STAFF PAPER

A FEASIBILITY ANALYSIS OF A FRUIT AND VEGETABLE DEHYDRATION PLANT IN KANSAS

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***Professor, Cooperative Extension Service and Graduate Research Assistant, Department of Agricultural Economics, Kansas State University, Manhattan, KS 66506-4011.**

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INTRODUCTION

Kansas produces more than 40 different fruit and vegetable crops but on relatively small acreage when compared to wheat and other cereal crops[2]. These small units are scattered throughout the eastern and south central parts of the state. As a result, alternative market outlets for fruits and vegetables in Kansas are limited. A dehydrating processing plant could provide an additional marketing alternative for fruit/vegetable farmers in Kansas besides roadside stands, local grocery stores, and canning or juice plants.

Dehydrated foods are widely used in snacks, cereals, instant soups, and microwaveable foods. Most dried vegetables and some dried fruits go to processors as components for their food products. White (1973) describes four advantages of dehydrated foods: (1) lower transportation and storage costs, (2) no refrigeration costs, (3) prolonged shelf-life, and (4) compatibility with other ingredients in dry food mixes. Export markets for dehydrated food also are growing alternatives.

Cruess and Christie (1921) mentioned that dehydrating a variety of products in a single plant can reduce the per unit fixed costs for a firm. Based on this statement, five products produced in Kansas were selected to be processed. A few studies have dealt with using sun-drying for food preservation but not with the economic feasibility of machine dehydration of fruits and vegetables. An organized marketing information system for dehydrated products is also lacking.

OBJECTIVES

One objective of this study is to determine monetary incentives to farmers selling fruits and vegetables to a dehydration plant compared to selling through traditional markets. Another objective is to estimate average returns and evaluate fixed and variable costs for a dehydration plant. Long-term total returns will have to be equal to or greater than total costs for the project to be successful.

During several years, especially in the initial phases of development, revenues may not be greater

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[1]Professor, Cooperative Extension Service and Graduate Research Assistant, respectively, Department of Agricultural Economics, Kansas State University, Manhattan, Kansas. This article is based on research for a Master's Thesis.

[2]Fruit Farming; Marr and Lamont, Jr.

than costs. However, revenues should make up the difference within a reasonable time or the opportunities for investment will not be favorable. This type of economic information should be available when producers and/or investors are considering building dehydrating plants for crops grown in Kansas. Only crops grown in sufficient quantities will be considered in this study. These include apples, potatoes, sweet potatoes, cucumbers, and tomatoes. Dried products have more marketing alternatives in processed foods and exports because they are easier to store and ship.

Estimates of costs and returns for a dehydration processing plant will be based on the secondary data now available. A processing system for dehydrating apples, potatoes, and sweet potatoes will be considered as will a slightly different processing procedure for tomatoes and cucumbers. This study will combine the two systems by using conveyors that will save equipment costs. The production of apples, potatoes, sweet potatoes, tomatoes, and cucumbers needed in Kansas to support a processing plant, as well as the minimum cultivated acreage for each crop, will be estimated.

The processing plant manager will have to consider the harvest periods and storability of fresh produce. The harvest period for apples in Kansas is from mid-June to late October, but most apples are harvested in August, September, and October. The harvest season for potatoes is from late June to mid-August. For sweet potatoes, September to mid-December is harvest time. Cucumbers are harvested from mid-June to mid-September. Early July to late September is the outdoor season for tomatoes.

Because tomatoes are difficult to store, their harvest period will be the time the dehydrating plant needs to process them. Apples, potatoes, sweet potatoes, and cucumbers may be stored and processed at times other than during the tomato season.

COMPARISON OF DIFFERENT DRYERS

Price quotations for dehydrating equipment were obtained from only a few companies. Therefore, this financial analysis is not representative of all suppliers but should provide a basic guideline for those interested in pursuing investments of this type.

Austin (1981) compared the modes and scales of operations on 12 different dryers and their capital and operation costs. Six of these dryers were considered suitable for dehydrating fruits and vegetables. They included a sun dryer, cabinet dryer, tunnel dryer, continuous conveyor dryer, belt trough dryer, and freeze dryer. Of these, the continuous conveyor dryer and the belt trough dryer were the two with the lowest operation costs. The belt trough dryer had 2-3 times the capital cost of a continuous conveyor dryer. Brown, et. al., (1973) discussed continuous conveyor dryers. Conveyor dryers are being used in more and more food dehydration plants in the United States and are now being applied to the drying of materials that have conventionally been dried on trays in tunnels, such as apple, beet, carrot, onion, potato, and sweet potato pieces. Primary reasons have been the substantial saving in cost of moving the prepared food into and out of the dryer and the ease of keeping the product surface in good condition to satisfy customers.

The dryer chosen for purposes of this analysis is called a two-stage continuous conveyor dryer. Brown, et. al., (1973) explain its functions. The first section can be supplied with air at a high temperature and moderate humidity because rapid evaporation from the wet material keeps the temperature down. The second stage can be operated with very dry air at a low enough temperature to avoid damage during the long, slow approach to the desired final level of moisture content.

The two-stage continuous conveyor dryer can process a "wide range of vegetables and some fruits" (Holdsworth, 1986). According to Austin (1981), this dryer has several advantages. Because it has shorter drying times, its end products have higher nutrient retention and more natural looking appearance than tunnel- or cabinet-dried products. There are also fewer sanitary problems than with tunnel or cabinet drying.

Holdsworth (1986) writes that two-stage continuous conveyor dryers provide "good control, high production rates, and more uniform quality" for dehydration. Considine and Considine (1982) point out the advantages of flexibility and uniformity for these dryers. The stages can be timed to give maximum processing flexibility. Transfer devices between stages reorient the product to provide effective processing uniformity.

ANALYTIC PROCEDURE

Total revenue is determined by market prices received times the quantity sold. Total annual costs are determined by combining all average annual variable and fixed costs based on the following assumptions: (1) the plant is located near a city in Kansas with adequate water, sewage, and electric supplies; (2) the plant dehydrates only five fruit and vegetable products; (3) the plant operates 8 hours a day and 52 days for each product; (4) one two-stage continuous conveyor dryer is used for processing; (5) only one product is processed during a production cycle; (6) the dryer is working at optimum capacity during operating days; (7) only one dried form and package is used for each product; (8) all final products are to be sold to secondary processors or to export brokers; (9) total amount of final products is relatively small compared to total dehydrated products necessitating an elastic demand function; (10) costs of raw materials are based on farm level prices; and (11) fresh products are bought during harvest seasons and stored until processed.

Dehydration Process and Production Capacity

The basic processing cycle for dehydrating fruits and vegetables includes 11 stages. The wet side of dehydration includes six stages: washing, peeling, coring, inspecting, dicing/slicing, and blanching. On the dry side, the five stages include dripping, pre-drying, final drying, packaging, and sealing.

Only about 50.5 percent of the total fresh apples purchased are dried during the dehydration process, based on technical literature from Sandvik Process Systems, Inc. (Modular Dryer). The selection process discards about 15 percent, 8.5 percent is out-of-size, and 26 percent is peelings and cores. For potatoes and sweet potatoes, about 8 percent of fresh products are estimated to be discarded in selection, 5 percent are out of size, and 10 percent are peelings. Seventy-seven percent of fresh potatoes and sweet potatoes are suitable to make final products. About 12 percent of the tomatoes and cucumbers will be discarded in selection, leaving about 88 percent to go through the dryer where they will be sorted and peeled.

The capacity of the dehydration plant depends on the capacity of the dryer[3]. The capacity of the two-stage continuous conveyor dryer for dehydrating fresh products for 1 hour is about 2,088 pounds of prepared apples, about 2,867 pounds of prepared potatoes, or sweet potatoes, or about 1691 pounds of prepared cucumbers or tomatoes. Dryer output for 1 hour is about 267 pounds dried apples, about 610 pounds dried potatoes or dried sweet potatoes, or about 75 pounds dried cucumbers or dried tomatoes. The weight difference between prepared fresh products and dried products is the amount of water that evaporates during processing. Moisture content is reduced from more than 80 percent to less than 10 percent for each product.

A two-stage continuous conveyor dryer will operate 7 hours a day at full capacity with 1 hour for preparing, loading, and cleaning. In a year, about 753 tons of apples, 678 tons of potatoes and sweet potatoes, and 350 tons of cucumbers and tomatoes will be needed for the dryers to produce 48.6 tons of dried apples, 111 tons of dried potatoes or sweet potatoes, and 13.7 tons dried of cucumbers or tomatoes. Total dehydrated production of these five products would be 298 tons annually.

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[3]The dryer used in this analysis is recommended by Sandvik Process Systems, Inc. because of economical processing scale provided. There are some dryers that provide the same quality of final products with higher capacities, but a higher drying capacity will cost more. (Sandvik, Trends)

COST ANALYSIS

Fixed Costs

Fixed costs include land and building depreciation, equipment depreciation, management salary, interest, and capital payment. About 1 acre of land is needed for the dehydration plant. The estimated cost of land within a city limits with required utility and water services provided is approximately $15,000. This can be amortized over 30 years, which results in an annual investment charge of $500. A plant building was estimated to be about 30,492 square feet (0.7 acre) for dehydration machines, equipment, utility installations, and offices for a manager and staff. A metal building that meets all building regulations would cost $1,219,680 using an estimated cost of $40 per square foot. Annual depreciation would be $40,656. The storeroom would require 8,712 square feet (0.2 acre). The storeroom would cost $435,600 and is estimated at $50 per square foot, which is 20 percent higher than the construction cost for the plant building. Annual depreciation would be $14,520. The remainder of the space, 4,356 square feet, is used for loading and packaging, with an estimated cost of $3.5 per square foot and total cost of $15,246. Annual depreciation would be $508. The average annual investment costs for land and buildings are estimated to be $56,184.

The type of equipment evaluated for the dehydration process is based on prices supplied by Sandvik Process System Inc. (Linden, 1991) and is compatible with other equipment with sufficient capacity and a good sanitary system. Total dehydration equipment costs are estimated at $1,149,075, with an annual collective depreciation of $64,891. In addition, one forklift, two cars, one pickup, and office equipment are estimated to cost $66,699 with an average estimated annual cost of about $13,019. Management salary is estimated at $35,000 annually.

Long-term average annual interest cost is calculated by dividing total investment by 2 and multiplying by a 12 percent interest rate[4]. The total investment is estimated to be $2,901,300. The average annual interest cost of the plant is estimated as $174,078.

Based on Kansas property tax law (Kansas Tax Reporter, 1991), there is an exemption for "real and personal property of a new or existing business facility that is used for economic development purposes." Therefore, the property tax of the dehydration plant is assumed to be exempted. Total fixed costs are estimated at $343,172 annually.

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[4]The salvage value of land and buildings may not be zero, but a certain amount of money will be required to reconstruct the site for some other use after the plant is closed.

Variable Costs

Based on the following average farm price per ton at harvest season in Kansas, apples at $370, potatoes at $116, sweet potatoes at $194, cucumbers at $450, and tomatoes at $980, the total cost for fresh products is estimated at $988,664.

Labor for the dehydration operation includes 2 foremen, 1 purchaser, 1 salesman, 2 secretaries, 12 on-line workers, 4 inspectors, and 3 sanitary workers. Total labor costs for salaries and benefits are $428,240.

The dehydration plant uses 18 gallons of water per minute to operate the dryer, which is the biggest user of water in the plant. About 2.8 million gallons of water is estimated to be used yearly to operate and clean equipment at an estimated expenditure of $4,565. Sewage cost is based on the amount of water consumption and is estimated at $2,625. The annual cost for electricity is estimated as $145,333.

Steam is another special utility needed in the dehydration plant, and generating it is part of the equipment costs. The main function of steam is to heat air for drying the fresh products during dehydration and for blanching. The cost of steam is estimated to be 25 cents per 100 pounds. The annual expenditure on steam consumption would be $14,082.

All the final dried products are packaged in uniform plastic bags at an annual cost of $4,913 and shipping boxes that cost $2,083. Machinery and equipment annual maintenance is estimated to cost $13,545, telephone $3,600, traveling expenses $12,480, and office supplies $1,236. The sums of variable costs, $1,621,366, and total fixed costs, $343,172, equal a total annual cost of $1,964,538.

Revenue

If the dryer is operating at 100 percent of a rated production capacity, gross income from each product is $281,845 from dried apples, $266,448 from dried potatoes, $466,284 from dried sweet potatoes, $173,082 from dried cucumbers, and $125,580 from dried tomatoes. Total gross income is $1,313,239. (Table 1)

Based on the assumptions of the previous section, total cost is $1,964,538, which is higher than the total gross income. Therefore, producing these five products and using the described equipment is not profitable. A net loss of $651,299 would be realized annually given these data (Table 1).

Table 1. Annual Gross Income, Total Cost, and Net Income from Five Dehydrated Products

Category	Production (pound)	Price* ($/lb)	Gross Income ($)
Apples	97,188	2.90	281,845
Potatoes	222,040	1.20	266,448
Sweet Potatoes	222,040	2.10	466,284
Cucumbers	27,300	6.34	173,082
Tomatoes	27,300	4.60	125,580
Total Gross Income			1,313,239
Total Cost			1,964,538
Net Income			-651,299

* Prices of sliced dried apples and diced dried potatoes, sweet potatoes, cucumbers, and tomatoes.
Sources of prices: Spice King Corporation and California Vegetable Concentrates.

Value-Added on Production

Examination of the value-added is quite different for each product. For tomatoes, costs of raw products are greater than gross income of dried tomatoes sold for $4.60 per pound. Thus, dehydrating tomatoes is not profitable for this plant. Value-added for apples is $3,399, which is only 1 percent of the gross income for dried apples. Gross incomes for potatoes, sweet potatoes, and cucumbers are greater than the costs of raw products and contribute toward variable and fixed costs. Value-added of these three products is positive (Table 2).

Table 2. Value-Added on Dehydrated Products

Category	Gross Income of Final Products ($)	Costs of Raw Products ($)	Value-Added ($)
Apples	281,845	278,446	3,399
Potatoes	266,448	78,594	187,854
Sweet Potatoes	466,284	131,442	334,842
Cucumbers	173,082	157,400	15,682
Tomatoes	125,580	342,782	-217,202

ALTERNATIVE PRODUCTION COMBINATION

Because dried apples and tomatoes produce such a low value added, the alternative of dehydrating only potatoes, sweet potatoes, and cucumbers will be considered. Instead of allocating 20 percent of time and facilities to produce each product, the dehydration plant is reconfigured to allocate 40 percent of time and facilities to potatoes, 40 percent to sweet potatoes, and 20 percent to cucumbers. Total production of these three products is estimated at 458 tons. This amount is higher than producing all five products, because the dehydration capacity for potatoes and sweet potatoes in the dryer is higher than for apples and tomatoes. Annual productions are estimated at 222 tons each for dried tomatoes and sweet potatoes and about 14 tons for dried cucumbers.

Cost Analysis

Investment in land and plant construction is assumed to be the same for producing five products or three products. However, a different equipment configuration is required for dehydrating three products. Two operation lines can be merged after the peeling machine instead of starting at the dripping conveyor when apples and tomatoes are processed. One storing/washing tank, one peeling machine, three coring machines, one conveyor, one inspection table, one dicer/slicer, and the blancher can be removed. Total cost of equipment for processing three products is $929,000. Annual depreciation is $51,421, which is $13,470 less than the annual depreciation for processing five products. Interest cost is lowered to $160,874. Total fixed cost is $316,498, with other fixed costs remaining the same.

Total costs of fresh potatoes and sweet potatoes are doubled, to $157,188 and $262,884 respectively. For cucumbers, total cost of raw products remains the same at $157,400. Total cost of purchasing these three fresh products is $577,472. Total salaries are reduced to $321,120 because of four fewer on-line workers, two fewer inspectors, and one less sanitary worker are needed.

To dehydrate potatoes, sweet potatoes, and cucumbers, 2.39 million gallons of water is estimated to be used, with an annual cost of $3,885. Sewage expenditure is estimated to be $2,235 a year. Annual cost for electricity is estimated to be $123,533, and steam consumption is estimated to be $8,706.

Annual cost for machinery and equipment maintenance is estimated to be $11,122 for these three products. The cost for plastic bags is estimated to be $7,549 and that for cardboard boxes is $3,204. Telephone, travel, and office supply expenditures are assumed to be the same whether producing three or five products. Total gross expenditures is estimated at $1,392,640, which is $571,898 less than that for processing five products (Table 3). The estimated annual fixed cost is $316,498, and variable cost is $1,076,142.

Revenue

Doubling production time for dried potatoes and sweet potatoes doubles gross income for them, but gross income remains the same for dried cucumbers. Total gross income is $1,638,546, which leaves an estimated net income before taxes of $245,906 (Table 3).

Table 3. Annual Gross Income, Total Cost, and Net Income from Five Dehydrated Products

Category	Production (pound)	Price* ($/lb)	Gross Income ($)
Potatoes	444,080	1.20	532,896
Sweet Potatoes	444,080	2.10	932,568
Cucumbers	27,300	6.34	173,082
Total Gross Income			1,638,546
Total Cost			1,392,640
Net Income			245,906

* Prices of diced dried potatoes, sweet potatoes, and cucumbers.
Sources of prices: Spice King Corporation and California Vegetable Concentrates.

BREAKEVEN ANALYSIS

There are two ways to estimate breakeven prices for this alternative. One is to decrease the total gross income to equal total cost by decreasing prices of dried products. Another is to increase prices paid for fresh products. The quantities produced at breakeven prices are the target volumes for the plant, which are 444,080 pounds of dried potatoes and sweet potatoes and 27,300 pounds of dried cucumbers.

By making an assumption that each of the three products shared in the total gross income based on price and weight, this share will be used to calculate the breakeven prices for the final products. Many combinations could be calculated, but this one will be used for illustration. Based on this assumption, dried potatoes contribute 32.5 percent of the total gross income, dried sweet potatoes 56.9 percent, and dried cucumbers 10.6 percent. The minimum breakeven prices for the three products are estimated at $1.02 per pound for dried potatoes, $1.78 per pound for sweet potatoes, and $5.39 per pound for dried cucumbers. If the product price for any one of the three products is less, given no change in the others, then continued operation would not be profitable unless other costs were to be reduced at the same time.

Another type of breakeven analysis is to estimate the maximum prices that can be paid for the raw products to be processed. The net profit figure, $245,906, can be used to pay higher prices for one or all products used in the plant. Based on the contributing percentage of each raw product, breakeven prices could be increased from 5.8 cents per pound to 8.8 cents for potatoes, from 9.7 cents to 14.9 cents per pound for sweet potatoes, and from 22.5 to 26.2 cents for cucumbers. These price ranges could be used for negotiating a purchase price for the raw products or for forward contracts for any or all of the raw products.

The dehydration plant could operate two shifts a day, but because more than 75 percent of total cost is from variable costs, this would double variable costs and would result in only a minor decrease of total average unit costs. The dehydration plant could be used to process only one commodity on one shift, such as sweet potatoes, the highest value-added product. However, the plant may have a difficult time selling 1,110,200 pounds dried sweet potatoes to markets, or to forward contract with farmers the 6,775,363 pounds of fresh sweet potatoes that are needed to keep the plant in operation for the entire year. This would require increasing acreage from 26 acres that was harvested in 1987 to 493 acres.

MINIMUM CULTIVATED ACREAGE FOR RAW PRODUCTS

The numbers of acres needed to produce the raw products for the dehydration plant are about 135.5 for potatoes, 197.1 for sweet potatoes, and 42.4 for cucumbers[5]. Harvested acres for these three products in Kansas (1987 data) are 643, 26, and 121 acres, respectively. Enough potatoes and cucumbers are produced in Kansas for the dehydration plant to operate. For sweet potatoes, forward contracts could provide a useful way for the plant to get enough raw products. Given appropriate cultivation practices, a gross income for sweet potatoes of about $2,000 per acre can be expected. This may be enough to interest some producers to consider growing this crop.

SUMMARY AND CONCLUSION

Marketing alternatives for fresh fruits and vegetables produced in Kansas are roadside stands, local grocery stores, and canning or juice plants. A dehydration plant located in Kansas could provide an additional alternative for fruit/vegetable farmers. The major focus in this research is to present a feasibility analysis of such a plant. Apples, potatoes, sweet potatoes, tomatoes, and cucumbers are considered as possible products to be processed in the dehydration plant, because they are currently produced in Kansas and are suitable for dehydration and are marketable.

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[5]Average yield per acre is about 20,000 pounds of potatoes, 13,750 pounds of sweet potatoes, and 16,500 pounds of cucumbers. (Farming a Few Acres of Vegetables, 1991, Marr and Lamont, Jr.)

Based on available cost and return data, dehydrating these five products is not profitable. Total cost, $1,964,538, is greater than total gross income, $1,313,239. The net loss is $651,299. There would be no incentive to invest in this type of dehydration plant to produce dried apples, potatoes, sweet potatoes, tomatoes, and cucumbers.

Considering only potatoes, sweet potatoes, and cucumbers, a dehydration plant would be able to increase total gross income to $1,638,546 and decrease total cost to $1,392,640. These vegetables are the most profitable to dehydrate. These figures are based on using 40 percent of costs on dehydrating potatoes, 40 percent on sweet potatoes, and 20 percent on cucumbers. This alternative provides $245,906 profits.

Based on the cost-benefit analysis of producing three products, the total returns could be decreased to equal total costs if prices for dried potatoes, sweet potatoes, and cucumbers were as low as $1.02, $1.78, and $5.39 per pound instead of $1.20, $2.10, $6.34 per pound, respectively. Breakeven input prices offered to vegetable farmers are $.088, $.149, and $.262 per pound of fresh potatoes, sweet potatoes, and cucumbers compared to of $.058, $.097, and $.225 per pound, respectively. The dehydration plant can either sell finished products at the lower prices, pay higher prices for fresh products, or some combination and still remain in operation.

At breakeven prices, the breakeven output of the plant is 444,080 pounds each for dried potatoes and sweet potatoes and 27,300 pounds dried cucumbers. The minimum cultivated acreage to produce fresh products for the plant are 135.5 acres of potatoes, 197.1 acres of sweet potatoes, and 42.4 acres of cucumbers. Currently, not sufficient sweet potatoes are produced in Kansas for the plant. Forward contracts may be one way to ensure an adequate supply of sweet potatoes from Kansas farmers.

The economic impact to the producers of potatoes, sweet potatoes, and cucumbers could be an additional $245,906, if the prices paid for the raw products were at the breakeven prices. That could mean extra gross returns per acre of $600 for potatoes, $715 for sweet potatoes, and $610 for cucumbers. Management and growing various crops will determine actual profitability of any dehydration plant.

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