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DRY BEAN FLOUR
Economic Aspects of Production and Marketing

by

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ABSTRACT

Michigan is the largest grower of navy beans and one of the major producers of all categories of dry beans. Dry bean consumption continues to decline in the U.S., however. One opportunity for expanding consumption of dry beans is to find new uses, such as in food ingredients. Dry beans offer a rich source of protein, as well as quality fiber and starch components. A roasting, milling and air classifying system to produce dry bean flour fractions has been developed at Texas A&M. Bean flour protein, fiber and starch ingredients have been tested in baking, meat products and snack foods at Michigan State University. This report indicates that dry bean flour can compete with other protein, starch and fiber ingredients and provide sufficient returns to attract venture capital based on the following central assumptions:

- the availability of sufficient quantities of quality cull and/or edible split dry beans to lower the overall price of the raw bean input;
- the ability to balance the production and sales of starch with protein and fiber components;
- the cost of capital of the investing firm and its research, marketing and financial resources; and
- the ability to overcome any market, institutional or Food and Drug Administration barriers or pre-conditions.

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Preface

Need is not economic demand. The decision to produce dry bean flour is a complex economic question of production, distribution and consumption. The functional characteristics of the various bean flour fractions, their substitutes and their uses are still being investigated. The market for special ingredient flours is also complex and little production data for the industry is publicly available. Also, trends in consumer preference and the regulatory activity of government are other key aspects determining feasibility.

It is important in this report to recognize the excellent help and work of Professors Mark Uebersax and Mary Zabik, Food Scientists at Michigan State University and Professors Joseph Dietz and Ed Lusas at Texas A&M University. Their research for USDA and knowledge were instrumental in this report. Also, numerous industry representatives provided valuable information and helped in guiding the research. Finally, crucial to this undertaking was the support of the MSU Department of Agricultural Economics and the Michigan Department of Agriculture. The authors remain fully responsible for any errors or omissions in this report.

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1. INTRODUCTION

There is considerable interest on the part of Michigan farmers, agribusiness and dry bean industry in the development of a dry bean flour industry. Michigan grew 30 percent of the dry edible beans in the U.S. in 1982 including 82 percent of the navy beans. It has been suggested that as much as 33-50% of food grade protein will come from plant protein in the future (Bird, 1974). Dry edible beans provide an excellent source of protein and a balance of other essential nutrients to the diets of both developed and subsistant populations (Muggio and Uebersax 1981).

At the same time that consumption of vegetable proteins is expected to increase, U.S. per capita consumption of canned and packaged dry beans has continued to decline from 7.6 pounds per year in 1962 to 4.1 pounds per year in 1981 (see Appendix 1). Whole beans require soaking and long cooking times. Canned beans, one of the first convenience foods, have become a staple but less promoted product on retail shelves. A study by the National Science Foundation identified five potential areas for increasing the per capita consumption of dry beans, including the development of food products based on legumes (Adams et al. 1978). New technologies for altering the form of dry edible beans into specialty flours have been developed by the Protein Research Center at Texas A&M University and tested at the Food Science and Human Nutrition Department at Michigan State University. Dry bean flour is a new product to the industry whose marketability and costs are not known. The purpose of this study therefore is to provide information to determine the market value and feasibility of manufacturing dry bean flours.

This research relies on secondary data and interviews with individuals well acquainted with the food industry and market. The analysis will concentrate on navy bean flour production for food uses in the U.S.

Further consumer testing of the products would not be possible or even desirable until a later stage in produce development. At this point trends in demand for candidate products will be analyzed based on interviews with industry and research specialists. Implications for commercial food demand abroad and food aid will also be examined.

Estimations of price of bean flour can be derived from farm prices of dry beans and processing costs. Supplementary and complementary products will also be looked at. Some estimates of plant costs can be derived from amounts necessary to establish a pilot operation. For a full scale commercial operation, judgement of those in the industry will be obtained. These costs will be projected over the decade of the 1980s. Profit on a new product cannot be easily quantified but some indication of prices and volumes necessary to achieve certain profit objectives will be made.

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2. DRY BEAN FLOUR RESEARCH

2.1 Dry Bean Flour Products and Uses

Dry beans are an excellent but undeveloped source of protein. On the average they contain 26% protein and 65% carbohydrates. Dry beans contain balanced amounts of the essential external amino acids and minerals used for protein conversion by the body. Dry beans are methionine limited but rich in lysine which makes them a natural complement to other vegetable proteins, especially cereals, such as corn, wheat, and rye. Dry beans are also a good source of starch for energy and compare favorably to wheat in dietary fiber content. Dry bean flour fractions refers to the three types of flour that are produced through air classifying; high protein flour (HPF), high starch flour (HSF) and high fiber flour (HFF). The fractions, their functional characteristics and potential food uses are shown in Table 2.1.

Research conducted at Michigan State University and Texas A&M University has evaluated the bean flour fractions produced under different processing conditions. Heating temperature, heating time, and ratio of beans to solid heat exchange material were varied. The resulting products were evaluated for moisture, fat, protein, protein solubility, ash (mineral) and dietary fiber (Table 2.2). These evaluations characterize the nutritional properties of each fraction and their suitability for use in selected products. Following is an overview of the flour fractions and their uses.

2.1.1 Whole Bean Flour

Whole navy bean flour can be used to replace up to 45% of wheat flour in highly flavored baked goods without adversely affecting physical or sensory characteristics. Flavor problems may be encountered with less highly flavored baked goods, at higher concentrations or with other more strongly colored or flavored beans. Higher concentrations of whole navy bean flour would dilute the gluten and starch necessary for the structure of the baked

Table 2.1 Potential Uses of Dry Bean Flour Fractions in Formulated Foods

Flour Fraction	Major Characteristics Contributed to Food	Potential Uses in Foods
Whole bean flour	Protein supplement thickening agent	Soups, sauces, dips, baked products (doughnuts, cakes, cookies) master mix, quick breads
High fiber flour (HFF)	Dietary fiber water binding	Baked products
High protein flour (HPF)	Protein concentrate	Comminuted meats (franks, sausages, meat loaves) high protein baked protein
High starch flour (HSF)	Gel structure thickening agent	Puddings, pie fillings, prepackaged sauces and gravies, extruded snacks and cereals

Source: Adapted from Uebersak, M.A. and M.E. Zabik. "1980 Update: Bean Flour Product Utilization," Michigan Dry Bean Digest, 1980.

Table 2.2 Composition of Roasted Whole Beans and Fractions Produced During Processing

Fraction	Composition (%)					
	Moisture	Protein[a]	Fat[a]	Fiber[a]	Dietary Fiber[a]	Ash[a]
Navy						
Whole Beans (Raw)	14.1	26.2	2.1	4.5	7.2	4.9
Whole Beans (Roasted)	11.0	26.3	2.1	4.5	7.2	4.9
Hulls	9.0	22.2	1.9	27.6	44.2	4.9
Cotyledons	9.8	24.3	2.2	1.5	2.4	4.4
Coarse I.	9.6	26.1	2.4	3.6	5.8	4.7
High Starch (Coarse II)	9.8	15.5	1.5	2.0	3.2	3.6
High Protein (Fines II)	9.2	44.1	3.7	1.5	2.4	5.4
Pinto						
Whole Beans (Raw)	13.5	26.5	1.9	4.6	7.4	4.0
Whole Beans Roasted)	10.4	26.5	1.9	4.5	7.2	4.0
Hulls	7.6	22.8	1.43	27.5	44.0	4.3
Cotyledons	6.2	24.5	1.22	1.6	2.6	4.2
Coarse I	7.1	27.6	1.82	3.4	5.4	4.2
High Starch (Coarse II)	7.8	12.2	0.87	2.3	3.7	3.0
High Protein (Fines II)	6.6	44.2	1.14	1.8	2.9	6.0
Black						
Whole Beans (Raw)	14.1	26.8	2.0	4.7	7.5	6.4
Whole Beans (Roasted)	10.0	26.7	2.0	4.6	7.4	6.4
Hulls	8.7	22.5	1.5	27.8	44.5	6.3
Cotyledons	8.4	27.1	2.0	1.5	2.4	5.5
Coarse I	8.4	30.0	1.8	3.6	5.8	6.3
High Starch (Coarse II)	8.1	12.4	1.2	2.4	3.8	3.7
High Protein (Fines II)	7.3	45.5	0.82	1.9	3.0	8.0
Moldy Black						
Whole Beans (Raw)	14.7	26.9	1.9	4.5	7.2	4.8
Whole Beans (Roasted)	9.5	26.9	1.9	4.6	7.4	4.8
Hulls	8.5	22.9	1.8	27.5	44.0	4.7
Cotyledons	10.1	26.5	2.2	1.4	2.2	4.6
Coarse I	9.0	28.1	2.1	3.6	5.8	4.9
High Starch (Coarse II)	9.2	13.6	1.4	2.7	4.3	3.8
High Protein (Fines II)	8.5	46.4	1.3	1.6	2.6	5.7

[a] Moisture-free basis.

Source: Dietz, Joseph and Edmund Lusas. Process Development for Preparing Ingredients and Products from Pinto, Black and Navy Beans. College Station, Texas A&M Food Protein Research and Development Center for USDA/ERS, January 15, 1983.

product. This would result in decreased product volume and increased crumbly texture. Bread made with 10% navy bean flour, tested at MSU, was highly acceptable, especially when combined with dough conditioners. Doughnuts substituting up to 30% of the required wheat flour resulted in good product quality. A "master mix" made with 30% bean flour could be used for cakes, cookies, biscuits, pancakes with only the addition of water and perhaps sugar. A master mix would provide higher nutrient levels while still being convenient for in home use. It may be possible that the bean flours absorb less oil in fried applications, such as doughnuts. This would result in a lower calorie product with good nutritional quality (Spink et al., 1984).

Whole bean flour's use as a thickening agent would be limited by its tendency to "weep" or separate fluid from the gel structure. This would not pose a problem for pet or canned food applications as discussed and high starch flour (HSF).

2.1.2 High Fiber Flour

High fiber flour made from navy bean hulls contains 44% dietary fiber. Dietary fiber has long been recognized by the medical profession in maintaining bowel regularity. For all types of beans the major dietary fiber component was water insoluable hemicellulose. Hemicellulose increases water holding capacity and improves stool weight, transit time, and possibly dilutes and removes carcinogens. Navy, black and pinto beans were also good sources of other dietary fibers, including, cellulose, lignin and pectin. Pectin has been found to lower serum cholesterol and may have potential in reducing heart disease. Cereal brans have less than 1% pectin vs. 3.3% to 10.5% for black bean and navy bean hulls.

High fiber flour (HFF) made from navy bean hulls has been shown to be very acceptable for high fiber baked goods. Banana bread prepared with 10%

and 20% of the flour replaced by the high fiber flour had excellent sensory characteristics, good volume and color. Dilution of the flour gluten also resulted in a more tender product. Flour in bread could be substituted up to the 10% level with the inclusion of .5% dough conditioners.

2.1.3 High Protein Flour

The high protein flour (HPF) fraction contained at least 44% protein. The protein fraction contained notably higher amounts of iron magnesium phosphorus and zinc than the corresponding whole flours. Tests show that the protein fraction can be substituted at the 15-30% level in bread, quick bread and high flavored breads. The binding and emulsifying properties of navy bean protein indicate it could be used at levels comparable to current use of soy or milk protein (3.9% of the meat). Initial studies indicate that texturized products could not be produced from 100% HPF due to the stickiness of the dough. Texturized blends with 10% to 30% HPF with soy flour were produced with no difficulty. Vegetable protein makes a low-cost, high-protein meat extender that can also provide low fat, low calorie options to the consumer.

2.1.4 High Starch Flour

High starch flour (HSF) fractions contained 75% starch. All bean starches showed controlled swelling requiring temperatures of 80-82^{o}C to initiate increases in viscosity. No susceptibility to shear was noted, illustrating a curve typical of a chemically bonded starch. This means that a chemically unmodified product could be used in place of a chemically modified product such as corn starch. This is an attractive feature to natural ingredient conscious consumers.

The use of bean starch is limited by its susceptibility to retrogradiation causing severe synerisis (separation of water from a gel). This would not pose a problem in applications such as dog food and canned goods.

The main attractive feature of the high starch flour is its expansion properties under extrusion. The starch is found to have excellent potential either by itself or in combination with navy bean hulls.

2.2 Dry Bean Flour Production Technology

Dry beans naturally contain antinutritional factors (trypsin inhibitors and hemaglutinins). Cooking of dry beans is necessary to develop acceptable flavor and texture, to inactivate these antinutritional factors, to make the bean protein nutritionally available and to prevent hard shelling. Hard shelling is caused by the bean drying out during storage; the beans then fail to imbibe water remain hard during cooking. Roasting has little effect on the proximate composition of navy, pinto, and black beans as shown in the composition of bean flour fractions (Table 2.2).

Lusas, Aguilera and Dietz (1980-1983) developed a dry roasting process based on the work of Harper 1974-1978. The technique uses a dual chamber solid to solid heat exchanger with ceramic beads as the heat transfer medium. The solid to solid heat transfer was more efficient than air transfer or wet process in heat treating the beans to 113^{o}C (bean temperature). Adding moisture to cook the beans in a wet process would require further energy to dry out the bean product for ingredient use. Wet processes also result in greater product loss during processing. Heating the beans with beads raised to a temperature of 240^{o}C at a ratio of 1:5 for 100 seconds in the chamber was found to be effective in inactivating the antinutritional factors in beans and decreasing the degree of hard shelling effects. The heat exchanger was constructed by Food Processes, Inc. (Saginaw, MI).

2.2.1 Roasting in Solid to Solid Heat Exchanges

The following excerpt from Dietz and Lusas (1983 pg. 6) describes the schematic representation of the roasting equipment shown in Figure 2.1.

> It is composed of two metallic rotatable drums. The heat transfer medium is heated by a direct gas flame as it leaves the lower drum. From this drum, the heated medium enters a bucket elevator and is transported to the upper drum, where they are mixed by parallel baffles. Through this mixing action, heat is transferred from the medium to the beans. As the mixture leaves the end of the upper drum, the medium and beans are separated by a screen, with the medium being returned to the lower drum and the processed beans discharged from the system.
>
> The equipment is equipped with controls to regulate the speed of the two drums, the bucket elevator and the bean inlet screw. Another controlled variable is the angle of each drum, which regulates the retention time in the drums. Temperature of the medium as it leaves the bottom drum is controlled by a combustion safeguard and gas throttling device. Monitoring devices are employed to measure temperatures at the points shown in Figure 2.1 and to measure the consumption of gas by the burner.
>
> The heat transfer medium employed in this study was 1/16 inch (1.6 mm) diameter type A, 90% aluminum oxide ceramic beads (Coors Ceramic Co., Golden City, CO) with a specific gravity of 3.6 g/cm^3 (Dietz, et al., 1983, pg. 6).

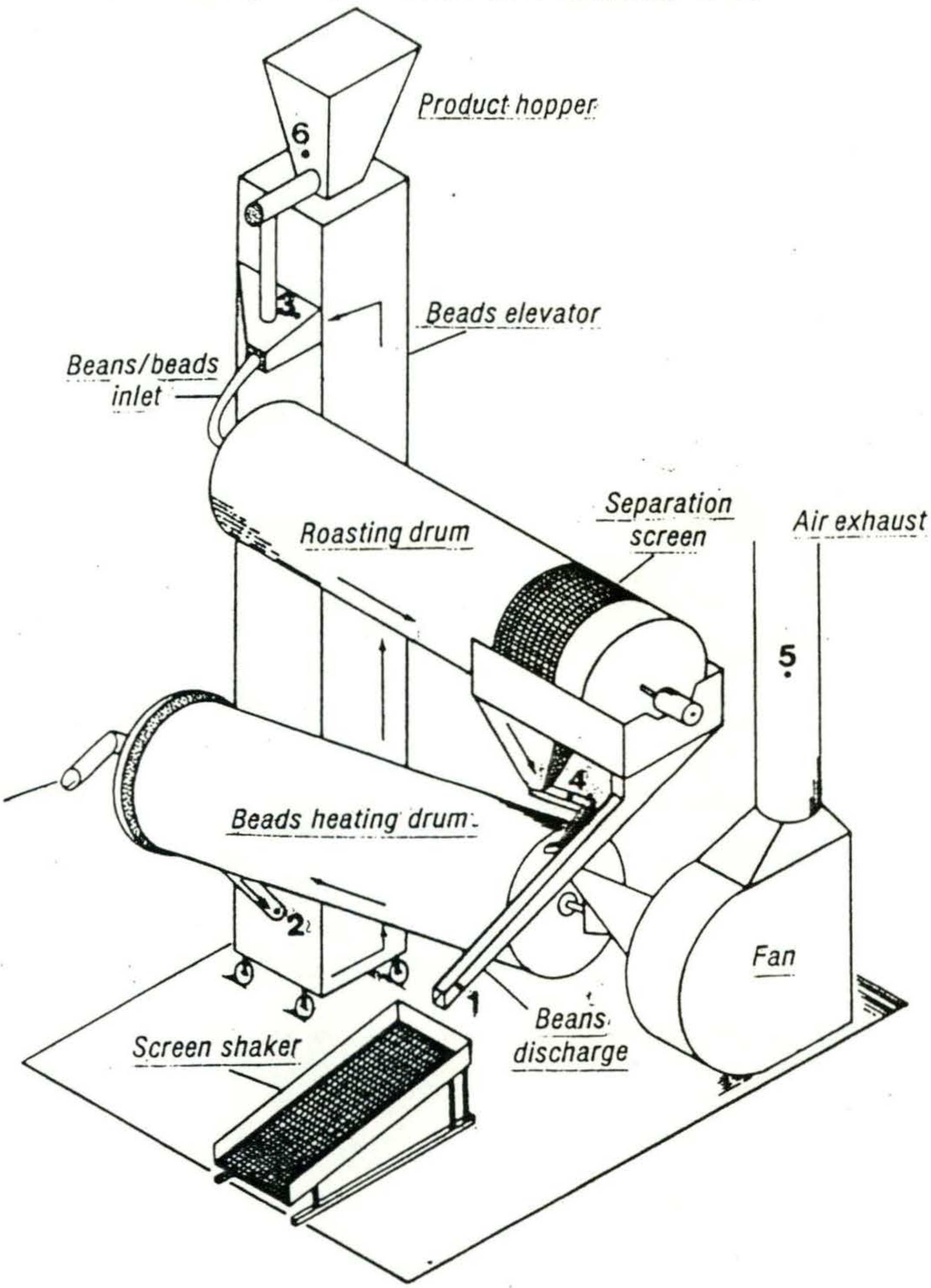
2.2.2 Dehulling and Classifying

Starch granules tend to be less brittle and denser than protein granules. This allows fractionation of these two components by grinding and air classification. Air classification has been used to fractionate many cereals, as well as soybeans (Stringfellow and Peplniski 1964; Preifer et al., 1960; Stringfellow et al. 1961 and 1971; cited in Dietz and Lusas 1983, p. 5). The following excerpt from Dietz and Lusas (1983, p. 8) describes the dehulling and classification process.

> A flow diagram of the dehulling, separation, grinding and air classification process is presented in Figure .2. Roasted beans were cracked through a corrugated roller mill (Ferrell Ross, Oklahoma City, OK) into 6 to 8 pieces. The hulls then were removed in a zig-zag aspirator (Kice Metal Products, Wichita, KS). The cracked cotyledons were

Figure 2.1

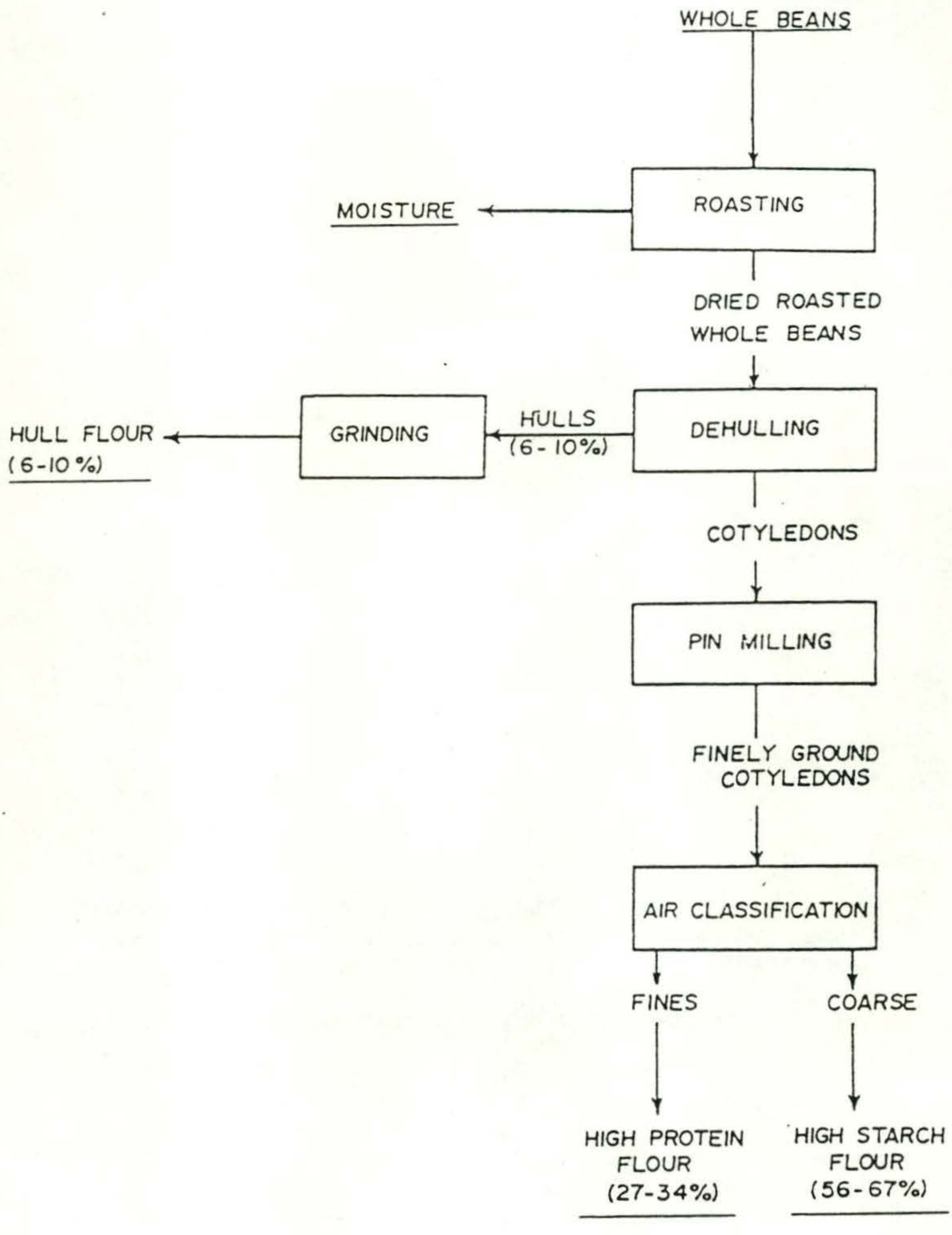
Schematic drawing of the solid-to-solid heat exchanger. Points 1 to 6 represent places where temperature was monitored during processing. 1. Product; 2. Beads out of roasting drum; 3. Beads into roasting drums; 4. Beads returning to heating drum; 5. Air exhaust from roasting drum; 6. Beans into roasting drum.



Source: Dietz and Lusas 1/1983 p. 7.

Figure 2.2

Materials Balance for Production of Hull, Protein and Starch Flours From Dry Edible Beans.



Source: Dietz, Lusas, Uebersax, Zabik, Fall 1983 (Dry bean flour Seminar Materials) finely ground in a Model 250 CW stud impact mill (Alpine American Corp., Natick, MA) at a mill speed of 11,789 RPM and a door speed 5,647 RPM. The resulting flours then were air classified in a Model 410 MPVI air classifier (Alpine American Corp., Natick, MA) at a rotor speed of 2200 RPM and a brake ring setting of 3, using a 3 inch screw feeder operating at 25 RPM. The fine fraction was reclassified using the same classifier under the following conditions: rotor speed = 2200 RPM; brake ring setting = 0; 3 inch screw feeder operating at 25 RPM. Thus, three fractions from each dry roasted bean were produced: course one (C1) course two (C2) and fine two (F2).

Flours also were produced from the aspirated hull fraction by grinding through a swinging blade Model D6 Fitzmill (W.J. Fitzpatrick Co., Chicago, IL) using the impact surfaces for pulverization through a 1/37 in (0.69 mm) round hole screen) (Dietz et al., 1983 pg. 8).

3. DRY BEAN FLOUR COST ANALYSIS

Costs incurred in the production of dry bean flour can be broken down into two categories, variable costs and fixed costs. Variable costs are those which vary depending on the level of output and are under the control and discretion of the manager. Variable costs include labor, utilities, raw product costs, sales, research and development and cost of goods sold. Fixed costs do not vary over incremental levels of output and are not under the discretionary control of the manager. Fixed costs include two categories (1) cash fixed costs (real estate taxes, maintenance and repairs, intermediate and long term interest, insurance) and (2) noncash fixed costs (facility and equipment depreciation) (Burghardt, Fassler, 1983, Van Horne, 1983). Delineating variable costs and fixed costs will set the stage for an analysis of the breakeven volume and margins necessary for profitable bean flour production.

3.1 Dry Bean Production, Costs and Trends

Varieties of dry beans include pinto, navy, great northern, red kidney and more than ten others as shown by "U.S. Dry Bean Production by Variety" in Table 3.1. Michigan was the largest producer of dry beans in 1982 followed by North Dakota, Idaho, California and Nebraska.

Table 3.1 U.S. Dry Edible Bean Production by Variety (1,000 CWT)

Variety	1982	1981	1980
Large Lima	623	639	758
Baby Lima	581	661	447
Blackeye	1,100	875	698
Garbanzo	60	50	67
Navy	7,537	5,550	5,717
Great Northern	2,736	2,686	2,112
Small White	236	312	186
Cranberry	358	320	330
Small Red	489	610	646
Pink	867	1,941	1,750
Red Kidney	2,038	1,542	1,757
Black Turtle Soup	242	2,244	1,451
Pinto	6,999	14,029	10,008
Other	898	724	468
Total	24,764	32,183	26,395

Source: U.S. Department of Agriculture.

While the farm price of dry beans will continue to fluctuate from year to year with production and demand variability, prices in the long run will be related to production costs and returns to competing crops. Producers have substantial flexibility in shifting acres into and out of dry beans. This keeps returns in line with other crops, with allowances for higher risk in growing dry beans.

In the period from 1960 to 1972, the farm price of dry beans increased gradually from around $6.00 per cwt. to the $10 level (Figure 3.1). Corn prices also rose from around $1.00 per bushel to $1.25 and then to $1.50 in 1972. In the 10 year period from 1973 to 1982 following the world grain shortage, the oil embargo and accelerating inflation, the farm price of dry beans in Michigan averaged $20 per cwt., ranging from a high of $27.30 in 1973 to a low of $12.30 in 1982. Corn prices fluctuated between $2 and $3 per bushel during this 10 year period. For the remainder of the 1980s, a slower rate of inflation and a more moderate expansion in export demand for U.S. crops will likely keep dry bean and corn prices under pressure with only modest gains in sight over the 1973-82 averages.

An econometric analysis of planted acreage of dry beans in Michigan for the 1960-82 period indicated that the most important explanatory factors were the previous year's acreage and (also for the previous year) the gross margin over variable costs per acre in producing dry beans, the gross margin over variable costs per acre in producing corn and the Consumer Price Index. These variables "explained" about two-thirds of the variation in planted acres. Of these influences, the most important were the pervious year's gross margin over variable costs on dry beans and the Consumer Price Index. The supply equation was as follows:

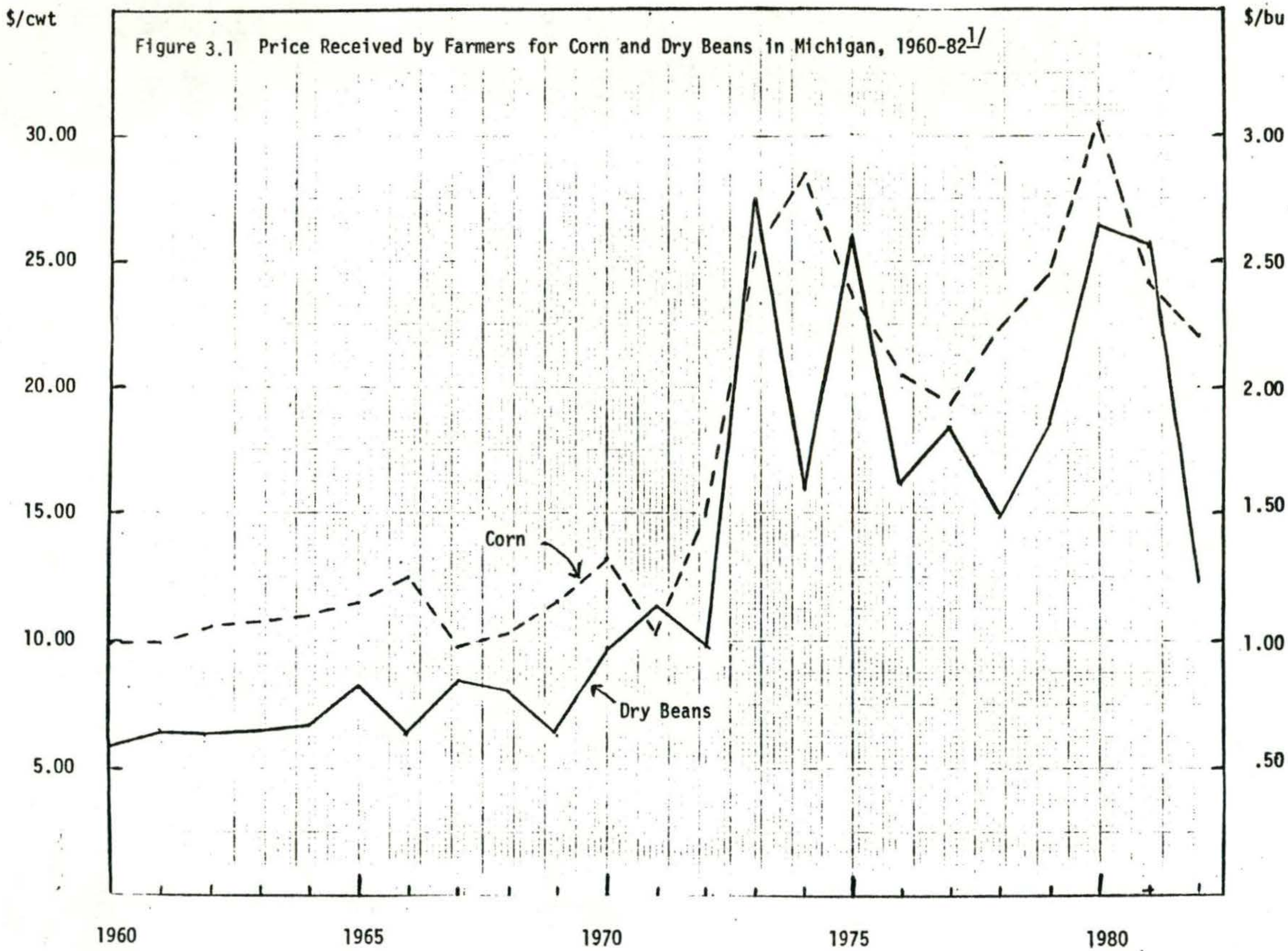


Figure 3.1 Price Received by Farmers for Corn and Dry Beans in Michigan, 1960-82[1/]

[1/] Source: Michigan Agricultural Reporting Service.

$$APDBMI = 493 + .2785\ APDBMI1 + 1.002\ GMVCDBMI1$$
$$(1.31) \qquad (3.56)$$

$$- .8456\ GMVCCNMI1 - 82.15\ CPI1$$
$$(-1.69) \qquad (-3.36)$$

$R^2 = .64$ $\bar{R}^2 = .56$ SEE = 11% of mean D.W. = 1.66

where:

APDBMI = acreage planted to dry beans in Michigan (1000 acres)

APDBMI1 = APDBMI in the previous year (1000 acres)

GMVCDBMI1 = gross margin over variable costs on dry beans in Michigan, in the previous year, (\$/acre)

CMVCCNMI1 = gross margin over variable costs on corn in Michigan, in the previous year, (\$/acre)

CPI1 = Consumer Price Index in the previous year, (1967 = 1.000)

Numbers in parentheses are "t" values.

This equation would indicate that, given the expectations for corn prices and costs of production for both corn and dry beans over the remainder of the decade of the 1980s, the farm price of dry beans would have to average about \$25 per cwt. in order to hold bean acreage at a level that would match demands. This assumes that the CPI will remain below the double digit level and increase by about 4-6 percent per year over the balance of the decade.

This is consistent with another approach for establishing prospective dry bean prices. Over the 1960 to 1982 period, the gross margin over variable costs per acre on dry beans averaged 41 percent higher than on corn and 34 percent higher than on soybeans. This reflects the higher risk involved in dry bean production.

The MSU Agriculture Model (Department of Agricultural Economics, Michigan State University, Fall 1983) projected U.S. farm prices on corn and soybeans for the coming decade. Adjusting these prices to Michigan (about 15 cents per bushel lower) and projecting yields and variable costs, gross margins over variable costs on corn and soybeans were derived for Michigan. If gross margins over variable costs on dry beans continue to average above those on corn and soybeans as in the past, Table 3.2 provides a scenario of the 1984-1990 prices with a comparison to 1978-1983. The projected dry bean prices are not forecasts since production and demand will influence prices in any given year. The projections are shown to provide a longer term view of average prices which would be in line with historic relationships with corn and soybeans. The corn relationship would be expected to have the strongest effect on dry bean prices.

Production cost data also support the position that the equilibrium level on dry bean prices is around $20 for the mid 1980s with the prospect that this level may move up to around $25 by the end of the decade. Enterprise costs on dry beans in Michigan in 1983 have been estimated to be between $18 and $23 per cwt. This includes variable costs and an allowance for machinery ownership, land and general farm overhead (Poindexter, 1983). Based on Telfarm records, variable costs were estimated at $8-9 per cwt. (Schwab, Nott, Kelsey, Ho, 1983). The USDA calculated variable costs for 1981 at $11 and total costs at $22 (USDA's Firm Enterprise Data System, 1983).

Projected prices on dry beans in Michigan were compared with U.S. average farm prices on wheat in Table 3.2. Wheat prices were calculated on a per cwt. basis to be comparable in weight with dry beans. Dry bean prices for 1978-83 and projected to 1990 (based on historic relationships with gross margins on corn) were divided by past and projected wheat prices. Note that the dry bean:wheat price ratio is expected to converge to around 3.3. The relevance of this relationship is more for analyzing comparative ingredient costs on bean and cereal products than for projecting supplies.

Table 3.2 Farm Prices on Michigan Corn, Soybeans and Dry Beans and the U.S. Average Farm Price on Wheat, 1978-83 and Projected to 1990

Year	Michigan Average Farm Prices: Corn $/bu	Soybeans $/bu	Dry Beans $/cwt		U.S. Farm Price on Wheat $/cwt	Michigan Average Farm Price on Dry Beans ÷ U.S. Farm Price on Wheat
1978	2.22	6.81	14.80		4.95	2.99
1979	2.46	6.13	18.50		6.30	2.94
1980	3.05	7.47	26.40		6.60	4.00
1981	2.39	6.02	25.60		6.08	4.21
1982	2.20	5.35	12.30		5.88	2.09
1983[f]	3.20	7.35	24.00		5.83	4.11
			Historic Relation to Gross Margin on: Corn	Soybeans		
1984[p]	2.73	6.87	21.87	23.72	5.43	4.03
1985[p]	2.34	6.83	17.72	23.42	5.28	3.36
1986[p]	2.57	7.16	20.16	21.61	6.07	3.32
1987[p]	2.86	7.69	23.12	26.60	6.82	3.39
1988[p]	3.01	8.38	24.47	29.04	7.30	3.35
1989[p]	3.19	9.14	26.26	21.88	7.88	3.33
1990[p]	3.36	9.98	27.85	34.76	8.52	3.26

f = partially forecast

p = projected based on MSU Agriculture Model

One option available to increase the price competitiveness of dry bean flours would be to provide a steady supply of high quality culls or edible splits at low prices. Some of the variation in bean production is due to superficial weather spotting and damage that would not negate the use of cull beans as a flour. Dry beans culled for internal mold foreign material, "bin burn," or badly damaged would have to be further cleaned and sorted for use.

Table 3.3 shows high and low estimates for the quantity of navy bean inhuman consumption and all dry bean splits and culls. The year 1981 was a time of low navy bean production in N. America, 700 million pounds. Quality cull beans and/or edible splits suitable for human consumption have been estimated at 1% to 2% of the dry bean crop. Even at the low rate for quality culls in a low navy bean production year there is a sufficient quantity in Michigan each year, 7.2 million pounds, to support half of the full capacity of a navy bean flour plant 15.873 million pounds. If the quantity of quality culls should slip below 1% there would be bean culls available in nearby navy bean production areas, Ontario, Minnesota and North Dakota. There is also the possibility of substituting other dry bean varieties to supplement any navy bean cull shortfall. A high rate of cull beans in a high navy bean production year (such as 1982) would result in as much as 18 million pounds or more of quality navy bean culls being available.

Other competing uses of navy bean culls at $.04-$.06 per pound are main ly animal feed. There are many inexpensive substitutes for navy bean culls for feed purposes that would not compete for dry beans at the $.12 per pound price level. High quality "edible splits" grade beans are mostly imported by Japan at $.12 per pound for use in poi, a type of bean paste confectionary. Therefore, a sufficient quantity of quality dry bean culls should be available at around $.12 per pound.

Table 3.3 Navy Beans, Dry Edible Bean-High and Low Quality Cull Estimates[1] (million pounds)

	1981 High Estimate						1982 High Estimate					
	Production		Estimated Culls at 1%		Estimated Culls at 2%		Production		Estimated Culls at 1%		Estimated Culls at 2%	
	Navy Bean	Dry Bean	Navy Bean	Dry Bean	Navy Bean	Dry Bean	Navy Bean	Dry Bean	Navy Bean	Dry Bean	Navy Bean	Dry Bean
Minnesota	61.0	127.7	.61	1.28	1.22	2.56	55.4	94.9	.55	.95	1.10	1.90
North Dakota	87.0	456.5	.87	4.57	1.74	9.14	84.0	252.0	.84	2.52	1.68	5.04
Michigan	407.0	719.8	.41	7.20	.82	14.40	614.3	742.5	6.14	7.43	12.28	14.86
Ontario Canada	145.0	145.0	1.45	1.45	2.90	2.90	150.0	150.0	1.50	1.50	3.00	3.00
Total N. America	700.0	3218.3	7.00	32.18	14.00	64.36	903.7	2626.4	9.04	26.26	18.08	52.52
1000 Metric Tons	(317.5)	(1459.8)	(3.18)	(14.60)	(6.36)	(28.20)	(409.9)	(1191.3)	(4.10)	(11.91)	(8.20)	(23.82)

Source: Production Statistics are taken from Weber, Michael 1982-1983, Dry Bean Outlook, MSU Ag. Econ. Staff Paper #1982-106.

[1]Culls and dry edible splits suitable for human consumption.

The most important element in the validity of bean flour production is the evaluation of the unique performance of bean ingredients in the food system. Specific applications based on functional properties may command premium prices for dry bean flour fractions.

3.2 Dry Bean Flour Production Costs

Equipment and costs for production of dry bean flour have been estimated by Aguilera and Lusas (1981, pgs. 55-77) based on a pilot plant. The pilot plant was designed to a 300 kg/hr capacity although the roaster should operate at 10 times that capacity. Equipment for the pilot plant also includes a mill for grinding and an air classifying system. Total equipment cost would be $259,200 as shown at the top of Table 3.4. The following assumptions were used to assign monetary value to the pilot plant engineering data:

plant capacity:	300 kilograms/hour (kg/hr) 2.4 metric tons/day (mt/day) 720 mt/year 300 working days/year
cost of capital:	15%/year
useful life of equipment:	10 year
salvage value:	0
installation costs:	20% of initial capital investment
ancillary equipment:	10% of main equipment

Also shown in Table 3.4 is an equipment cost estimate for commercial Plant 1 which has ten times the capacity of the pilot plant and commercial Plant 2 which has 20 times the capacity of the pilot plant. Equipment for commercial Plant 1 would cost $590,000 and operate at 3,000 kg/hr - fully utilizing the capacity of the roaster. Equipment for commercial Plant 2 would operate at 6,000 kg/hr and cost $875,500. Aguilera et al. used the pilot plant to estimate labor and utility operating costs "to test the process under operating conditions simulating those of the final plant in almost

Table 3.4 Capacities and Cost of Roasting, Grinding and Air Classifying Equipment

Equipment	Capacity[a] (kg/hr)	Cost ($/unit)	Total Cost ($
A. Pilot Plant	300		
Roaster	3,000	30,000	30,000
Alpine 250 CW Contraplex Mill[b]	220-270	45,000	60,000
Alpine 400 MPS Milcroplex Classifier[c]	570-640	110,000	110,000
Ancillary Equipment (10%)			18,500
Installation (20%)			40,700
Total			259,200
B. Commercial Plant 1	3,000		
Roaster	3,000	30,000	30,000
Alpine 710 CW Contraplex Mill[b]	1980-2430	150,000	150,000
Alpine 800 MPS Air Classifier[c]	1,710-1,920	130,000 (2x)	260,000
Ancillary Equipment (10%)			50,000
Installation (20%)			100,000
Total			590,000
C. Commercial Plant 2	6,000		
Roaster	6,000	30,000 (2x)	60,000
Alpine 1120 CW Contraplex Mill[b]	4,400-5,400	250,000	250,000
Alpine 800 MPS Air Classifier[c]	1,710-1,920	130,000 (3x)	390,000
Ancillary Equipment (10%)			58,500
Installation (20%)			117,000
Total			875,500

[a]Pilot plant capacities recorded during processing of navy beans (Aguilera et al., 1980). Other equipment estimates based on personal communication with Witt Maddern, Alpine American Corp. (1983).

[b]Including motors, feeder, discharge hopper, exhaust blower bag house electric control panel (partial), no mounting legs, no starting equipment panel.

[c]Including explosion proof motors, feeder and bag house.

every respect except capacity" (Aguilera et al., 1981, pg. 56). Table 4.5 shows the operating and capital costs for a plant with the capacity of commercial Plant 1, 3 mt/hour, based on the work of Aguilera et al., 1981. To the capital costs in Table 3.5 have been added interest expense, facility costs, miscellaneous equipment, storage, insurance property taxes, etc.

Facility costs include a 6,500 square foot insulated steel "Butler" type building. The facility includes 1000 square feet for storage, office and uses other than production. The cost of a rail siding has been included to receive raw bean shipments, although its use may prove optional. Total capital costs for commercial Plant 1 would be $918,300.

Operating costs have been adjusted to Michigan 1983 wage and labor rates. The labor force has been expanded from 3 laborers to operate the pilot plant to 3 in product receiving, 4 in plant operations, 3 in product shipment, 2 clerical and one supervisor. Total costs of bagging are based on estimates of the cost of bagging wheat flour into 100 pound bags. Bagging costs include labor, equipment and bags. Bagging expense could be eliminated by bulk shipping the dry bean flour in pneumatic trailers or rail cars. Allowance for bagging was included as a more expensive and hence more conservative operating option.

Operating costs per metric ton and per pound are shown in the last two columns of Table 3.5. Adding the $.09/lb operating costs to the cost of dry beans, $.12-$.30, suggests that dry bean flour price of $.21-$.39 would just cover variable costs. Other components of variable costs besides production costs include sales, research and development, transportation, etc. These costs will be examined after a brief look at the effect of sales volume, plant size, and sales margin on the break-even volume and return on investment (ROI).

Table 3.5
Dry Bean Flour Plant Operating and Capital Cost

Capacity
Per year 7,200 MT/15.873 mil. lbs
Per hour 3.0 MT/6614 lbs

Equipment	Capacity (MT/hr)	Quantity	Unit Cost($)	Total Cost($)	($/7200 MT/yr)	($/15.873 Mil lbs/yr)
Roaster	3	1	30000	30000		
Mill (Alpine 710 Contraplex)	2-2.4	1	150000	150000		
Air Classifier (800 MPS Microplex)	1.7-1.9	2	130000	260000		
Ancillary Equipment (10% of main)				44000		
Installation (20% of main)				96800		
Interest Expense 1 year (ave.)				46000		
Total				626800	87.06	.04
Facility						
Building & Construction (6500 sq.ft. @ $15/sq.ft)				97500		
Land				30000		
Rail Siding				100000		
Interest Expense 1 year (ave.)				23000		
Total				250500	34.79	.02
Miscellaneous				30000		
Total Capital				907300	126.01	.06

	Quantity	Unit	Cost	($/MT)	($/LB.)
B. Raw Material Cost				264-660	.12-.30
C. Operating Costs					
Labor, operators, loaders (inc. fringe)	12	10.50/hr	126	42.00	.02
Supervision	1	15.00/hr	15	5.00	.00
Utilities					
Electricity	6200 kwh	0.05/kwh	310	103.33	.05
Natural Gas	20000cf.	4.86/1000cf.	97.2	32.40	.01
Maintenance			6	2.00	.00
Bagging	66	.70-.90/c	59.4	19.80	.01
Total Operating Costs			613.6	204.53	.09

(1) Equipment and operating cost based on Aguilera et. al. 1981, p. 73-76, and personal communication with Witt Maddern, Alpine American Corporation, 1983. Other costs based on communication with industry specialists.
(2) Ancillary equipment includes mezzanine steelwork, starter equipment panel, belt and pneumatic conveyor system.
(3) Miscellaneous includes storage, insurance, property taxes, working capital expense, etc.

3.2.1 Economies of Scale

The trend in the food processing industry is to larger plants in order to capture economies of scale. As the quantity of output from the plant increases, the cost of fixed capital allocated per unit decreases. The size of a specialty flour mill will not begin to approach the size of a soybean crushing mill, but consideration of the impact of capacity on the rate of return needs to be made. The interaction of fixed costs, variable cost and revenue is illustrated in Figure 3.2. The illustration shows that fixed costs are constant regardless of the quantity of flour produced while total costs are a positive sloped line because it includes variable costs which increase at a constant rate with the quantity of flour produced. Imposing a revenue line (quantity sold * revenue per unit) determines the breakeven volume by the intersection of the total revenue and the total cost lines. The area above the breakeven quantity represents operating profit, while the area below the breakeven point represents operating loss.

Two other points of reference that will be used are the contribution margin and Return On Investment (ROI). The Contribution Margin per Unit (CMU) is defined as Revenue Per Unit (RPU) less Variable Costs Per Unit (VCU).

$$MU = RPV - VCU$$

The contribution margin represents the revenues available to cover fixed costs. The Break Even (BE) volume can be calculated as Total Fixed Costs (TFC) divided by the Contribution Margin Per Unit (CMU)

$$BE = \frac{TFC}{CMU}$$

The effect of plant size and sales margin on the return on investment (ROI) is shown in Table 3.6. Three plant sizes are considered, a pilot

Figure 3.2

Break-Even Chart

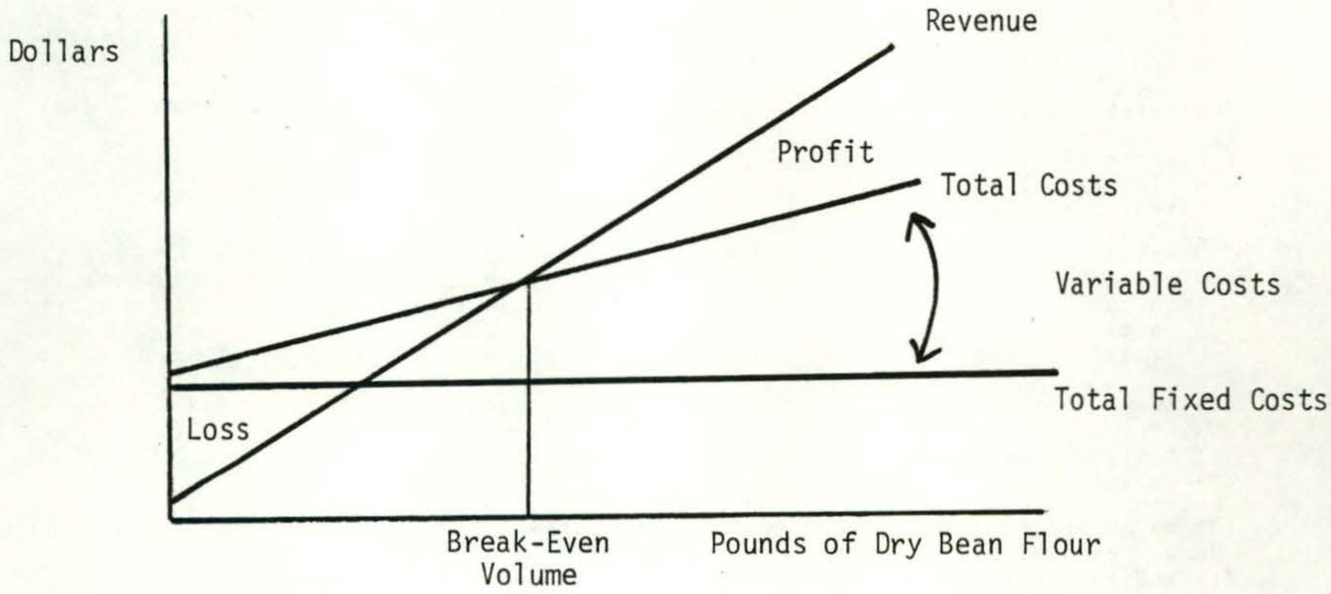


Table 3.6 Dry Bean Flour Production:
Rate of Return and Break Even Volume for Three Plants

Annual Return on Investment (%)

		Dry Bean Flour Contribution Margin(1) ($/lb)					
A.Pilot Plant		.01	.03	.05	.07	.09	.11
Cap. Investment $ 600000							
Volume (mil.lbs)	Utilization (%)						
1.59	1.00	2.65	7.95	13.25	18.55	23.85	29.15
1.06	.67	1.77	5.30	8.83	12.37	15.90	19.43
.53	.33	.88	2.65	4.42	6.18	7.95	9.72
Breakeven (1000 lbs)		60000	20000	12000	8571	6667	5455
B.Commercial Plant 1							
Cap. Investment $ 900000							
Volume (mil.lbs)	Utilization (%)						
15.90	1.00	17.67	53.00	88.33	123.67	159.00	194.33
10.60	.67	11.78	35.33	58.89	82.44	106.00	129.56
5.30	.33	5.89	17.67	29.44	41.22	53.00	64.78
1.59	.10	1.77	5.30	8.83	12.37	15.90	19.43
Breakeven (1000 lbs)		90000	30000	18000	12857	10000	8182
B.Commercial Plant 1							
Cap. Investment $ 1200000							
Volume (mil.lbs)	Utilization (%)						
31.80	1.00	26.50	79.50	132.50	185.50	238.50	291.50
21.20	.67	17.67	53.00	88.33	123.67	159.00	194.33
10.60	.33	8.83	26.50	44.17	61.83	79.50	97.17
5.31	.17	4.43	13.28	22.13	30.98	39.83	48.68
1.59	.05	1.33	3.98	6.63	9.28	11.93	14.58
Breakeven (1000 lbs)		120000	40000	24000	17143	13333	10909

(1) Contribution Margin =Total Revenue Less Total Variable Cost
(2) Equipment Cost Estimates taken from Table 3.2. Facility $227,500. and interest and miscellaneous equipment,$110,000 taken from Table 3.3.
(3) Calculations: Annual Return on Investment(ROI)=(Sales Volume*Contribution Margin Per Unit)/Total Capital Investment
Break Even=Total Capital Investment/Contribution Margin per Unit

plant, commercial plant 1 with ten times the capacity of the pilot plant and Commercial Plant 2 with 20 times the capacity of the pilot plant. Across the top of Table 3.6 are several levels of contribution margins, ranging from 2% to 20%. The contribution margin represents the post-tax revenues that would be available to the firm after all variable expenses. Along the side of Table 3.6 are several levels of plant capacity utilization and sales.

The return on investment estimates in the body of the table are calculated by multiplying sales (i.e. capacity) times the contribution margin, to get total "contribution" revenue, and dividing by the total investment. A break-even sales volume for each margin is also calculated by dividing total investment by the contribution margin.

The break-even volume for the pilot plant at a contribution margin of $.05/lb. is 12 million pounds. At a capacity of 1.6 million pounds production per year, 7.5 years of production would be required to reach the break-even sales volume. It would be possible to reduce the time to break-even through increasing output through increasing the number of shifts or in decreasing the amount of fixed capital investment. If the pilot plant could be installed without the expense of a new facility the break-even would be closer to 8 million pounds or about 5 years. Even at a $.11/lb. contribution margin, however, the break-even sales volume would require 3.5 year's production.

If the target ROI were 20%, then the pilot plant does not begin to show adequate returns until near full plant capacity is utilized and contribution margins are greater than $.07/lb.

Commercial plant 1 shows a break-even volume of 18 million pounds of flour with a $.05/lb. contribution margin. This is equal to a little over one year's production at full capacity. At $.05/lb., ROI is greater than 20% at utilization rates above 23%. The commercial plant appears to be an attractive alternative to the pilot plant, especially at higher volumes. Even at low volumes, for example 1.59 million pounds at $.05/lb. margins, ROI for the commercial plant is only 5% lower than the pilot plant, 8.83% vs. 13.25%.

3.3 Dry Bean Flour Marketing Costs

The following section will describe the cost assumptions leading up to the income projections in Table 3.7.

3.3.1 Packaging and Transportation

The flour can be shipped in bulk or in bags weighing up to 100 lbs. In bulk shipments, a pneumatic truck trail or rail car would be filled directly from the plant and shipped out at approximately $1.30 per mile (truck). Bagging is more expensive, costing $.01/lb. for equipment, labor and bags, and $1.20/mile for trucking costs. Bagging costs were included in the cost estimate because its higher cost results in a more conservative estimate of income.

Transportation costs from the plant to the ingredient user were estimated at $.013/lb. This estimate is based on trucking costs of $1.20 per mile on an average round trip of 500 miles with a 46,000 lb. load (in-state 50,000, out-state 44,000). Transportation costs could be substantially reduced through backhauling but it was assumed that this would not be done in order to ensure control over the sanitation of the vehicle container. Shipping is assumed to be carried out by contract carrier.

Transportation costs from the bean shipper to the flour mill is assumed to be included in raw bean cost. Provision for a rail siding has been made under capital investments - land (Table 3.7) and is included in the income statement under depreciation costs. The $100,000 rail siding may prove to be an optional expense.

Table 3.7
Break-Even Analysis and Rate of Return: 18 Margin Scenarios
Commercial Plant At 33% Plant Utilization
Total Capital Cost $ 900000

		Gross Margin Level $.14/lb. At 3 Levels of Var. Costs			Gross Margin Level $.18/lb. At 3 Levels of Var. Costs			Gross Margin Level $.22/lb. At 3 Levels of Var. Costs		
Item		Low(-15%)	Medium	Hi(+15%)	Low(-15%	Medium	Hi(+15%)	Low(-15%	Medium	Hi(+15%)
Total Sales	(lbs)	5238090	5238090	5238090	5238090	5238090	5238090	5238090	5238090	5238090
Bean Flour Price	($/lb)	.27	.27	.27	.38	.38	.38	.45	.45	.45
Raw Bean Cost	($/lb)	.13	.13	.13	.20	.20	.20	.23	.23	.23
Variable Costs	($/lb)	.15	.13	.11	.15	.13	.11	.15	.13	.11
Contribution Margin	($/lb)	-.01	.01	.03	.03	.05	.07	.07	.09	.11
Breakeven Volume	(lbs)	-7.039e7	90000000	33246061	33071775	19091172	13418641	13390160	10327946	8405647.
Plant Utilization	(%)	33	33	33	33	33	33	33	33	33
Rate of Return	(%)	-13.05	-7.25	-1.46	-1.41	4.39	10.18	10.23	16.03	21.82
Income Item										
Total Sales		1414284	1414284	1414284	1990474	1990474	1990474	2357141	2357141	2357141
Raw Bean Cost		680952	680952	680952	1047618	1047618	1047618	1204761	1204761	1204761
Gross Margin		733333	733333	733333	942856	942856	942856	1152380	1152380	1152380
Variable Costs										
Processing Cost	(.090/lb)	542142	471428	400714	542142	471428	400714	542142	471428	400714
Transportation	(.013/lb)	77726	67588	57450	77726	67588	57450	77726	67588	57450
Marketing & Sales	(.008/lb)	48190	41905	35619	48190	41905	35619	48190	41905	35619
Research & Dev.		115000	100000	85000	115000	100000	85000	115000	100000	85000
Miscellaneous		17250	15000	12750	17250	15000	12750	17250	15000	12750
Total Variable Cost		800309	695921	591533	800309	695921	591533	800309	695921	591533
Fixed Costs										
Interest on Debt		69000	69000	69000	69000	69000	69000	69000	69000	69000
Depreciation		84000	84000	84000	84000	84000	84000	84000	84000	84000
Miscellaneous		15000	15000	15000	15000	15000	15000	15000	15000	15000
Total Fixed Cost		168000	168000	168000	168000	168000	168000	168000	168000	168000
Earning Before Tax		-234977	-130588	-26200	-25453	78935	183323	184071	288459	392847
Income Tax	(50%)	-117488	-65294	-13100	-12727	39468	91662	92035	144229	196423
ITC										
Net Income		-117488	-65294	-13100	-12727	39468	91662	92035	144229	196423
Depreciation		84000	84000	84000	84000	84000	84000	84000	84000	84000
Net After Tax Cash Flow		-33488	18706	70900	71273	123468	175662	176035	228229	280423

See Footnotes at end of table.

Table 3.7 (cont'd)
Break-Even Analysis and Rate of Return: 18 Margin Scenarios
Commercial Plant At 67% Plant Utilization
Total Capital Cost $ 900000

Item		Gross Margin Level $.14/lb. At 3 Levels of Var. Costs			Gross Margin Level $.18/lb. At 3 Levels of Var. Costs			Gross Margin Level $.22/lb. At 3 Levels of Var. Costs		
		Low(-15%)	Medium	Hi(+15%)	Low(-15%	Medium	Hi(+15%)	Low(-15%	Medium	Hi(+15%)
Total Sales	(lbs)	10634910	10634910	10634910	10634910	10634910	10634910	10634910	10634910	10634910
Bean Flour Price	($/lb)	.27	.27	.27	.38	.38	.38	.45	.45	.45
Raw Bean Cost	($/lb)	.13	.13	.13	.20	.20	.20	.23	.23	.23
Variable Costs	($/lb)	.14	.12	.10	.14	.12	.10	.14	.12	.10
Contribution Margin ($/lb)		.00	.02	.04	.04	.06	.08	.08	.10	.12
Breakeven Volume	(lbs)	3.484e10	49225167	24629982	22485480	15441808	11758430	11246369	9157199.	7722615.
Plant Utilization	(%)	67	67	67	67	67	67	67	67	67
Rate of Return	(%)	-9.32	1.47	12.26	14.32	25.10	35.89	37.95	48.74	59.52
Income Item										
Total Sales		2871426	2871426	2871426	4041266	4041266	4041266	4785710	4785710	4785710
Raw Bean Cost		1382538	1382538	1382538	2126982	2126982	2126982	2446029	2446029	2446029
Gross Margin		1488887	1488887	1488887	1914284	1914284	1914284	2339680	2339680	2339680
Variable Costs										
Processing Cost	(.090/lb)	1100713	957142	813571	1100713	957142	813571	1100713	957142	813571
Transportation	(.013/lb)	157808	137225	116641	157808	137225	116641	157808	137225	116641
Marketing & Sales	(.008/lb)	97841	85079	72317	97841	85079	72317	97841	85079	72317
Research & Dev.		115000	100000	85000	115000	100000	85000	115000	100000	85000
Miscellaneous		17250	15000	12750	17250	15000	12750	17250	15000	12750
Total Variable Cost		1488613	1294446	1100279	1488613	1294446	1100279	1488613	1294446	1100279
Fixed Costs		1505863	1309446	1113029	1505863	1309446	1113029	1505863	1309446	1113029
Interest on Debt		69000	69000	69000	69000	69000	69000	69000	69000	69000
Depreciation		84000	84000	84000	84000	84000	84000	84000	84000	84000
Miscellaneous		15000	15000	15000	15000	15000	15000	15000	15000	15000
Total Fixed Cost		168000	168000	168000	168000	168000	168000	168000	168000	168000
Earning Before Tax		-167725	26442	220608	257671	451838	646005	683068	877234	1071401
Income Tax	(50%)	-83863	13221	110304	128836	225919	323002	341534	438617	535701
ITC										
Net Income		-83863	13221	110304	128836	225919	323002	341534	438617	535701
Depreciation		84000	84000	84000	84000	84000	84000	84000	84000	84000
Net After Tax Cash Flow		137	97221	194304	212836	309919	407002	425534	522617	619701

3.3.2 Sales

A new product without the benefit of an established market needs to be successfully communicated to the ingredient buyer. There are several methods of employing sales services, including brokers, agents and an inside sales force. An expense of $.008/lb. was assigned to provide up to $127,000 to cover salesmen, expenses, and clerical support.

3.3.3 Research and Development

The continued success of the development of a dry bean flour is contingent upon the development and recognition of function and value of the product. Over $300,000 has been invested to pioneer the processing and application technique of dry bean flour. This effect needs to be expanded and continued if dry bean flour is to become commercially successful. Such research is costly and carried on diligently by the major food ingredient manufacturers.

A bare minimum of $100,000 is included to allay some of the research costs. This includes contract research but not the expense of establishing a lab testing facility. Some lab testing capability may be necessary in-plant to ensure product quality. This is not included. Perhaps other sources of research financing can be solicited or carried on by the on-going research efforts of a food ingredient manufacturer.

3.4 Dry Bean Flour Capital Costs

Capital costs include equipment, building, land and miscellaneous, as detailed in Table 3.5. The total cost to set up a plant with 15.873 million pounds of processing capacity is $918,300.

A value of $84,000 was assigned to the annual capital depreciation expense, using straight line depreciation over a 10 year period. Interest expense is included as detailed by the schedule of depreciation and interest expense in Table 3.8. At 15% the average of the first five years of interest expense is $69,000. There are many accounting methods, financial packages and tax incentives such as the Investment Tax Credit that could be used to ameliorate even the conservative impact of this investment.

Working capital would also be necessary to cover the cash flow for 30 days until sufficient payment of sales invoices covered the expense of wages and salaries, marketing and sales, research and development, etc. Interest expense on working capital is included under miscellaneous variable costs.

3.5 Break-Even Sensitivity: Sales Volumes and Margins

The income from one year's production is shown in Table 3.7 under 18 scenarios. The essential variables tested are sales volume and contribution margin (revenue less variable costs). The contribution margin is allowed to vary from -$.01/lb. to $.12/lb. Three levels of gross margins are used, $.14/lb., $.18/lb. and $.22/lb. Within each gross margin scenario, variable costs are varied +15% to create a low contribution margin scenario and -15% to create a high contribution margin scenario. The first 9 scenarios assume a sales volume equivalent to 33% of plant capacity or 5 million pounds. The second nine scenarios assume a sales volume equivalent to 67% of plant capacity or 10 million pounds.

Table 3.7 suggests that a contribution margin at $.03/lb. or less will result in negative return on investment at sales volumes of 5 million pounds or less. When the sales volume reaches 10 million pounds per year, a contribution margin above $.02/lb. will produce a positive return on investment. A target rate of return of 20% per year can be achieved a contribution margin above $.11/lb. and a sales volume of 5 million pounds or a contribution margin above $.04/lb. and a sales volume of 10 million pounds. The break-even volume

Table 3.8 Debt Amortization Schedule

Building & Land ($000)		
Year	Deprec.	Balance
1984		228
1985	23	205
1986	23	182
1987	23	159
1988	23	137
1989	23	114
1990	23	91
1991	23	68
1992	23	46
1993	23	23
1994	23	0

Debt Amortization ($000)				
Payment	Dep	Balance	Interest	Accum. In
		839		
1	84	755	126	126
2	84	671	113	239
3	84	587	101	340
4	84	503	88	428
5	84	419	75	503
6	84	335	63	566
7	84	252	50	616
8	84	168	38	654
9	84	84	25	679
10	84	0	13	692

Equipment($000)		
Year	Dep.	Balance
1984		611
1985	61	550
1986	61	489
1987	61	428
1988	61	367
1989	61	306
1990	61	244
1991	61	183
1992	61	122
1993	61	61
1994	61	0

[1]Straight line depreciation method
Commercial Plant 1
Capacity 3000 kg/hr

of 15 million pounds, one year's production at full capacity appears to lie between \$.05/lb. and \$.07/lb.

The next 3 sections will examine the volumes and margins that are possible in the protein, starch and fiber, fiber and starch ingredient markets.

The price analysis would indicate that the price of bean flour would range between \$.26/lb. and \$.46/lb. with \$.12-\$.30 cull or commercial raw dry beans, \$.09/lb. variable costs and a \$.05 to \$.07 contribution margin. The price will depend upon the volume of sales and the competitive price level. Sections 4-6 will examine the markets for protein, fiber and starch ingredients to provide estimates of dry bean flour sales and competitive prices. The rate of return presented in this section only looked at one year's income. A more accurate picture of return will be presented in section 7 using the present value of the stream of income over the expected life of the investment, 10 years.

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4. THE PROTEIN INGREDIENT FOOD MARKET

Per capita consumption of meat can be expected to increase as incomes rise. U.S. animal protein consumption was roughly equal to vegetable protein consumption at the beginning of the twentieth century, now it accounts for two-thirds of the total protein supply. Overall, however, U.S. protein consumption was highest at the beginning of the twentieth century (Chou, 1983). Since the 1960's, consumers show a stronger demand for lighter foods, and are shifting from eating too much (quantity) to eating healthy foods and avoiding harmful foods (quality) (Van Dress 1980). This trend in animal and vegetable protein consumption parallels the general trend in other industrialized countries and is sensitive to changes in price and income (Craven 1983).

One of the more remarkable developments in the substitution of a vegetable protein for animal proteins has been the increasing number of applications and quantity of soyfoods in the U.S. diet. Soybean production was first introduced into the U.S. in the 1920s from China where it had been a staple food for many centuries. In the U.S. for many years soymeal, the product left after extracting the oil, was used primarily as a protein source for animal feed. Human consumption now accounts for 62 percent of soy protein use. In ten years, the number of bushels used for human consumption, excluding oil, has grown five times (to 50 million bushels in 1981), and doubled as a percent of total soybean production (to 2% in 1981) (Brown, 1981).

The factors that have opened present markets for soybean proteins will also influence the acceptance of dry bean protein, including:

1. Economic Factors
2. Continued growth of the processed foods market
3. Flavor characteristics
4. Functional properties

5. Nutritional aspects
6. Government regulation
7. Consumer acceptance

4.1 Economic Factors

Dry bean flour protein ingredients are interchangeable in many applications with other animal and vegetable protein ingredients, such as milk, eggs and soybeans. Economics plays a major role in ingredient selection; if function and flavor are the same then the manufacturer will choose the lowest cost ingredient. In addition, lower priced protein ingredients can be combined to achieve the desired function of higher priced protein ingredients where one protein source alone does not meet all the desired criteria. For example, combinations of soy and whey are used to replace higher priced nonfat dry milk in baking. Economics is a key factor that opens new markets.

The economic advantage of using vegetable proteins is shown in Table 4.1. The table shows 1982 consumption, protein contents and 1983 price for milk and vegetable protein ingredients. Comparing price per pound of protein, nonfat dry milk and whey proteins average $1.15 to $2.58 per pound, dry bean high protein flour (HPF) would average $.79 to $1.02 and soybean flours and grits range as low as $.28-$.30 per pound of protein. Soybean flours and grits cost about the same as whey but contain about four times as much protein. High protein dry bean flour (HPF) costs 2-3 times as much as soy flours and grits for about the same protein content. A high protein flour made from culled dry beans would be economically competitive with soy concentrates at $.52 to $.59 per pound of protein.

Nonfat dry milk more than triped in price in the mid 1970s and ingredient suppliers turned to milk replacers based on soy and/or whey. Even though the price of nonfat dry milk has since moderated, bakers--especially

Table 4.1 Domestic Consumption, Protein Content and Prices of Proteins Used for Processed Food, 1982[1]

Protein	Consumption in 1982 (mil lbs)	Protein Content (%)	Bulk Price Per Pound ($)	Price Per lb. of Protein ($)
Milk products				
Nonfat dry milk	443.0	.36	.93	2.58
Dry whole milk		.26	.95	3.65
Casein	127.8	.95	1.14	1.20
Whey	745.2	.13	.15	1.15
Whey protein concentrate		.34	.47	1.38
Soybean products				
Flours and grits	350.5	.50	.14-.15	.28-.30
Concentrates	79.4	.70	.40-.60	.57-.86
Isolates	90.4	.90	1.10-1.35	1.22-1.50
Textured flours	94.8	.50	.27-.35	.54-.70
Textured concentrates	8.8	.70	.60	.86
Textured isolates[2]	20	.20	.50+	2.50+
Wheat protein concentrate		.92	1.90	2.06
Wheat gluten isolate	70			
Whole bean flour		.26	.35-.45	.96-1.73
Whole cull bean flour		.26	.23-.26	.88-1.00
Dry bean flour		.44	.35-.45	.79-1.02
Culled dry bean high protein flour		.44	.23-.26	.52-.59

[1]Milk protein data, except casein figure, are taken from USDA ERS Dairy Situation (1982). Casein figure is for 1981 from Agricultural Statistics (1982). Soybean production data is taken from Wolf USDA NRRC (1983). Prices are from 1983 except as noted.

[2]1973 consumption. Protein content frozen 60 percent moisture basis. Price for 1975 as reported by Wolf (1976).

white bread bakers--have continued to rely on high functional milk replacers. Soybean products are currently the most important protein ingredient additive and its use as a milk replacer is likely to continue. Cheese whey is expected to be a strong contender in the protein ingredient market as a milk replacer because of its low price and the lack of alternatives for this cheese by-product: it may always be cheaper to produce saleable by-products from whey then to dispose of it (Frost & Sullivan, 1982).

Soybeans were first introduced into the American diet as a meat extender. Meat is the largest category of protein consumption in the U.S., and a natural market for the lower price soy protein. Soy protein for use in meats is cooked and extruded (forced through a small opening at high temperature) to give it the texture of meat. Soy protein blended with beef was prevalent until beef prices dropped. A 1974 USDA study found that when the price differential for all beef hamburger versus a beef and vegetable protein blended product dropped below 20 cents a pound most consumers stopped buying it (cited also in Wolf, 1976). Institutional markets have continued to use and develop products using soy as a meat extender. The military has saved more than $10 million annually with successful applications of soy meat extenders. The food service industry often introduces new products which are then adapted into the American diet (Chou, 1983).

4.2 Growth of Processed Foods Market

Processed foods offer variety, convenience, nutrition, and cost savings that will cause them to continue to grow over the next several decades. New processing applications have resulted in soy proteins alone being used in about 300 grocery items. With better processing techniques and growing consumer acceptance, sales of vegetable proteins should increase in the growing processed food market. Soy protein may follow the example of margarine, which 10 to 15 years ago competed on a price basis. Today consumer familiarity and concern over saturated fats and cholesterol has led margarine to outsell butter 3 to 1.

Protein use in processed foods is shown in Table 4.2 based on an extensive survey by Hammonds and Call (1972) and cited in Wolf (1976). Hammonds and Call projected protein use to 1980 based on their findings. Although meat product extension was thought to be the primary market for textured vegetable protein, growth areas have been in pet foods, bakery ingredients and dairy products instead. The estimate for protein use in canned and processed meat in 1980 may be much lower than projected to by Hammonds and Call. Overall sales growth is projected at 5-7 percent per year 1980-1989 according to Frost and Sullivan (1982). Protein ingredient use growth estimates made in the 1970s were too high based on domestic food shortages which failed to materialize. Sales projections made by Frost and Sullivan are shown in Table 4.3. Gross estimates of these dollar sales translated into volume based on todays prices are provided by this author. These sales projections include some animal feed uses. At current shares, 38 percent animal use and 62 percent human use, 2536.4 million pounds of protein ingredients will go to human consumption in the U.S. in 1989.

4.3 Flavor

A major consideration in the acceptance of new products in the ingredient market is flavor. The dry bean flour process developed at MSU produces a bland food ingredient capable of a wide variety of applications. Flavor has been a chief deterrent to soy flour which has a bitter, grassy taste. New processing methods have eliminated the negative flavor in soy isolates and concentrates and reduced considerably the taste in flour and grits.

Table 4.2 Protein Use, 1969, and Growth in Use, Projected 1980

Use	Annual Growth Rate	Protein Use	
		1969	1980 (proj.)
	Pct.	Ml. lb.	
Baby food	1.0	3.5	3.9
Baked goods and baking needs:			
snack food	6.0	10.0	19.0
all other	1.5	91.0	107.1
Breakfast food:			
instant breakfast	8.0	12.8	29.8
all other	1.7	5.1	6.2
Candy	3.0	16.6	23.0
Canned and processed meat	19.3	92.2	642.4
Coffee whitener	6.0	12.0	22.8
Dairy products:			
imitation milk	---	---	188.0
synthetic ice cream	5.0	3.8	6.5
all other	1.0	98.1	109.1
Desserts and toppings	6.0	31.7	60.0
Diet drink	2.0	8.4	10.5
Frozen food	3.6	3.8	5.6
Macaroni/pasta products	3.0	1.5	2.1
Pet food	5.4	[1]229.3	426.0
Soup	0.0	1.5	1.5
Subtotal		621.3	1,663.5
All other uses	9.3[2]	207.3	555.0
Total		828.6	2,218.5

[1]Includes 51.9 million lb. from ingredients not fit for human consumption.

[2]Weighted average growth rate for all protein ingredients.

Source: Hammonds and Call (1972) cited in Wolf 1976 pg. 41.

Table 4.3 Sales of Protein Ingredients for Food and Feed

Protein Ingredients	Growth Rate (Percent)	1980 (Million Dollars)	1989 (Million Dollars)	1980 Million Pounds (Estimated)	1989 Million Pounds (Estimated)
Dried whey	6.5	109	205	726.7	1576.9
Modified wheys	3.7	43	62	126.5	131.9
Soybean					
Flour & grits	5.4	112	189	746.7	1260.0
Concentrates	5.2	33	55	66.0	110.0
Isolates	5.2	110	183	100.0	166.4
Textured soy	6.4	35	65	100.0	185.4
Other including whey concentrate, whey blends, debittered yeast, other years	3.2	72	99	480.0	660.0
Total	5-7%	514	858	2345.9	4090.9

Source: Dollar sales in 1980 dollars are from Frost & Sullivan (1982). Quantity of sales are estimated conservatively by Perraut based on 1983 prices listed in Table 4.1.

4.4 Functional Properties

Proteins have many different functional properties, some of them uniquely suited to certain applications; for example, the baking properties of wheat gluten, the whipping properties of eggs, and the stability of sodium casienate (a milk by-product) in hot coffee.

The functions that proteins perform can be significantly altered through heat, chemical or texturing processes. Textured vegetable protein used to extend or replace meat product lowers cost and cuts fat and calorie levels (Food Processing 7/1983 p. 68). Soy proteins combined with whey act as a lower cost nonfat dry milk replacer that also lessens the need for preservatives in white bread.

An example of processing technique that is indicative of the potential market for dry bean flour is the production of soy concentrates and isolates versus soy flours and grits. Soy flours and grits have a very low price per pound of protein but their use is limited by the characteristic bitter taste. Still, soy flours and grits are used in baking, protein fortification, antibiotic culture production, meats, cereals, dietary foods, soup mixes and confections.

Soy concentrates are further processed and have somewhat less objectionable taste and a greater degree of digestibility. Soy isolates have no objectionable flavor and a higher cost. Some 50 varieties of concentrates are used in applications including a variety of processed and frozen meats, breakfast foods and infant foods. Soy concentrates are a high quality protein with good water and fat absorption. Soy isolates are also appropriate for a wide variety of applications including infant formulas, coffee whiteners, breakfast foods and meat extenders and meat analogs. Soy isolates have good foaming, whipping characteristics as a milk replacer in candy bars, whipped toppings, etc.

4.5 Nutritional Properties

In many ingredient applications the nutritional aspects are a secondary consideration to their functional uses. When used in small amounts as a functional ingredient, vegetable protein products add little to the products overall nutrition. Nutritional properties of vegetable proteins become more important where they are a major ingredient or in certain markets such as health foods, high protein breads, and food supplements for infants, for the elderly or for import.

4.6 Government Regulations

Food composition is regulated for many foods by standards of identity established under the Federal Food, Drug and Cosmetic Act and enforced by the Food and Drug Administration. These standards limit or exclude protein ingredients from certain foods. For example, the reclassification of whey as GRAS (generally recognized as safe) list in mid-1981 should strongly encourage its development and usage. It sometimes takes 5-7 years for new product ingredients to be accepted by the FDA although a simple bean flour might not face a complication of this sort.

Meat and poultry product composition is regulated by the Federal Meat and Poultry Inspection program of the USDA. Standards of identity do not allow added protein ingredients above a certain amount.

Government regulations may also stimulate the development of new food products. In 1971, textured vegetable protein was approved for use in the School Lunch Program by the Food and Nutrition Service of USDA. Military and institutional use of vegetable proteins has spurred their development. In vegetable protein exports, coordination is needed in to establish standards of identity and eliminate unnecessary restrictions. Further agreements on labelling need to be made.

Government foreign assistance feeding programs have had a positive impact on blended soy product sales. These programs have been shown to have a positive impact on nutrition (Graham and Baertl, 1974). Recently the quantity of soy used in these programs has been decreased and its future is not certain. Studies have shown that protein deficiency is more commonly a function of insufficient caloric intake and not an isolated phenomena. When calorie intake is sufficient, protein intake is usually sufficient.

4.7 Consumer Acceptance

Consumer eating habits change slowly especially with regard to staple foods. With the exception of oriental foods, soy is not directly consumed as food as dry beans are. The recent U.S. experience however, with increased consumption of variety breads, margarine and "light foods" seem to indicate a sizeable portion of the population is exercising some control over their diet.

Whole bean pastes are used in a variety of ethnic foods. McCormic and Co. has developed a full flavor bean paste for Mexican foods made through a wet process using pinto beans. This product is being tested in fast food restaurants and will soon be introduced to consumers as a retail product. The Japanese use azuki (red) beans to make poi, a confection. U.S. edible split beans are often purchased by the Japanese for use in these products. The Chinese use bean paste in a similar confection called manju. The acceptance of these products may not be large outside of their ethnic groups. These are fast growing ethnic groups, however, and candidates for full flavor bean flour products.

Dry bean flour or dry bean curd may be used to substitute for other traditional soy foods such as tofu, tempeh and miso. Some retail stores, especially coops, natural and health food stores, now sell a variety of soy products while plain oriental soyfoods are moving into American supermarkets. In 1982, 45.4 million pounds of tofu, 1.1 million pounds of tempeh and 3.1 million pounds of miso have been produced in the U.S. (Wolf, 1983). Tofu is a custard-like product made from curdled soybean milk. Tofu is as popular in Japan as bread is in the U.S. Tempeh is a stable food from Indonesia made from fermented soybean cake. Tempeh tastes like fried chicken. Miso is a basic staple and food flavoring in China and Japan made from fermented soybean paste. It is used as the basis for soups and sauces (Brown, 1981).

Trends that will strengthen the direct consumption of vegetable protein products are the growth in natural food consumer segment, Asian and Mexican ethnic groups, and consumer trends of light eating and the avoiding of protein sources with high fat and cholesterol. Consumer acceptance of vegetable proteins is less important where vegetable proteins are not a major ingredient. With a greater awareness of nutritional labelling, soy ingredients do not seem to discourage consumer purchases. Trends that will strengthen the acceptance of vegetable protein are the demand for nutrition, convenience, low fat, low cholesterol and increasing familiarity with vegetable protein products. In addition, further development of vegetable proteins themselves will improve their acceptability.

4.8 Dry Bean Flour Potential in the Protein Ingredient Market

Although vegetable protein use in meat products is growing more slowly than forecast in the 1970s, it can be expected to continue to grow, nonetheless. Meat products are a major market for vegetable proteins. A high protein flour, priced \$.52 to \$.59 per pound of protein, made from cull dry beans can compete economically with soy isolates and soy concentrates, priced \$.57 to \$1.22 per pound of protein. The cost of cull beans is estimated at \$.12 per pound; a price thought to be high enough to assure adequate supply. Combined with bean flour, processing costs of \$.12 to \$.15 per pound, cull beans could even be mixed with commercial grade beans and remain competitive with soy concentrates and soy isolates. (Extra costs to clean up badly damaged or dirty beans are not included.)

A high protein flour made from commercial grade beans, costing \$.20 to \$.30 per pound of beans and \$.79 to \$1.02 per pound of protein, would be less likely to make any inroads against the well established soy products. It is important to remember function here, since the higher priced soy concentrates and isolates serve specialized functions and are 70% to 90% protein whereas a high protein flour made through the roasting, air classifying method is 44% protein and may be less suitable for highly specialized uses. As far as soy flours and grits, wherever the drawbacks of objectionable taste are not a problem, they will be preferred to dry bean flour because of their abundant supply and low price.

As an extruded meat analog, 10 to 30 percent of soy concentrates and isolates used in texturized applications can be replaced with a high protein four made from dry beans. Although the dry bean high protein flour is not texturizable by itself, it can serve to lower the overall cost of the texturized soy product. Replacing 10 to 30 percent of soy concentrates and isolates used in texturized applications would result in sales of 3.0 to 8.6 million pounds of dry bean high protein flour.

Consumer acceptance of vegetable protein in meat products is likely to change only slowly, unless the per pound price differential between the all meat and the blended product increases beyond the \$.20 per pound threshold. Institutional adaptation of vegetable protein applications in meat products however, may serve to spur consumer experimentation.

The binding and emulsifying properties of dry bean flour indicate it could substitute for up to 3.9 percent of the meat in comminuted meats such as frankfurters and sausages. The contention is that vegetable proteins improve emulsion, stability and processing yields, thus reducing formulation costs. About 3 billion pounds of sausages and frankfurters were prepared in the U.S. under federal inspection in 1981 (Agricultural Statistics, 1982, pg. 313). Each percent of frankfurter production substituting dry bean high protein flour for 3.9% of the meat would result in approximately one million pounds of dry bean flour sales.

The United States school lunch program currently uses 44 million pounds of frankfurters per month (Patel, 1980). Each 10% of frankfurters consumed in the school lunch program with 3.9% of the meat substituted for by dry bean high protein flour would result in 2 million pounds of HPF sales per year.

This investigation would indicate that HPF would be competitive with soy concentrates and soy isolates. Total annual sales of HPF in extruded meat products and comminuted meats are estimated to be 4-9.6 million pounds per year - not including government programs. Government programs and regulations need to be further investigated and could be instrumental in the utilization of HPF. More research is needed concerning the effects of vegetable protein and dry bean HPF on processing yields.

Dry bean flour can be used in bread and baked goods in three ways: (1) as a protein substitute for non-fat dry milk; (2) as a flour replacement for wheat flour; and (3) as a fiber ingredient. Considering only the first application as a protein substitute in this section on protein, HPF could compete for the 6+ million pounds of soy concentrate used in baking (Hammonds and Call, 1972). Strong competition for the over 100 million pounds of protein ingredients used in baked goods will come from surplus milk products, low cost soy flour, and new developments in wheat proteins and cheese whey concentrates (Frost and Sullivan, 1982, Food Processing, 5/1983, and International Wheat Gluten Association). The USDA is promoting programs to subsidize bakers producing products with high levels of non-fat dry milk (Baker's Digest 12/1982, pg. 30). The reclassification of whey as a safe food product by the FDA will encourage the development of whey protein products. The adaptation of dry bean HPF as a protein ingredient for baked products can be expected to be highly conditional upon the many competitive products and their comparative functional advantages. More discussion of the use of dry bean flour in baked products will follow in the sections on fiber and starch.

A third application for the use of dry bean HPF is in protein fortification of processed foods. Consumer awareness of nutrition and demand for nutritionally evident foods is increasing. Protein is not deficient in the American diet and is not as major concern to consumers as salt, sugar and fat consumption. There is interest, however, in fortifying foods for consumer groups needing higher protein consumption, such as children or the elderly, and for protein deficient, high consumption items such as snack foods. Arguably, the most important consumer considerations in buying snack foods are more likely to be flavor, texture, freshness and price than protein content (Lorenz, 1983, Warren et al., 1983). For the same price, flavor, etc. however, the consumer might be persuaded to buy a nutritious snack food in the place of a less nutritious snack food.

Protein fortification in processed foods is also used in humanitarian food assistance to needy people who do not have adequate protein intake, manufacturing facilities, technical expertise or energy requirements. The

United States finances the sale and export of commodities through USDA's Commodity Credit Corporation and Foreign Agricultural Service under Title II of the P.L. 480 Food for Peace Program. The quality of the Title II fortified processed foods are specified through formulation, analytical and performance requirements.

In 1982, 119 million metric tons of fortified processed food and 146 MMT of blended food supplements were donated under Title II (Bookwalter, 1983). At 15% protein supplementation, approximately 87.978 million pounds of soy flour is utilized per year. Because the objective of fortification is maximum tonnage of protein at low cost and other factors such as function and palatability are less important, it is not likely that soy flour will be substituted for by HPF made from dry beans.

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5. THE FIBER INGREDIENT FOOD MARKET

In recent years interest in dietary fiber has become more intense. Dieticians, physicians, food faddists and consumers are advising increased fiber intake in the diet. Its importance in maintaining bowel regularity has been recognized by the medical profession perhaps as early has Hippocrates in 430 B.C. who wrote "wholemeal bread clears out the gut and passes through as excretement."[1] In 1915 and 1916, Kellogg Co. introduced 40% Bran Flakes and All Bran cereal as foods having desirable effects on the bowel function. In 1923 Kellogg's publication of these benefits popularized the concepts of "roughage" and "regularity." The incidence of diverticular disease, cardiovascular disease and colonic cancer has increased over the last century at the same time that fiber intake has been decreasing. Other cultures, such as rural Africa have diets high in fiber intake and low incidence of these diseases. Consequently, many new foods being introduced today are high in fiber.

What is dietary fiber? Although the definition and measurement of dietary fiber is hampered by some disagreement, dietary fiber is basically plant cell walls that resist digestion by the enzymes and secretions of the gastrointestinal tract. Dietary fiber includes cellulose, hemicellulose, pectin, gums and lignin, a non-carbohydrate component of plant cell walls. Plant foods such as fruits, nuts, vegetables and grains, are a natural source of dietary fiber. In addition, because of widespread consumer interest,many companies are marketing fiber supplements often composed of cellulose and bran.

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[1] McCance RD, Widdowson O: "Old thought and new work on breads white and brown." Lancet 2:205-210, 1955. Cited in Slavin (1983).

5.1 Economic Factors

Just about every conceivable source of fiber has been applied to breadmaking at some time, from whole grains, to grain hulls, to seeds, even to wood fiber and coconut husks. Some of the more common sources of fiber and their costs are shown in Table 5.1. Whole wheat fiber is the most expensive fiber at about 5¢ per percent of fiber added, followed by wheat bran. Pea hull flour is the least expensive and dry bean hull flour is the most expensive after wheat bran. High fiber flour made from cull beans would be competitive with corn bran but more expensive than pea flour and cellulose. High fiber flours made from dry beans have some additional beneficial characteristics that may justify their increased cost over pea hulls and cellulose as discussed under section 5.4 "Functional Properties."

Table 5.2 shows the composition of breads. White enriched bread made with white flour at about 9¢ per pound contains .3 percent fiber. Whole wheat bread made with whole wheat flour at 12-18¢ per pound contains 1.6 percent fiber. Wheat bran costs 1.09-1.36 per each percent of fiber. Thus, to "buy up" the fiber content of white bread to the level of whole wheat would require 1.4 pounds of wheat bran (per 100 lbs. of flour - per 160-180 pounds of bread). With lower cost fiber ingredients, several marketing opportunities exist; a low cost high fiber white bread, a lower cost wheat bread with the equivalent fiber of whole wheat bread, or a "high fiber" bread with 15-20 percent (total flour weight) fiber ingredients. ("Whole wheat" is defined as made with 100% whole wheat flours only). The fiber source used can vary greatly in terms of specific fiber content, and color, texture and impact on bread volume. Generally, fiber ingredients are very price competitive. Variety breads sell at a 15-20% premium over white breads, however, and might enable some flexibility and modest return from valued ingredients (see Cereal Foods World 11/78, p. 638).

Table 5.1 Domestic Consumption, Dietary Fiber Content and Prices of Fiber Used for Processed Foods, 1982

Fiber	Consumption in 1982 (mil lbs)	Dietary Fiber (Percent)	Bulk Price Per lb. (dollars)	Price Per % of Fiber (cents)
White enriched flour		0.2	.09	.30.00
Whole wheat flour		2.5	.12-.18	4.80-7.20
Wheat bran		11.0	.12-.13	1.09-1.36
Staley wet corn bran	2.0	88-92	.50-.60	.62-.68
Pea hull flour	1.0	51	.12-.13	.23-.25
Cellulose	2.0	99	.45-.60	.45-.60
Bean hull flour		44	.35-.45	.80-.98
Cull bean hull flour		44	.23-.26	.52-.59

Table 5.2 Composition of Breads

Bread	Calories	Moisture (%)	Protein (%)	Fiber (%)	Calcium (mg)	Iron (mg)	Riboflavin (mg)	Thiamine (mg)	Niacin (mg)
White Enriched	269	35.8	8.7	0.2	70	2.4	0.17	0.25	2.3
Italian Enriched	276	31.8	9.1	0.2	17	2.2	0.20	0.29	2.6
French Enriched	290	30.6	9.1	0.2	43	2.2	0.22	0.28	2.5
Whole Wheat	243	36.8	10.5	1.6	99	2.3	0.12	0.26	2.8
Cracked Wheat	263	34.9	8.7	0.5	88	1.1	0.09	0.12	1.3
Rye	243	35.5	9.1	0.4	75	1.6	0.07	0.18	1.4
Pumpernickel	246	34.0	9.1	1.0	84	2.4	0.14	0.23	1.2
Fresh & Natural	245	34.8	9.73	1.1	38.4	2.21	0.10	0.20	2.74
Fresh Horizon	175	45.0	9.0	7.5	176	3.2	0.24	0.40	3.5

[a]100 grams.

Source: Owen, David F. and Robert H. Cotton. "Dietary Fibers," _Cereal Foods World_, AACC, 10/1982, Vol. 27, No. 8, Pg. 519-520.

5.2 Growth of the Fiber Market

One of the largest uses of fiber ingredients is in bread. The trend in the sale of nonwhite or variety breads is indicative of the trend in demand for health and fiber ingredients. Production of variety breads increased 11.2 percent between 1972 and 1977, while white bread production decreased .7 percent (Cereal Foods World, 11/78, pg. 638). Variety breads now account for about 40% of bread sales according to industry specialists. Among the high fiber breads are Continental Bakeries "Fresh Horizons" bread made with cellulose, Roman Meal made with a variety of fibers and a white bread made with pea hull fibers by Cooperative Bakery. Fresh Horizons is advertised not as a high fiber bread but as 1/3 fewer calories than regular bread. The pea hull fiber bread may be discontinued because of oxidation/spoilage problem caused by the pea hull ingredient.

Fiber ingredients are also used in diet foods, such as low cal breads, pastas and diet drinks, and breakfast cereals, such as Kelloggs 40% bran flakes bran buds, General Foods Fruit and Fiber and Quaker Oats corn bran cereals. Sales of Staley's wet corn bran have fallen short of 2 million pounds in 1982. Sales of corn bran have not taken off as expected in a breakfast cereal application. There is some sentiment that the faddishness of demand for fiber ingredients is now over. Consumption of foods with high fiber content will probably remain a consumption habit at present levels or grow only slowly. Wheat fiber seems to be the most acceptable to the consumer, i.e., in whole grain products. Fiber ingredients are also included in low calorie and health food products.

5.3 Flavor

The flavor of roasted bean fiber flour is fairly bland, varying somewhat by type of bean. Navy bean flour has been successfully tested in cookies, cakes and bread at the 10-20% level by MSU food scientists. Soy hulls carries some of the bitter soy flavor and is not a recommended dietary ingredient.

5.4 Functional Properties

Fiber ingredients add roughage and reduce calories. Fiber ingredients are limited to their use by flavor, dilution of gluten in breads and their tendency to cause volume compression of the bread at higher concentration. Pea hull flour was found to increase the oxidation of the bread and cause it to sour or spoil more quickly. Several studies have shown that flour made from dry bean hulls is a feasible ingredient for high fiber baked goods.

5.5 Nutritional Properties

How does dietary fiber work? Fiber increases fecal volume, normalizes transit time and reduces constipation. It resists digestion and provides a great deal of surface area for bacteria to break down and synthesize many food components. Dietary fibers may limit cholesterol absorption by binding bile acids. Pectin and other water soluable fibers have reduced the insulin needs of some diabetics in clinical studies. It can also bind metals such as calcium, iron or zinc. High fiber foods are lower in calories and helpful in weight control according to research conducted by the University of Iowa, the Mayo clinic in Minnesota, ITT Continental Bakery Company and Olaf Mickelson at Michigan State University.[2] Not all fiber ingredients are identical in their fiber content. Legumes are high in hemicellulose and pectins which are important in lowering serum cholesterol. Cereal brans have

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[2]Owen, David F. and Robert H. Cotton, ibid.

less than 1% pectins. Hemicellulose has good water holding properties and influences stool weight transit time and possible dilution of potential carcinogens (MSU & TAM, Fall 1983).

Vegetables contain a high percentage of cellulose. Purified cellulose (generally a wood fiber) has a minimal effect as a stool softener while bran is very effective. Bran has little effect on serum cholesterol. Bean fibers are an excellent source and combination of dietary fibers.

5.6 Government Regulations

Fiber ingredients and their levels of use are regulated by the U.S. Food and Drug Administration. The demise of soy hulls as a fiber ingredient was due to a great extent to its lack of recognition as a dietary ingredient. Claims of reduced calories are stringently specified and must be 33% or more. "Whole wheat" baked products can only be made from whole wheat flour. Various labelling laws would also apply.

5.7 Consumer Acceptance

It has been estimated that the average American consumed 20 grams of fiber per day. This amount could be increased to 50 grams per day to achieve the positive effects of dietary fiber while still avoiding the potential negative effects of too much fiber; gas, diarrhea, voluvus (twisting of the intestinal tract) and decreased mineral absorption (Stephen, 1981, Mendlehoff, 1977, cited in Slavin, 1983).

In mass consumption of baked goods, it is expected that sales of variety breads will continue to be strong especially among the affluent, the educated, and the older age groups. Although the growth in variety breads sales will probably slow somewhat, their perception as being natural, having "no preservatives," and containing high fiver are likely to result in continued high levels of consumption. Variety breads will be a major market for dietary fiber, although wheat fiber will probably continue to take the lions share because of its close association with wheat gluten. Wheat gluten is a specialized protein necessary for bread.

Sales of high fiber cereals are expected to remain strong. Other applications of fiber in diet drinks and diet foods will continue to occupy the weight conscious segment of the market. Further exploitation of fiber proucts for special consumer groups such as diabetics and consumers with cholesterol and weight problems offers opportunity. Furthermore, education efforts on the benefits of dietary fiber by dieticians, physicians, food faddists, and consumers are likely to continue.

5.8 Dry Bean Flour Potential in the Fiber Ingredient Market

A high fiber flour (HFF) made from the hulls of dry beans is very acceptable in baking applications. The characteristics of the fiber content makes HFF all the more desireable for cholesterol, cancer and diabetic concerns. Using culled dry beans would bring the HFF price down to being competitive with cellulose products. When a high fiber white bread using pea hulls was introduced in 10 markets, approximately 1 million pounds of fiber flour was used. Roughly 2 million pounds of cellulose is used in a low calorie bread by ITT Continental bakers. Thus sales of dry bean HFF in breads could be expected to amount to 1 to 2 million pounds per year. Other applications of fiber material include low calorie and special diet foods.

Slavin, Joanne. Fiber in the Diet. St. Paul Food Science and Nutrition, University of Minnesota Agricultural Extension Service, Fact Sheet No. 35-1982.

Slavin, Joanne. "Dietary Fiber," Dietetic Currents Columbus Ross Laboratories Vol. 10-No. 6 Nov.-Dec. 1983.

Stephen A.M. "Should we eat more fiber?" Journal of Human Nutrition, 35:403-414, 1981.

Mendelhoff A.I. "Dietary Fiber and Human Health," New England Journal of Medicine, 297:811-814, 1977.

SouthgateDAT "Dietary Fiber: Analysis and Food Sources," American Journal of Clinical Nutrition, 31:5107-5110, 1978.

Owen David F. and Robert H. Cotton, "Dietary Fibers" Cereal Foods World, St. Paul: American Association of Cereal Chemists 10/1982 Vol. 27 No. 10 pg. 519-520.

Mrdeza, George "Trends for Specialty Breads," Cereal Foods World, St. Paul: American Association of Cereal Chemists 11/1978 Vol. 28 No. 11 pg. 635-637.

Dietz, Joseph, Edmund Lusas, Mark Uebersax and Mary Zabik. Dry Bean Flour Processing and Utilization. Research conducted by Department of Food Science and Human Nutrition, Michigan State University and Food Protein Research and Development Center, Texas A&M for USDA. Fall, 1983.

6. THE STARCH INGREDIENT FOOD MARKET

Less than 15 percent of disappearance of corn in the U.S. is used for food and industrial purposes. Corn, however, is the most important ingredient in the starch market, accounting for about 95 percent of all food starch ingredients. Twenty percent of milled corn is dry milled into meal and grits for breakfast foods, brewers grits, corn meal, hominy grits, corn flour, snacks, and industrial uses. Eighty percent of milled corn is wet milled into germ, hull, protein, and starch. After extracting the oil from the germ, the germbake and other byproducts are sold as feed. About 70 percent of the starch produced by wet milling is converted into corn syrups and sweeteners. High fructose corn syrup (HFCS) is an increasingly popular sweetener used by major soft drink manufacturers. About one-sixth of milled corn becomes starch packaged for human consumption or sold to food manufacturers for use in food products such as sauces, gravies, puddings and baking powder. Other non-edible uses of starch for industrial use include textiles, paper, cosmetics, explosives, corn binders in foundries and laundry products (Leath et al, 1982).

6.1 Economic Factors

Industry estimates put food use of starch at 800 million pounds. Half of this starch is unmodified for use in sauces, gravy, brewing and retail packaging. The other half of the starch is modified by one of several chemical processes to produce a starch with specific characteristics. For example, starch can be treated with hydroxpropyl for use in sauces and condiments. Sterified waxy maize has high clarity and is used for pie filling. Starch is modified to control swelling, lower viscosity, improve clarity and change swelling response to acid, temperature and pressure.

As shown in Table 6.1 unmodified starch sells for 11-18¢ per pound and modified food starch sells for 11-25¢ per pound depending upon the modification process used.

Starch made from dry beans would cost at least .47¢ using dry beans priced at 30¢/lb. Using cull beans for the high starch flour would bring the price of the starch closer to the upper end of modified corn starch prices.

A wet milled corn flour is used for extruding into a popular cheese flavored corn puff snack or for breakfast cereals. This extruded snack starch is more expensive and not beyond the level of competition offered by an extruded product made from beans.

6.2 Growth of the Starch Market

Per capita consumption of starch and breakfast cereal products has remained at 1.9 pounds and 2.3 pounds respectively since 1968.[1] Certain segments of the starch market show continued growth potential. For example, spaghetti sauce has grown 96 percent in volume 1975-1982 because of the strong demand for pasta and the increased demand for ethnic food. Demand for other ethnic food sauces is expected to remain strong.[2] An estimated 50 million pounds of starch is used in sauces. Consumers spent $618 million on baked and $303 million on frozen pies, including an estimated 50 million pounds of modified starch. Dollar sales of pies increased about 1.5 percent in 1982 over 1981.[3]

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[1]Leath, Meyer, Hill, U.S. Corn Industry, USDA 2/82, pg. 19.

[2]Food Engineering, "State of the Food Industry," 8/83, pg. 74.

[3]Milling and Baking News, "Changing Face of Breadstuffs," 11/83, pg. 118.

Table 6 1. Domestic Consumption, Starch Content, and Prices of Starch Used for Processed Foods, 1982

	1982 Consumption	Starch Content	Bulk Price Per Pound	Price Per Pound Starch
	(mil lbs)	(%)	($)	(%)
Unmodified corn starch	400		.11-.18	
Modified corn starch	400		.11-.25	
Extruded corn starch	160	.93	.41-.61	.44-.66
Whole bean flour		.51	.35-.45	.61-.80
High starch flour		.75	.35-.45	.47-.60
Cull bean flour		.57	.23-.26	.40-.46
Cull bean starch flour		.75	.23-.26	.31-.35

Extruded snacks use an estimated 160 million pounds of corn product. Extruded snacks are a small part of snack food market sales, $262.2 million in 1982 (4.6 percent of total). Sales were relatively flat in 1982. Extruded snacks are dominated by cheese flavored corn puffs. Frito's cheetos sales alone exceed $100 million. Other products include Borden's Cheese Doodles, General Mills "Bugles," Nabisco "Diggers" and Frito Lays "Fun Yuns." Manufacturers are optimistic about sales growth.

6.3 Flavor and Nutrition

Flavor and nutrition aspects of starches are not as important as the functional aspects. The flavor should be enhanced or neutral in most cases. Nutrition has not been a major element in the snack food market, although education and consumer groups have made it more so.

6.4 Functional Properties

The dry bean starch showed similar characteristics to modified corn starch; controlled swelling, late gelatinization, resistance to temperature, acid or pressure stresses. However, its use as a food starch would be limited by their susceptibility to syneresis (separation of water from a gel). This could be compensated for with a gum as needed. The properties of the bean starch would be acceptable in canned and retort packaged foods. Its expansion characteristics also make bean flour a candidate for extruded snacks. Other starch ingredients include potatoes, wheat, and tapioca. Both tapioca and potato starch, however, tend to be stringy, viscuous, to shear and gelatinize early.

6.5 Government Regulations

Modified starch is regulated by section 121.1031 of Food and Drug Administration's Food Additives Regulations.

6.6 Consumer Acceptance

Consumer concern over chemically modified ingredients would be a plus for the roasted, milled bean starch. As a small portion functional ingredient, bean starch would not generate much consumer interest or resistance. As a recognizable ingredient in extruded snacks, corn has recognition and consumer awareness that bean flour does not. Convenience, taste and texture could open the door for an extruded bean snack. Increasing awareness may develop a market niche for a nutritious bean snack.

6.7 Dry Bean Flour Potential in the Starch Ingredient Market

An extruded snack made from dry bean starch, or in combination with hull flour seems to offer the most potential for high starch flour (HSF) in the starch market. With the extruded product there is not the functional problem of synerisis. Price should not present a problem, especially if the product could be made from culled dry beans. Price per pound of starch for commercial dry bean flour is \$.47-\$.60, for corn \$.44-\$.46, and for culled dry bean HSF \$.31-\$.35. Most modified corn starches are priced \$.11-\$.18 per pound of starch, below the level that HSF could compete at. Sales of an extruded starch flour made from culled dry beans could easily reach 3.2-10.0 million pounds of HSF with only 2-6% of the 160 million pounds of corn used for extruded snacks.

Dry bean flour would probably be very acceptable to consumers in a snack food product. Combinations of starch fiber and protein could offer the additional appeal of a good nutritious extruded snack. It seems that an extruded product made from dry beans would have less appeal as a breakfast cereal but further investigation could be made.

Scales, Harold "The U.S. Snack Food Market," Cereal Foods World, American Association of Cereal Chemists 5/1982 27:5 pg. 203-205.

Groves, Peg "Applications for Cereal in Candy Manufacturing", Cereal Foods World, American Associates of Cereal Chemists 12/1982, pg. 589-591.

"The Snack Food Industry, 1982-1983" Chipper Snacker Potato Chip/Snack Food Association 9/1982.

Leath, Mack N., Lynn Meyer, Lowell D. Hill. U.S. Corn Industry USDA ERS Agricultural Economic Report No. 479 2/1982.

Feed: Outlook and Situation USDA ERS FdS-290 8/1983.

"State of the Food Industry," Food Engineering 8/1983.

Uebersax, M.A. and M.E. Zabik. Characterization and Utilization of Dry Heated Edible Bean Flour: Project Report 1982. East Lansing: Dept. of Food Science and Human Nutrition MSU, 1982.

7. MARKET POTENTIAL FOR DRY BEAN FLOUR AND ECONOMIC FEASIBILITY

Three questions need to be asked in evaluating the economic feasibility of a project:

1. how much income will be generated and when,
2. how much will the project cost, and
3. how should the investment decision be made?

Income depends upon sales volume and sales margin (i.e. total revenue less all expenses). Not only is the amount of income important but the timing of income flows can be a matter of survival to a new project.

The cost of a project depends not only on the cost of equipment, land and facilities but also on the cost of money, or interest charge that the firm must pay. Assuming 100% debt financing will result in the highest interest expenses and the lowest estimate of return to investment; therefore it is employed in this analysis to produce the most conservative estimate of return. Assuming 100% equity financing would result in a higher estimate of returns to investment but raise other questions of equity capital raising and tax accounting.

The cost of capital that a firm must pay is influenced by the size of the firm, the ratio of debt to equity financing, and the fast and expected future and volatility of its earnings. Methods for calculating a risk premium for a project, a firm or an industry do exist.[1] The cost of capital for a new project is also influenced by the projects expected returns and the firms risk preferences. A firm could use data from its own income or new projects or industry statistics to calculate its required risk and return requirements.

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[1]Weston, J. Fred. "Investment Decisions Using the Capital and Pricing Model, Financial Management. Spring, 1980. pg. 25-33. VanHorne, James C. "An Application of the Capital Asset Pricing Model to Divisional Required Returns," Financial Management. Spring, 1980, pg. 14-19.

For this general study of feasibility we will assume a 15% cost of capital and estimate the present value of returns using the "risk free" rate that Treasury bills are receiving, 8.5%. Managers of a firm or an interested investor can then compare the rate of return against their own cost of capital and risk and return preferences in evaluating the attractiveness of the project.

7.1 Sales Volume and Sale Price

A total of 15 to 69 million pounds of dry bean flour could be sold each year according to the discussion of the protein, starch and fiber ingredients markets in sections 4, 5 and 6 of this report. These estimates are based on ingredient function characteristics and price per pound or price per percent of ingredient. A summary of these high and low estimates of flour fraction sales and competitive price by application is shown in Table 7.1

A major contention of this analysis is that a high protein flour made from dry beans could compete on a price and function basis with soy protein concentrates and isolates. For example, soy protein concentrates are 70% protein and cost \$.57 to \$.86 per pound of protein. Soy protein isolates are 90 percent protein and cost \$1.22 to \$1.50 per pound of protein (see Table 4.1). Dry beans are at least 44% protein. The equivalent price per pound of dry bean high protein flour is \$.25 (\$.57 * 44%) to \$.37 to compete with soy concentrates and \$.53 to \$.66 to compete with soy isolates.

Concentrates and isolates have a higher percentage of protein and therefore may have fewer non-protein effects in ingredient applications. Dry bean high protein flour, on the other hand, may have a more acceptable and bland taste than soy concentrates and are equally a high quality protein. In any event, vegetable proteins are called on to perform many functions in

Table 7.1 Summary of Dry Bean Flour Sales Potential

Bean Flour Fraction	Product Type	Million Pounds Annual Sales: Low Estimate Sales	Low Estimate Penetration %	High Estimate Sales	High Estimate Penetration %	Total Ingredient Market (mil lbs)	Competitive Bean Flour Fraction Price
High Protein Flour (HPF - Yield 27-34%, 44% protein)							.27-.45
(@ 3.9% meat substitution)	Meat Analogs	3.0	(10)	8.6	(30)	28.8	.25-.66[1]
	Franks, Sausages	2.0	(2)	10.0	(10)	100.0	.25-.66
	School lunch franks	-	-	6.0	(30)	21.0	.25-.66
(@ 10-30%)	Baked goods	1.0	(1)	8.0	(8)	107.1	.25-.66
	Fortified Snack food	0.2	(1)	3.0	(16)	19.0	.12-.13[2]
	Fortified PL480 Exports	-	-	-	-	88.0	.12-.13
	Pet food	-	-	-	-	9,029.0	.12-.13
	Breakfast food	0.4	(1)	4.0	(10)	36	.12-.66
	Other Canned, Processed Meat	2.5	(.5)	5.0	(1)	500.0	.12-.66
	Diet Drinks	.1	(1)	1.5	(10)	10.5	.25-.66
	Frozen Foods	.1	(1)	.6	(10)	5.6	.25-.66
Total		9.3		46.7		200[3]	
High Fiber Flour (HFF - Yield 6-10% 44% Dietary Fiber)							.27-.45
	Baked Goods	1.0		3.0			.10-.30[4]
	Specialty Diet Foods	1.0		2.0			.10-.30
Total		2.0		5.0			
High Starch Flour (HSF - Yield 56-67%, 75% starch)							.27-.45
	Pudding, Pie Filling	-		-		50.0	.08-.18[5]
	Gravy, Sauces, Condiments	-		-		25.0	.08-.18
	Canning	-		-			.08-.18
	Extruded Snacks, Cereals	3.2	(2)	16.0	(10)	160.0	.30-.46
	Confectionary	-		-			
	Soups	-		-			
	Frozen Goods	-		-			
Total		3.2		16.0		400[6]	
Grand Total		14.5		68.7			

[1] Navy bean HPF equivalent of price per pound of protein of soy concentrates, isolates before texturizing.

[2] Same as 1 for soy flours and grits. [3] Total soy concentrates, isolates. [4] Navy bean HFF equivalent of price per percent of fiber for competing products.

[5] Navy bean HSF equivalent of price per pound of competing starch products. [6] Total sales modified starch.

ingredient usage and dry beans are likely to be as acceptable or preferred in some of them. The low estimate of bean flour as a protein ingredient totals 9.3 million pounds per year, less than 5% of soy concentrate and soy isolate uses, less than 5% of the over 2 billion pounds of protein ingredient sales (see Table 4.3).

A low sales estimate of 2.0 million pounds of dry bean fiber is also shown in Table 7.1. The bean fiber has many excellent nutritional benefits as described in section 5. The market for fiber additives does not appear too large and commands a relatively low price because of the many products and byproducts which are available. More investigation into specialty diet markets such as for weight control, heart conditions, and diabetics could prove fruitful.

Extruded snacks made from dry bean starch flour looks promising. The expansion characteristics of the bean starch make it excellent for extrusion either alone or combined with the bean hull fiber flour. High starch flour sales for extrusion could exceed the low estimate of 3.2 million pounds per year, 2% of the starch used in extruded snacks each year. Starch used for extrusion commands a premium price that makes it advantageous to dry bean flour sales.

A second key contention of this analysis of sales potential is the availability of ample supplies of cull beans which would be suitable for flour use at a competitive price. Table 3.4 details an estimate of cull bean availability. The use of cull beans is crucial to lowering the cost of bean flours for most uses, except perhaps, starch for extruded snacks. The higher priced proteins are specialized and probably less susceptable to replacement by the more complex (lower protein percent) bean protein flour. Further investigation of the quantity, quality, cost to clean up, and flour processing impact of using cull beans needs to be undertaken.

The composition of bean flour fractions and their portion of the total flour is also important. Further developments at Texas A&M in processing methods are increasing the precision with which the protein, starch and fiber fractions are classified. This ability directly improves the cost and competitiveness of the flour fractions. Also, larger capacity equipment is being tested for efficiency in bean flour production.

Product yields, according to 1981 tests at Texas A&M, are as follows: 23% high protein flour (50% protein), 57% high starch flour (75% starch) and 20% hull fiber flour. The sales estimates in Table 7.1 shows sales potential of 65% HPF, 22% HSF and 14% HFF. The mix of the fraction sales is important because it could result in higher costs if the fraction sales are too unbalanced.[1] It also presents an opportunity to set forth a differential pricing strategy that enhances the sale of each of the fractions. The starch fraction will probably require the most product and marketing development because it is the largest component of dry beans and it apparently is competitive with only a narrow range of starch products.

Full flavor dry bean flours are being texturized and used in ethnic bean foods, such as Mexican bean paste and bean dip. McCormick and Co. is using a wet process to process beans into a quick cooking bean paste for refried beans. This product is being test marketed in Mexican fast food restaurants in the U.S. and will soon be introduced to retail shoppers. Oriental ethnic groups use full flavor bean paste to make confections such as Japanese poi, manju or chinese baotz. The Japanese import most of the edible splits from the U.S. for use in these products. A full flavor whole bean flour could be produced using the dry roasting process by adjusting the temperature

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[1] Air classified wheat flour was popular years ago. General Mills large wheat classifying plant in Buffalo closed because it could not sell all of its fractionated products.

and roasting time. Further testing of this full flavor process needs to be undertaken. The market for full flavor ethnic bean foods is large and rapidly growing both in the U.S. and abroad.

More product applications are being investigated by on-going research at MSU and in the food industry. Surveys of food manufacturers would serve to further qualify and quantify bean sales potential.

7.2 Ten Year Projection of Returns to Investment

A ten year projection of return to investment is made in Tables 7.2A, B, C, D, E and F. Initial sales are assumed to be 5 million pounds and to grow by 8% per year to 10 million poinds in year 10. Contribution margins of 1%, 3%, 5%, 7%, 9% and 11% are used in the six tables by setting sales price to \$.34, \$.36, \$.38, \$.40, \$.42 and \$.44. All other costs in the table are constant or vary with sales volume. Raw dry bean costs are assumed to be \$.20/lb. No attempt to allow for inflation is made. The important price relationship is the margin between sale price and costs. A sale price of up to \$.45/lb. would be possible in the starch and protein markets according to Table 7.1. Depreciation and interest are based on the straight-line, 10 year depreciation schedule shown in Table 3.8.

The stream of after tax income is discounted to year 1 by using an approximation of the risk free rate, 8.5%. The results are as follows:

Sale Price	Contribution Margin	Present Value of Return on Investment	Present Value Average ROI (Less 8.5%)
\$.34	\$.01/lb.	-29.84%	-3.0
\$.36	\$.03/lb.	22.70%	2.3
\$.38	\$.05/lb.	75.24%	7.5
\$.40	\$.07/lb.	127.79%	12.8
\$.42	\$.09/lb.	180.33%	18.3
\$.44	\$.11/lb.	232.87%	23.3

The returns are positive when the contribution margin is greater than \$.02/lb. A target return of 20% per year is achieved by a contribution margin between

TABLE 7.2A

Bean Flour Production Income Statement: Years 1 to 10

Commercial Plant:$ 900000
Contribution Margin .01$/lb.
Sales Growth/Year 1.08%

Item	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Total Sales (lbs)	5238090	5657137	6109708	6598485	7126364	7696473	8312191	8977166	9695339	10470966
Bean Flour Price ($/lb)	.34	.34	.34	.34	.34	.34	.34	.34	.34	.34
Raw Bean Cost ($/lb)	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20
Variable Costs ($/lb)	.13	.13	.13	.13	.13	.13	.12	.12	.12	.12
Contribution Margin ($/lb)	.01	.01	.01	.01	.01	.01	.02	.02	.02	.02
Plant Utilization (%)	33	36	38	42	45	48	52	57	61	66
Return on Invest. (%)	-10.42	-9.02	-7.62	-6.11	-4.54	-2.95	-1.23	.51	2.39	4.32
Present Value ROI										
Discounted @8.5% (%)	-9.61	-7.66	-5.97	-4.41	-3.02	-1.81	-.69	.27	1.15	1.91
PV of 10yr.ROI (%)	-29.84									
Income Item										
Total Sales	1780951	1923427	2077301	2243485	2422964	2616801	2826145	3052236	3296415	3560128
Raw Bean Cost	1047618	1131427	1221942	1319697	1425273	1539295	1662438	1795433	1939068	2094193
Gross Margin	733333	791999	855359	923788	997691	1077506	1163707	1256803	1357347	1465935
Variable Costs										
Processing Cost (.090/lb)	471428	509142	549874	593864	641373	692683	748097	807945	872581	942387
Transportation (.013/lb)	67588	72995	78835	85142	91953	99309	107254	115834	125101	135109
Marketing & Sales (.008/lb)	41905	45257	48878	52788	57011	61572	66498	71817	77563	83768
Research & Dev.	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000
Miscellaneous	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
Total Variable Cost	695921	742395	792586	846793	905337	968564	1036849	1110597	1190244	1276264
Fixed Costs										
Interest on Debt	126000	113000	101000	88000	75000	63000	50000	38000	25000	13000
Depreciation	84000	84000	84000	84000	84000	84000	84000	84000	84000	84000
Miscellaneous	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
Total Fixed Cost	225000	212000	200000	187000	174000	162000	149000	137000	124000	112000
Earning Before Tax	-187588	-162396	-137227	-110005	-81646	-53057	-22142	9207	43103	77671
Income Tax (50%)	-93794	-81198	-68614	-55003	-40823	-26529	-11071	4603	21552	38836
ITC										
Net Income	-93794	-81198	-68614	-55003	-40823	-26529	-11071	4603	21552	38836
Depreciation	84000	84000	84000	84000	84000	84000	84000	84000	84000	84000
Net After Tax										
Cash Flow	-9794	2802	15386	28997	43177	57471	72929	88603	105552	122836

(1) CONTRIBUTION MARGIN- Total Revenue Less Total Variable Costs
(2) Calculations:
Annual Return on Investment(ROI)-(Sales Volume*Contribution Margin Per Unit)/Total Capital Investment
(3) Present Value Return on Investment-Sum (Net Income/(1.085)**N)/Total Investment

Table 7.2B
Bean Flour Production Income Statement: Years 1 to 10

Commercial Plant:$ 900000
Contribution Margin .03$/lb.
Sales Growth/Year: 1.08%

Item	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Total Sales (lbs)	5238090	5657137	6109708	6598485	7126364	7696473	8312191	8977166	9695339	10470966
Bean Flour Price ($/lb)	.36	.36	.36	.36	.36	.36	.36	.36	.36	.36
Raw Bean Cost ($/lb)	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20
Variable Costs ($/lb)	.13	.13	.13	.13	.13	.13	.12	.12	.12	.12
Contribution Margin ($/lb)	.03	.03	.03	.03	.03	.03	.04	.04	.04	.04
Plant Utilization (%)	33	36	38	42	45	48	52	57	61	66
Return on Invest. (%)	-4.60	-2.74	-.84	1.22	3.38	5.60	8.01	10.49	13.17	15.95
Present Value ROI										
Discounted @8.5% (%)	-4.24	-2.32	-.65	.88	2.25	3.43	4.52	5.46	6.32	7.05
PV of 10yr.ROI (%)	22.70									
Income Item										
Total Sales	1885712	2036569	2199495	2375455	2565491	2770730	2992389	3231780	3490322	3769548
Raw Bean Cost	1047618	1131427	1221942	1319697	1425273	1539295	1662438	1795433	1939068	2094193
Gross Margin	838094	905142	977553	1055758	1140218	1231436	1329950	1436347	1551254	1675355
Variable Costs										
Processing Cost (.090/lb)	471428	509142	549874	593864	641373	692683	748097	807945	872581	942387
Transportation (.013/lb)	67588	72995	78835	85142	91953	99309	107254	115834	125101	135109
Marketing & Sales (.008/lb)	41905	45257	48878	52788	57011	61572	66498	71817	77563	83768
Research & Dev.	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000
Miscellaneous	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
Total Variable Cost	695921	742395	792586	846793	905337	968564	1036849	1110597	1190244	1276264
Fixed Costs										
Interest on Debt	126000	113000	101000	88000	75000	63000	50000	38000	25000	13000
Depreciation	84000	84000	84000	84000	84000	84000	84000	84000	84000	84000
Miscellaneous	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
Total Fixed Cost	225000	212000	200000	187000	174000	162000	149000	137000	124000	112000
Earning Before Tax	-82827	-49253	-15033	21964	60881	100872	144102	188750	237010	287091
Income Tax (50%)	-41413	-24626	-7517	10982	30441	50436	72051	94375	118505	143545
ITC										
Net Income	-41413	-24626	-7517	10982	30441	50436	72051	94375	118505	143545
Depreciation	84000	84000	84000	84000	84000	84000	84000	84000	84000	84000
Net After Tax										
Cash Flow	42587	59374	76483	94982	114441	134436	156051	178375	202505	227545

(1) Contribution Margin =Total Revenue Less Total Variable Costs
(2) Calculations:
Annual Return on Investment(ROI)=(Sales Volume*Contribution Margin Per Unit)/Total Capital Investment
(3) Present Value Return on Investment=Sum (Net Income/(1.085)**N)/Total Investment

Table 7.2C
Bean Flour Production Income Statement: Years 1 to 10

Commercial Plant:$ 900000
Contribution Margin .05$/lb.
Sales Growth/Year: 1.08%

Item	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Total Sales (lbs)	5238090	5657137	6109708	6598485	7126364	7696473	8312191	8977166	9695339	10470966
Bean Flour Price ($/lb)	.38	.38	.38	.38	.38	.38	.38	.38	.38	.38
Raw Bean Cost ($/lb)	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20
Variable Costs ($/lb)	.13	.13	.13	.13	.13	.13	.12	.12	.12	.12
Contribution Margin ($/lb)	.05	.05	.05	.05	.05	.05	.06	.06	.06	.06
Plant Utilization (%)	33	36	38	42	45	48	52	57	61	66
Return on Invest. (%)	1.22	3.55	5.95	8.55	11.30	14.16	17.24	20.46	23.94	27.58
Present Value ROI										
Discounted @8.5% (%)	1.12	3.02	4.66	6.17	7.52	8.68	9.74	10.65	11.49	12.20
PV of 10yr.ROI (%)	75.24									
Income Item										
Total Sales	1990474	2149712	2321689	2507424	2708018	2924660	3158632	3411323	3684229	3978967
Raw Bean Cost	1047618	1131427	1221942	1319697	1425273	1539295	1662438	1795433	1939068	2094193
Gross Margin	942856	1018285	1099747	1187727	1282745	1385365	1496194	1615890	1745161	1884774
Variable Costs										
Processing Cost (.090/lb)	471428	509142	549874	593864	641373	692683	748097	807945	872581	942387
Transportation (.013/lb)	67588	72995	78835	85142	91953	99309	107254	115834	125101	135109
Marketing & Sales (.008/lb)	41905	45257	48878	52788	57011	61572	66498	71817	77563	83768
Research & Dev.	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000
Miscellaneous	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
Total Variable Cost	695921	742395	792586	846793	905337	968564	1036849	1110597	1190244	1276264
Fixed Costs										
Interest on Debt	126000	113000	101000	88000	75000	63000	50000	38000	25000	13000
Depreciation	84000	84000	84000	84000	84000	84000	84000	84000	84000	84000
Miscellaneous	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
Total Fixed Cost	225000	212000	200000	187000	174000	162000	149000	137000	124000	112000
Earning Before Tax	21935	63890	107161	153934	203409	254801	310346	368293	430917	496510
Income Tax (50%)	10968	31945	53581	76967	101704	127401	155173	184147	215458	248255
ITC										
Net Income	10968	31945	53581	76967	101704	127401	155173	184147	215458	248255
Depreciation	84000	84000	84000	84000	84000	84000	84000	84000	84000	84000
Net After Tax										
Cash Flow	94968	115945	137581	160967	185704	211401	239173	268147	299458	332255

(1) Contribution Margin =Total Revenue Less Total Variable Costs
(2) Calculations:
Annual Return on Investment(ROI)=(Sales Volume*Contribution Margin Per Unit)/Total Capital Investment
(3) Present Value Return on Investment=Sum (Net Income/(1.085)**N)/Total Investment

Table 7.2D

Bean Flour Production Income Statement; Years 1 to 10

Commercial Plant:$ 900000
Contribution Margin .07$/lb.
Sales Growth/Year: 1.08%

Item		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Total Sales	(lbs)	5238090	5657137	6109708	6598485	7126364	7696473	8312191	8977166	9695339	10470966
Bean Flour Price	($/lb)	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40
Raw Bean Cost	($/lb)	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20
Variable Costs	($/lb)	.13	.13	.13	.13	.13	.13	.12	.12	.12	.12
Contribution Margin	($/lb)	.07	.07	.07	.07	.07	.07	.08	.08	.08	.08
Plant Utilization	(%)	33	36	38	42	45	48	52	57	61	66
Return on Invest.	(%)	7.04	9.84	12.74	15.88	19.22	22.71	26.48	30.44	34.71	39.22
Present Value ROI											
Discounted @8.5%	(%)	6.49	8.35	9.98	11.46	12.78	13.92	14.96	15.85	16.66	17.35
PV of 10yr.ROI	(%)	127.79									
Income Item											
Total Sales		2095236	2262855	2443883	2639394	2850545	3078589	3324876	3590866	3878136	4188386
Raw Bean Cost		1047618	1131427	1221942	1319697	1425273	1539295	1662438	1795433	1939068	2094193
Gross Margin		1047618	1131427	1221942	1319697	1425273	1539295	1662438	1795433	1939068	2094193
Variable Costs											
Processing Cost	(.090/lb)	471428	509142	549874	593864	641373	692683	748097	807945	872581	942387
Transportation	(.013/lb)	67588	72995	78835	85142	91953	99309	107254	115834	125101	135109
Marketing & Sales	(.008/lb)	41905	45257	48878	52788	57011	61572	66498	71817	77563	83768
Research & Dev.		100000	100000	100000	100000	100000	100000	100000	100000	100000	100000
Miscellaneous		15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
Total Variable Cost		695921	742395	792586	846793	905337	968564	1036849	1110597	1190244	1276264
Fixed Costs											
Interest on Debt		126000	113000	101000	88000	75000	63000	50000	38000	25000	13000
Depreciation		84000	84000	84000	84000	84000	84000	84000	84000	84000	84000
Miscellaneous		15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
Total Fixed Cost		225000	212000	200000	187000	174000	162000	149000	137000	124000	112000
Earning Before Tax		126697	177033	229355	285904	345936	408731	476589	547837	624823	705929
Income Tax	(50%)	63348	88516	114678	142952	172968	204365	238295	273918	312412	352965
ITC											
Net Income		63348	88516	114678	142952	172968	204365	238295	273918	312412	352965
Depreciation		84000	84000	84000	84000	84000	84000	84000	84000	84000	84000
Net After Tax											
Cash Flow		147348	172516	198678	226952	256968	288365	322295	357918	396412	436965

(1) Contribution Margin -Total Revenue Less Total Variable Cost
(2) Calculations:
Annual Return on Investment(ROI)-(Sales Volume*Contribution Margin Per Unit)/Total Capital Investment
Break Even-Total Capital Investment/Contribution Margin per Unit
(3) Present Value Return on Investment-Sum (Net Income/(1.085)**N)/Total Investment

Table 7.2E

Bean Flour Production Income Statement: Years 1 to 10

Commercial Plant:$ 900000
Contribution Margin .09$/lb.
Sales Growth/Year: 1.08%

Item		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Total Sales	(lbs)	5238090	5657137	6109708	6598485	7126364	7696473	8312191	8977166	9695339	10470966
Bean Flour Price	($/lb)	.42	.42	.42	.42	.42	.42	.42	.42	.42	.42
Raw Bean Cost	($/lb)	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20
Variable Costs	($/lb)	.13	.13	.13	.13	.13	.13	.12	.12	.12	.12
Contribution Margin	($/lb)	.09	.09	.09	.09	.09	.09	.10	.10	.10	.10
Plant Utilization	(%)	33	36	38	42	45	48	52	57	61	66
Return on Invest.	(%)	12.86	16.12	19.53	23.22	27.14	31.26	35.71	40.41	45.49	50.85
Present Value ROI											
Discounted @8.5%	(%)	11.85	13.69	15.29	16.75	18.05	19.16	20.18	21.04	21.83	22.49
PV of 10yr.ROI	(%)	180.33									
Income Item											
Total Sales		2199998	2375998	2566077	2771364	2993073	3232519	3491120	3770410	4072042	4397806
Raw Bean Cost		1047618	1131427	1221942	1319697	1425273	1539295	1662438	1795433	1939068	2094193
Gross Margin		1152380	1244570	1344136	1451667	1567800	1693224	1828682	1974976	2132975	2303613
Variable Costs											
Processing Cost	(.090/lb)	471428	509142	549874	593864	641373	692683	748097	807945	872581	942387
Transportation	(.013/lb)	67588	72995	78835	85142	91953	99309	107254	115834	125101	135109
Marketing & Sales	(.008/lb)	41905	45257	48878	52788	57011	61572	66498	71817	77563	83768
Research & Dev.		100000	100000	100000	100000	100000	100000	100000	100000	100000	100000
Miscellaneous		15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
Total Variable Cost		695921	742395	792586	846793	905337	968564	1036849	1110597	1190244	1276264
Fixed Costs											
Interest on Debt		126000	113000	101000	88000	75000	63000	50000	38000	25000	13000
Depreciation		84000	84000	84000	84000	84000	84000	84000	84000	84000	84000
Miscellaneous		15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
Total Fixed Cost		225000	212000	200000	187000	174000	162000	149000	137000	124000	112000
Earning Before Tax		231459	290175	351549	417873	488463	562660	642833	727380	818730	915349
Income Tax	(50%)	115729	145088	175775	208937	244232	281330	321417	363690	409365	457674
ITC											
Net Income		115729	145088	175775	208937	244232	281330	321417	363690	409365	457674
Depreciation		84000	84000	84000	84000	84000	84000	84000	84000	84000	84000
Net After Tax											
Cash Flow		199729	229088	259775	292937	328232	365330	405417	447690	493365	541674

(1) Contribution Margin =Total Revenue Less Total Variable Cost

(2) Calculations:

Annual Return on Investment(ROI)=(Sales Volume*Contribution Margin Per Unit)/Total Capital Investment

Break Even=Total Capital Investment/Contribution Margin per Unit

(3) Present Value Return on Investment=Sum (Net Income/(1.085)**N)/Total Investment

Table 7.2F
Bean Flour Production Income Statement: Years 1 to 10

Commercial Plant:$ 900000
Contribution Margin .11$/lb.
Sales Growth/Year: 1.08%

Item		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Total Sales	(lbs)	5238090	5657137	6109708	6598485	7126364	7696473	8312191	8977166	9695339	10470966
Bean Flour Price	($/lb)	.44	.44	.44	.44	.44	.44	.44	.44	.44	.44
Raw Bean Cost	($/lb)	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20
Variable Costs	($/lb)	.13	.13	.13	.13	.13	.13	.12	.12	.12	.12
Contribution Margin ($/lb)		.11	.11	.11	.11	.11	.11	.12	.12	.12	.12
Plant Utilization (%)		33	36	38	42	45	48	52	57	61	66
Return on Invest. (%)		18.68	22.41	26.32	30.55	35.06	39.81	44.95	50.38	56.26	62.49
Present Value ROI											
Discounted @8.5%	(%)	17.22	19.03	20.61	22.04	23.31	24.40	25.39	26.23	27.00	27.64
PV of 10yr.ROI	(%)	232.87									
Income Item											
Total Sales		2304760	2489140	2688272	2903333	3135600	3386448	3657364	3949953	4265949	4607225
Raw Bean Cost		1047618	1131427	1221942	1319697	1425273	1539295	1662438	1795433	1939068	2094193
Gross Margin		1257142	1357713	1466330	1583636	1710327	1847153	1994926	2154520	2326881	2513032
Variable Costs											
Processing Cost	(.090/lb)	471428	509142	549874	593864	641373	692683	748097	807945	872581	942387
Transportation	(.013/lb)	67588	72995	78835	85142	91953	99309	107254	115834	125101	135109
Marketing & Sales	(.008/lb)	41905	45257	48878	52788	57011	61572	66498	71817	77563	83768
Research & Dev.		100000	100000	100000	100000	100000	100000	100000	100000	100000	100000
Miscellaneous		15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
Total Variable Cost		695921	742395	792586	846793	905337	968564	1036849	1110597	1190244	1276264
Fixed Costs											
Interest on Debt		126000	113000	101000	88000	75000	63000	50000	38000	25000	13000
Depreciation		84000	84000	84000	84000	84000	84000	84000	84000	84000	84000
Miscellaneous		15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
Total Fixed Cost		225000	212000	200000	187000	174000	162000	149000	137000	124000	112000
Earning Before Tax		336221	403318	473744	549843	630991	716590	809077	906923	1012637	1124768
Income Tax	(50%)	168110	201659	236872	274922	315495	358295	404538	453462	506318	562384
ITC											
Net Income		168110	201659	236872	274922	315495	358295	404538	453462	506318	562384.
Depreciation		84000	84000	84000	84000	84000	84000	84000	84000	84000	84000
Net After Tax Cash Flow		252110	285659	320872	358922	399495	442295	488538	537462	590318	646384

(1) Contribution Margin =Total Revenue Less Total Variable Cost
(2) Calculations:
Annual Return on Investment(ROI)=(Sales Volume*Contribution Margin Per Unit)/Total Capital Investment
Break Even=Total Capital Investment/Contribution Margin per Unit
(3) Present Value Return on Investment=Sum (Net Income/(1.085)**N)/Total Investment

$.05/lb. and $.09/lb. (after reintroducing the 8.5% discount rate). Under these scenarios a margin as low as $.03/lb. still provides a return above the risk free rate.

7.3 Market Structure

The purchase of ingredients in organizational markets is very dependent upon the relationships built up between buyer and seller. The sales of competitive products is dominated by a few very large firms. These firms have survived the uncertainty of the agricultural economy. The size of these firms would make the entry of a new firm into the protein, starch, and fiber ingredients markets very difficult without sufficient planning, organization and marketing strategy. For example, marketing snack food in large volume would not be possible without a substantial investment in distribution capacity as undertaken by such grants as Pepsico, Bordens and General Mills. The largest firms in the soybean and corn refining industries are listed in Table 7.3 as well as the largest manufacturers of sausages, flour, baked goods and extruded snack foods.

7.4 Conclusion

There are several decision criteria and techniques that would allow an individual or firm to assess the attractiveness of an investment in dry bean flour processing. According to the assumptions and analyses presented here, bean flour presents an attractive investment. Certainly, further research is needed, as described in the following section, but the introduction of a price competitive and functionally desirable ingredient into a large mature market presents an opportunity, especially for developing new markets for dry beans. New product development does <u>not</u> have a high rate of success, even by the most skilled of new product marketers. New products, however, are desired and rewarded by the market. With the hundreds of new and useful

Table 7.3 Market Structure: Firm Size and Rank by 1975 Food Sales in Selected Industries

Company	1975 Rank by Food Sales	1975 Food Sales (million $)
Corn Refiners and Soybean Product Manufacturers SIC#2046, #2075		
Archer-Daniels-Midland (ADM)	22	1,256
Cargill	16	1,355
A.E. Staley	46	700
Central Soya	29	1,083
Corn Products Corp. Intl. (CPC)	30	974
Rallston Purina	8	1,956
Grain Processing Corp.	119	245
National Starch & Chem. Corp.		71
Amstar Corp.	35	986
Sausages and Other Prepared Meats SIC# 2013		
Bluebird	81	403
Geo. A. Hormel	34	987
Hanson Trust (Hygrade)	91	350
Oscar Mayer	32	1,029
Rath Packing	83	399
Smithfield Foods	194	129
Flour and Other Grain Mill Products SIC#2041		
Con Agra	60	524
Hubbard Milling	124	225
International Multifoods	86	365
Peavy	102	304
Seaboard Allied Milling	104	298
Bread, Cake & Related Products #2051		
American Bakeries	80	413
Campbell Taggert	51	648
Flowers Industries	145	179
Interstate Brands	79	422
Ward Foods	74	452
Extruded Snacks SIC# 2099		
Frito Lay (Pepsico)	21	1,270
Bordens	7	2,050
General Mills	15	1,385
Nabisco	31	1,043

Table 7.3 Continued

Source: Connor, John M., and Lays L. Mather, Directory of the 200 Largest U.S. Food and Tobacco Processing Firms 1975, published jointly by ESCS (USDA) and NC-117, July 1978.

Additional sources of company information can be found in:

Corn Annual
Washington D.C.: Corn Refiners Association

Soya Bluebook
Washington D.C.: American Soybean Association

Soy Foods
Colerain, MA: Soy Crafters Association of N. America

Snack Foods - Buyers' Guide Issue
Chicago: Harcourt, Brace, Janovich, Inc.

Snack Foods - Bluebook
Chicago: Harcourt, Brace, Janovich, Inc.

Milling and Baking News - Milling Directory/Buyers Guide Issue
Kansas City, MO: Sosland Publishing

World Directory of Food and Drink Manufacturing Companies
London, England: EuroFood

American Meat Institute
National Food Processors Association

products that have been developed from corn and soybeans, and the basic quality of nutrition offered by dry beans, dry bean flour could become the miracle soy of the 1990s.

7.5 Proposed Research Agenda

Several areas of needed research have been mentioned in this report. In brief, this analysis concentrated on identifying potential market segments and forecasting income. Several questions remain before a business plan can be drawn up. A business plan would detail decisions on:

1. product,
2. price,
3. marketing channels,
4. plant location and physical distribution,
5. sales and promotion, and
6. control, including ownership, organization, production and finance.

Needed research efforts include:

1. Product Development-Specific Production Application in High Potential Sale Areas
    a. meat analogs, extenders and replacers,
    b. milk replacers and fiber in baked goods,
    c. protein fortified foods,
    d. extruded starch snack foods,
    e. specialty diet foods,
    f. ethnic and export foods, and
    g. pharmeceutical bases.
2. Raw Product
    a. cull bean availability, quantity, quality, impact on flour production and extra clean up costs.

3. Engineering Plant Cost Study
4. Organizational Buyer Behavior Survey
    a. to identify who, what, when, and how ingredient buyers purchase,
    b. to further quantify demand by specific product,
    c. to identify potential bean flour producing firms, and
    d. to develop marketing strategy.
5. Consumer Buyer Behavior and Consumer Acceptance of Dry Bean Flour Ingredients
6. Plant Location Analysis
7. Legal Environment Analysis
    a. food ingredient regulations and issues,
    b. school lunch program opportunities, and
    c. federal, state and local financing incentives (perhaps including analysis of impact on the local economy).

Appendix 1

Dry Bean Consumption

Dry Bean Consumption and Varieties

World consumption of dry beans is regionally determined by the ethnic origin of consumers, their local food habits, cultural and religious practices, income level and the geographic origin of bean varieties (Aguilera, et al. 1981). For example, people in Brazil consume mostly brown, red, or black varieties of beans at an annual rate of 56 pounds per person. Mexico's population consumes mostly pinto and black beans at a rate of 39 pounds per person per year. The nutritional content of the traditional Mexican diet of beans and corn is high calorie as well as balanced protein. White beans are preferred in Europe, great northern beans in France and navy beans in the United Kingdom. In the U.S., white beans are preferred in the north, black-eyed peas in the south and pinto and black beans by Spanish Americans mostly in the Southwest (Bean Commission Journal Fall 1982, pg. 24).

Table 1. Per Capita Consumption of Dry Edible Beans - 1962-1981

Year	Pounds Per Capita	Year	Pounds Per Capita
1981	4.1	1971	6.4
1980	4.3	1970	6.4
1979	4.3	1969	6.9
1978	4.8	1968	6.4
1977	6.2	1967	6.9
1976	6.2	1966	6.3
1975	6.6	1965	6.6
1974	5.0	1964	7.4
1973	7.0	1963	7.5
1972	5.6	1962	7.6

Source: U.S. Department of Agriculture.