SP, 45% sugar, 34% water, and 0.3% citric acid, was most acceptable by the laboratory taste panel. Due to the high starch content of SP roots compared to fruits, the proportion of SP to sugar was different from the standard formula of 45% parts of fruits and 55% parts of sugar in fruit jams (Gross 1974).

The SP jams with varied natural colors, e.g., light yellow, orange, and purple, can be processed from different varieties of SP. The orange-fleshed type (VSP-1 and VSP-2) produced an orange product rich in vitamin A. The SP jam with or without addition of 0.5% (w/w) of the locally semi-processed agar, galaman, was rated by a laboratory taste panel to be comparable to various commercial fruit jams in color, consistency, and general acceptability. Addition of artificial orange flavor at 0.5% (w/w) significantly increased the aroma score of SP jam. In a consumer acceptability test, SP jam with added orange flavor was preferred to a commercially popular orange marmalade but was rated lower than a commercial guava jelly. The quality characteristics of SP jam has been reported by Truong et al. (1991a).

Sweet potato beverage. The processing steps for SP beverage involve: washing, peeling, trimming to remove damaged parts, steaming, extracting, and formulating with 12% (w/v) sugar, 0.20% (w/v) citric acid, and 232 mg/l ascorbic acid as vitamin C fortification (Truong and Fementira 1989). The formulated beverage was bottled in 150 ml glass containers and pasteurized at 90–95°C.

Various SP varieties were evaluated for their suitability in processing into beverage. In general, the SP beverage with orange color was preferred to the product with other colors. Addition of juice or pulp of different fruits, e.g., guava, pineapple, Philippines lemon to SP beverage at concentrations of 0.6–2.4% w/v significantly improved the aroma scores of the product. Likewise, incorporation of artificial orange flavor also enhanced the aroma of the SP beverage. Over 85% and 96% of the consumer respondents "like" the SP-beverage and the guava-flavored SP beverage, respectively (Truong and Fementira 1990). The physical properties, e.g., total soluble solids, insoluble solids, pH, appearance, and color of the SP

beverage were similar to those of yellow–orange fruit juices and drinks available commercially. No significant difference in all sensory attributes was noted between the SP beverage and commercial fruit products. It was noted that artificial colors and flavorings were added to most commercial fruit juice as indicated on the labels of the products. The natural orange color, an indicator of high vitamin A content of SP beverage, is an advantage over commercial fruit drinks in promotion of the product. The orange SP beverage processed from VSP-1 had a vitamin A content of 1 844 I.U./100 g which is equivalent to 41% of the recommended daily allowance of vitamin A for humans. The vitamin C and mineral contents of SP beverage were also comparable with those of commercial fruit drinks (Truong 1991a).

Sweet potato leather. In the processing of SP leather, the steamed SP chunks were blended with water, sugar, salt, citric acid , and optionally with artificial fruit flavors. The slurry was then spread into thin layers on plastic sheets and dried in a mechanical drier until the desired moisture content and texture were obtained. A loading density of 4 kg slurry per m^2 produced the SP leather which was rated with high scores for thickness, texture, and general acceptability.

The product also had scores of over 7.0 for color, sweetness, and sourness. Pectin was also added to the SP leather formula at 0.05–0.15% w/w but did not improve the texture of the product (Truong et al. 1991b). Apparently, the pectin content of SP roots was sufficient to produce a product with a leathery texture. Tanafranca et al. (1987) reported a similar observation regarding the effect of added pectin on the texture of mango leather. The orange SP leather which was produced from VSP-1 and a newly released variety, VSP-7 with orange flesh color, had scores of over 8.0 for color, texture, and general acceptability. Sensory evaluation of the orange SP leather by a laboratory taste panel was performed in comparison with "orange roll-ups", an imported fruit leather and mango leather which was prepared from ripe mango, following the procedure described by Tanafranca et al. (1987). No significant difference in the scores for color, flavor, and general acceptability was noted for the 3 products. However, in an acceptability test by a consumer panel, mango leather was rated first, followed by SP leather and orange roll-ups as 3rd (Truong et al 1991b).

About the physicochemical properties, the SP leather had a similar pH range, higher total sugar content, and lower reducing sugar content than the fruit leathers. Due to its starchy nature, SP leather had a starch content which is 5 times higher than mango leather but was much lower than orange roll-ups. Nonetheless, the exact formula of orange roll-ups is unknown. SP and mango leather had very rich vitamin A content (14 067 and 16 689 I.U./100 g) compared with orange roll-ups (387 I.U./100 g).

TECHNOLOGY TRANSFER

Current status of the transferred technologies. The SP catsup technology has been adopted by farmers' organization, small-scale food processors, and catsup processing companies in different locations in the Philippines. Products with SP as an ingredient or a brand name of SP catsup are presently available in domestic markets. A banana catsup company which has a factory with a production capacity of 10 000 bottles of catsup per day, adopted the SP catsup technology and made a substantial profit in 1990. For SP jam, the technology has been adopted by a farmers' organization and integrated with SP catsup processing.

On the other hand, the technology for processing Delicious SP was exclusively transferred to an establishing food processing enterprise with a mutual agreement that the company would pay 1.5% of the gross sale to VISCA as royalty for 5 yr. However, the

exclusive terms of the contract was criticized because it contradicts the mandate of a government institution such as VISCA.

The Delicious-SP product was packed in attractive plastic material and named Tropical Delights. However, due to inadequate facilities and lack of experience in marketing of food products, the enterprise encountered difficulties in producing good quality product and market development. A fire accident in the location destroyed the processing facilities of the company and the agreement was nullified with the mutual consent of both parties. Recently, an association of SP growers and processors has adopted the technology for small-scale production of Delicious-SP.

The problems encountered in the transfer of the Delicious-SP technology had helped identify some limitations with regard to the technical capability of the technology user and the terms of agreement. A non-exclusive contract was signed between VISCA and a big food and beverage company for the transfer of SP beverage. In return, the company donated equipment to VISCA for R&D in food processing. The company got interested in the SP beverage with its high vitamin A content.

A joint pilot project for scaling up the beverage process for commercialization was undertaken by the company and VISCA. Details of the undertakings in translating the laboratory process to pilot-scale operations have been reported (Truong 1991a). Technically, there was no major problem in the trial runs for processing SP beverage at the company facilities. However, the launching of the product in the market has been delayed due to unexpected inadequate supply of fresh roots of VSP-1 and possibly, other managerial matters. Being a new variety, VSP-1 is not widely grown by farmers in the locality. Besides, timing the production of VSP-1 roots to match the schedule of operation of the company facilities for SP processing which would be carried out only when there is no fruit processing, was difficult.

Factors accelerating the process of technology transfer. Plans for commercial use of a developed technology should be initiated at the onset of the project and nurtured thereafter to ensure its successful transfer. Keffort (1984) stated that a systems approach to a project from idea to market is more likely to succeed. Based on our experiences in the transfer of the processing technologies for fruity-sweet potato products, the close relationship among the three sectors, i.e., government, research institution, and private sector is recognized as one of the determining factors in bringing research results to the target clientele. The analyses on the key factors accelerating the transfer of generated technologies to end-users are, therefore, discussed in relation to the two phases, i.e., technology generation and transfer.

Technology generation phase. One of the steps involved in product development is to conceive an idea or identify opportunities by generating and screening of product options, followed by concept testing, analysis on potential market demand, and profitability (Earle and Anderson 1985). However, this step is often bypassed and the consequence is that the research results may not have a chance to reach the target clients if market possibilities later prove negative. The product idea can be generated through consumer and market research (Truong et al. 1990c) which may reduce the risk of failure but may limit the researcher's innovativeness. Alternatively, researcher's analyses based on observations on existing products and their marketability, raw material characteristics (physicochemical and nutritional), and cost can indicate a potential product idea. As previously mentioned, the analogy identified between SP and fruits in terms of vitamin A, C, and mineral content provided a basis for the development of the fruity SP products considered earlier.

A good understanding of the market situation and the creativity of the researcher are key

factors determining the commercial potential of research results. The potential should be rigorously evaluated before being recommended for transfer to end users. An evaluation procedure, which takes into account 3 primary criteria including technical feasibility, marketability, and profitability, has been developed (Abejuela 1991). Based on such criteria, Delicious-SP and SP catsup technologies were rated favorably for commercial utilization. Reduction of the input cost to SP catsup was suggested (Abejuela. 1991); and the cost for raw materials used in SP catsup processing has been reduced to 50% of the original formulation. This improved the economic attractiveness of the technology and also accelerated the adoption of the technology by end users.

Technology transfer phase. Various barriers for commercialization of research results have been identified (Habito 1991). These include: (a) inadequate information on available new and promising technologies, and (b) immaturity of available technologies. The factors affecting the adoption of the processing technologies for fruity SP products, during technology transfer phase are the following:

(i) Information dissemination: The technologies for processing fruity food products from SP were widely disseminated to the public through various investment fora organized by the Department of Trade and Industry, national/regional science and technology fairs/seminars, and trainings. These raised the awareness of farmers, food processors, and companies about new SP products and, thus, accelerated the adoption of the developed technologies. Therefore, the important role which government can play in this aspect is to link potential investors with the generators of technology through provision of appropriate opportunities for them to interact.

(ii) Pilot testing: Pilot project, as a step toward commercialization aims to generate information needed to confirm the "maturity" of developed technologies in terms of technical and economic feasibility for commercial production. Factors that contribute to a successful pilot project have been discussed by Truong (1991b). Pilot testing of Delicious-SP technology was performed at the research laboratory. Equipment needed for the pilot processing line were fabricated and assembled. The data generated were used for cost and return analysis. An evaluation of the commercial potential of the technology indicated that it was feasible for commercialization (Abejuela et al. 1989).

SP catsup technology was adopted by a banana catsup manufacturer which has the established facilities as well as experience in processing and marketing of the product. The rapid adoption of the technology by catsup manufacturers can be attributed to the cost effectiveness of the process and the product quality. Indeed, several advantages of SP over banana in catsup making were recognized: (a) SP is cheaper than banana, (b) SP supply is less dependent on weather, (c) due to the favorable chemical properties of SP, the addition of stabilizer as is the case for banana catsup making is not required for SP catsup, and (d) SP catsup contains more vitamin A than banana catsup (Dignos et al. 1990, Truong et al. 1990).

The close partnership between the company and the researcher in the dissemination and refinement of the technology for commercialization greatly promotes the benefits of both parties. For small-scale food processors and farmers' organization that adopted SP catsup technology, several requirements have been identified for developing the capabilities for operating a food processing unit and for marketing the processed products. Among these, the development of entrepreneurship is essential to equip the potential users the with skills in technical and business management. This may be costly and take time to attain, but it is the only way to help the "small fish" survive in a competitive business environment.

For the SP beverage technology which has an industrial potential, VISCA does not have adequate facilities required for pilot testing. Collaboration with a private company is

considered a strategy for accelerating the commercialization of any developed product. A successful pilot testing would depend on the: (i) capability of the company, which determines the pace toward commercialization; (ii) partnership between the private company, and research institution; and (iii) supply of raw materials. A good production plan to ensure adequate and regular supply of raw materials is necessary. This is particularly critical for new varieties (e.g., VSP-1) which are not locally grown.

CONCLUSION

SP can be processed into products which have been traditionally made from fruits. The developed products namely SP beverage, jam, catsup, and leather are comparable or superior to various commercial products in sensory quality and nutrient content, particularly in vitamin A content. Development of fruity-food products from SP is considered a new approach to improving the economic value and upgrading the status of the crop. The reported technologies are simple and can be produced small scale or in large factories.

Technology transfer can be carried out through direct extension as well as non-exclusive contract with private companies. The SP catsup technology was adopted and has been successfully commercialized by catsup/food processing companies and farmers' cooperatives. The cost effectiveness of the process and the good product quality greatly facilitated the smooth transfer of the technology to private sector. Products with SP as an ingredient or a brand name of SP catsup are presently available in the domestic markets. For SP beverage the process developed in the laboratory was successfully translated into a pilot-scale operation by a joint university–industry team. Several activities are still required to develop an appropriate production scheme for raw materials and a marketing strategy to bring the fruity SP beverage and its diversified forms to the consumers. Nevertheless, the generation and transfer of technology, herein reported, enables SP, a low valued crop, to compete with expensive fruits as raw material for the commercial production of highly marketable food products.

It is realized that regardless of how much effort is put into bringing the research results to end-users, a reasonable time lag prior to the commercialization phase must be expected. This is particularly true for SP since tactful marketing strategies are needed to gain consumers' acceptance of the products prior to an accelerated penetration of the markets.

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