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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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PREPARATORY STUDY FOR THE ESTABLISHMENT OF A POTATO PROCESSING INDUSTRY

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INDIA

Terminal report*

Prepared for the Government of India
by the United Nations Industrial Development Organization

Based on the work of
E. Kissmeyer-Nielsen
Potato Processing Specialist

Backstopping Officer: H. Koenig, Agro-based Industries Branch

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TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIXES

I SUMMARY

A. Background

The present investigation of potato processing opportunities in India is focused on Uttar Pradesh State, which is the most important potato producing State in India. According to the Commodity Bulletin "Potato" published in March, 1983 by the National Agricultural Co-operative Marketing Federation of India Ltd. (NAFED) Uttar Pradesh State alone accounted during the 1981 - 82 season for about 45.6% (4,900,000tons) of the total potato production (10,075,000 tons) in India.

The Farukhabad District of Uttar Pradesh State accounted for approximately 20% of the potato production in U.P. State or for the 1981 - 82 season about 920,000 tons. The Farukhabad district is thus the most important potato growing District in U.P. and the entire India. The present potato production in the Farukhabad District is estimated to be between 1 and 1,2 million tons annually and that of the entire U.P. State to be between 5 and 6 million tons annually. The total Indian potato production has increased significantly since the 1981 - 82 season and is estimated to be between 110 and 130 million tons annually or about 17 - 18 kg per capita. The actual net consumption per capita will be considerably less considering the loss during handling and distribution. Allthough potatoes are not considered one of the stable food items of India it is still one of the most important vegetables consumed in India.

The Farukhabad District is considered an under developed rural area and receives as such special attention by the Indian Government. Since the climatic and soil conditions in the Farukhabad District are particularely suitable for potato production and the farmers are very skilled in this type of crop production the Indian Government has decided to focus on assisting this industry. It is thought this can best be done by helping to develop a potato based agro industry in the Farukhabad District and thereby create an additional outlet for potatoes during periods where there are surplus of potatoes on the market. It is thought this will improve the presently low farm gate price for potatoes. There is at present a lack of a well formulated potato marketing policy by which, particularely du-

ring the potato harvest periods, the growers have no power to regulate the flow of potatoes entering the consumer marketand thus prevent gluts with resulting low prices. Also the potatoes entering the market appears poorly, if at all, graded and are not marketed in attractive net bags or like, but presented in bulk.

At present Farukhabad District has a cold storage capacity of approximately 400,000tons thus leaving 600 to 700,000 tons without. These 600 - 700,000 tons potatoes must be marketed during the 80 to 100 days they can be kept in non refrigerated storage without excess decay. The aim is thus to divert the proportion of these 600 to 700 thousand tons of potatoes considered surplus into processing. Since this period constitutes approximately 90 days or one fourth of the yearthe actual present surplus is thus one fourth of 1 - 1,2 million tons or 250 to 300 thousand tons.

B. Purpose and Scope

The purpose of the project is to assist the Government of India in assessing the opportunities to develop economically viable potato based agro industry. The initial focus is on the Farukhabad District in the Uttar Pradesh State because it has the most intensive potato production in India. Further more the Farukhabad District is considered a under developped rural area in need of further economic development. This District has particularely favorable climatic and soil conditions for potato production and farmers highly skilled in potato growing.

At present Farukhabad District and U.P. State as a whole lacks a firm, well established potato marketing policy which has resulted in very poor farm gate potato prices. It is felt, that establishment of a potato based agro industry in the Farukhabad District, by creating an outlet for surplus potatoes, will create a more stable and higher farm gate potato price. It is furthermore thought this will stimulate the growers to improve their potato production through such measures as introduction and/or propagation of more suitable potato varieties for table as well as industrial uses and improved methods of cultivation.

There is need to introduce effective grading, packaging and marketing methods for table potatoes for the consumer market. It is thought, that a more presentable packaging of well graded potatoes in such as 1 - 5 kg net webb bags would create a increased volume potato market at increased prices. Off grades from such a grading and marketing system may serve as a cheaper source of raw material for basic potato processing such as the production of starch and ethyl alcohol. At present the socalled culls, i.e. bruised and oddly shaped but otherwise sound of flesh potatoes are marketed in the consumer market, which appears to create an adverse consumer appreciation of table potatoes.

Allthough the Farukhabad District is chosen as the focal point for this investigation and the primary area for establishment of a potato based agro industry, it is planned to form a design pattern for India as a

whole. An initial potato processing plant will serve as a training ground for potato processing technologies and producer of potato products for marketing trials. It will also provide opportunities to test out new varieties for their suitability for processing. It might in this respect cooperate with the Central Potato Research Institute in Shimla, which is developing numerable new potato varieties better adapted to Indian climatic conditions than varieties formerly imported from abroad.

The potato processing plant may also serve as a testing ground for improved cold storage methology, of which there appears to be a need.

C. Conclusions

The present potato production situation in the Uttar Pradesh State including the Farukhabad district suffers from a lack of a firm and well established potato marketing policy. It only possesses cold storage for a small proportion of its annual potato production of approximately 4,6 million tons. The U.P. district Farukhabad which is the focal point for this investigation, has a cold storage capacity of 400,000 tons of potatoes out of an annual potato production of 1,0 to 1,2 million tons. This limited cold storage capacity gives rise to gluts of potatoes on the market and particularely during the early part of the potato season. Potatoes may be stored 80 - 100 days during this period or up to about one fourth of the year.

It is estimated, that the annual potato surplus is between 250,000 and 300,000 tons.

The potatoes are not properly graded and packed before shipped to the consumer market but mostly marketed as a bulk item. It is estimated, that the Farukhabad potatoes contain between 15 and 20 percent culls, i.e. bruised, cut and odd shaped potatoesof otherwise sound flesh. If properly graded this would yield a total of about 150,000 to 200,000 tons of potatoes suitable for processing into such products as potato starch and ethyl alcohol which processes utilize the whole unpeeled but cleaned potato. It would appear, that grading and packing of the potatoes in suitable 1 to 5 kg mess bags would enhance their consumer appeal and thus help to hold their price up. At present the potatoes marketed are mainly of poor appearance. They are mainly marketed by traders, who buy the potatoes at the auction in Farukhabad, where the growers exhibit the potatoes in bulk for the potential buyers to inspect them prior to bidding. It would also appear advantageous to grade the potatoes tc be stored in cold storage so as to save the high cost of storage (which amounts to Rs.20 to 25 per Mk per season of about 5 to 6 months) of the inferior grade potatoes. For the Farukhabad district alone with its annual potato production of 1 to 1,2 million tons the 150 to 200 thousand tons of potential cull potatoes thus constitute a significant source of cheap raw material for an alcohol or starch production of significant size.

The better grade of the potatoes considered surplus potatoes may be utilized into production of more refined products such as whole potato flour, potato chips, shoe string potatoes or frozen french fries. To siphon off surpluses in the beginning of the potato season would diminish marketing gluts and thus help keeping the price up and assuring the grower a more favorable farm gate price.

An integration of grading, packing and marketing of table potatoes might be beneficial provided it could be properly managed and such integrated ventures doe exist in some of the most advanced potato processing countries such as U.S.A.. In Denmark potato processing has mainly been undertaken by grower cooperatives, but also the private sector such as the Danish Alcohol Factories, Inc. is producing alcohol, variously flavored potato chips, shoe string potatoes and instant mashed potatoes and has its own potato research center in Jutland.

During the expert's field trip to the Farukhabad district and meetings with numerable State and District officials and Farukhabad District growers in depth information about the potato growing and marketing situation was collected. The potato planting time is between September and November and the harvesting period between November and February The major potato varieties grown are according to the Farukhabad District potato development officer;

A. White Skinned (white fleshed)
   1. Kufri Badshah
   2. Kufri Bahal

B. Red Skinned
   1. Kufri Salima
   2. Kufri Sindhuri

Kufri Badshah is a recent introduction from the Central Potato Research Institute in Shimla, India and possesses a very smooth appearance and suitably large tuber sizes, well suited for processing into more refined potato products, where peeling is a must. The red skinned potatoes

are smaller, irregular sized with deep eyes and thus not suitablefor processing where peeling and trimming is a must. They may, however, be used for processihg into ethyl alcohol and starch, where peeling and trimming is not called for.

Thus initially the less desirable potatoes can be used in the latter processes until /and if more suitable industrial varieties are introduced. The Farukhabad district potato growers have allready declared their willingness to adopt to such varieties.

The present marketing system, the growers selling their potatoes through the Farukhabad potato auction is also not used in procuring potatoes for modern potato processing. Potato processors commonly contract directly with the growers and supply inputs such as seed potatoes and fertilizer on a credit scheme. They also commonly insist on a specific insect and fungizide spray sched .le. Introduction of such a radically different potato procurement system will take time, but in the meantime it is possible to introduce a smaller scale multiproduct potato processing enterprise based on the existing raw material supply situation and at best purchasing the potatoes directly from the growers at aggreed prices.

Initially a product mix of potato starch, alcohol and potato chips appears beneficial. Smaller trial units for potato chips and frozen french fries may be included. Farukhabad possesses an important essential oil industry producing essential oils for use in perfume production where potato ethyl alcohol is considered a highly beneficial solvent or carrier in perfume product sold in the consumer market. Potato alcohol is considered purer than alcohols produced from for instance grain or molasses in the sense of being lower in undesirable impurities. There is allready in Farukhabad a party with interest in establishment of production of Vodka based on potato alcohol and aimed at the export market.

Potato based starch and ethyl alcohol do have competition from maize

and molasses based starch and ethyl alcohol production. By using potato culls in these processes the price of the potatoes will be very much lower than for graded potatoes and render the processing more competitive. Potatoes contain 72-80 percent water, while maize contain only approximately 10 percent water and thus is far cheaper to transport in relationship to its drymatter than potatoes. It also possesses a far more stable storage life. However, by locating the potato processing plant centrally near the potato production sites the cost of transportation can be kept down. When producing starch from maize the process is different from that of using potatoes in the sense, that the maize germ must be removed prior to extracting the starch, which is a process in addition to that used in starch production from potato.In the second step, maize must,like potatoes, be finely ground and diluted with water prior to separating out the starch by elaborate centrifugal procedures. Thus production of potato starch is somewhat less complicated, starting out with the disintegration of the potato to free the starch grains from inside the cells. Furthermore potato starch differs in its properties from that of maize starch and has been considered superior in certain uses such as sizing of textile yarns and finishing of textile materials.

In the production of ethyl alcohol from potatoes and molasses the processes are identical apart from theinitial steps of cooking the potatoes and treating the cooked potatoes with enzymes to convert the starch to fermentable sugars. The ensuing fermentation and distillation steps are identical so one could theoretically operate a distillery with different raw materials such as potatoes, cassava, grains and molasses.

The material left after distillation is valuable as a feed ingredient, since it is high in protein partly from the yeast used in the fermentation process. As a matter of fact potatoes are considered an excellent substrate for the production of various microorganisms used in industry.

As regards the actual properties of the potatoes grown in the Farukhabad District, there is only limited information available about this, since potato processing activities likewise have been very limited. Some information is available from the Central Potato Research Institute at Shimla and in the NAFED Commodity Bulletin, "Potato" of March, 1983. These sources give a wide range of solids percentages commonly ranging between 22 and 25 percent for mature potatoes. Apparently the solids content is determined by use of vacuum drying and not correlated with specific gravity, which is most common in the leading potato processing countries such as U.S.A., Denmark, W. Germany and Holland. It appears, that the growers in the Farukhabad District are apt to harvest the potatoes immature early in the season to get in on the more lucrative early season potato market.

Considering 22 to 25 percent solids being a normal range 75 percent of which normally may be considered starch, the starch content varies between 16.5 and 18.8 percent. In ethyl alcohol production from potatoes each kg. starch equivalent about o.65 liter ethyl alcohol. Thus one ton of potatoes produces between 100 and 120 liter alcohol. The anticipated net starch production is about 80 percent of the gross starch content or between 132 and 15o kg, Ton of potatoes.

As regards the location of a potato processing plant in the Farukhabad area the following locations were given by U.P. Government officials in order of preference;

1. Chebramau, Tehsil
2. Fatehgash, Sadar
3. Kannauj

The expert has, however, not had the opportunity to visit these potential sites and reserves his opinion until and/if he has visited them.

D. Recommendations

The recommendations presented here are aimed at establishing a sound base for potato processing in Farukhabad District. This may serve as the nucleus for establishment of further processing ventures in the Farukhabad District and U.P. State as a whole. It may furthermore provide a pattern for nationwide potato processing ventures.

It is recommended initially to establish a Small Scale multiproduct potato processing plant in the Farukhabad District of U.P. State for processing of approximately 15,000 tons of potatoes per season. The 15,000 tons of potatoes will be processed as follows:

	tons of potatoes	Amount of Product*
a. Alcohol	7,500	750,000 liters
b. Potato Chips	2,500	700 Tons
c. Starch	5,000	900 Tons

*Estimated yields per ton of potatoes are based on the solids percent of the potatoes.

The potato chip processing will operate 250 days a year, three shifts. The main processing period is estimated as 100 days. This could be extended by using potatoes out of cold storage. Use of cold storage is, however, not considered economically viable in the production of starch and alcohol, since it will add too much extra cost to a low cost product. Use of cold storage is more appropriate in the production of more refined products suct as whole potato flour, instant mashed potato, potato chips, shoe string potatoes and frozen french fries. Year round production is a must for products such as potato chips and shoe string potatoes, since these products must be available in the market year round to keep the brand name in the consumers' mind.

A turnkey proposition for the entire plant is a must and the expert will contact the appropriate machine companies in Western Europe to attain this provided he is given sufficient time. This will include some training of the personnel to run the plant in Farukhaba District.

It is also recommended to send the future manager and chief quality controller for in plant training in a West European multiproduct potato processing plant, which the expert also can arrange given time.

The plant will serve as a training ground for potato processing technicians and provide potato products for test marketing. It will also have laboratory facilities for testing of new potato varieties for their suitability for processing.

Furthermore there is a need to establish more suitable potato cold storage technology and the processing plant would provide the setting for this.

II PRESENT SITUATION

A Potato Production

Allthough in India potatoes are not considered the most important staple food, it is one of the most important vegetables consumed and thus serves as a supplementary staple food. The Indian potato production trend has been increasing steadily for many years. From a 1950-51 production of 1.7 million tons, it reached slightly more than 10 million tons in 1981-82. The present per capita consumption is about 12 kg per anno.

Uttar Pradesh State is the most important potato production State in India. During the 1981-82 season it produced 4,590 thousand tons out of a total Indian production of 10,075,000 tons of potatoes or about 46 percent of the Indian production. The Farukhabad District, which according to the expert's terms of reference is his prime concern, produces about 25 percent of the Uttar Pradesh State potato production or between one and 1.1 million tons annually.

As well acreage grown as yield per hectare has increased from 6.9 tons/ha in 1950-51 to 13 tons/ha in 1981-82. These increases are caused by improved cultural practices, improved seed potatoes and introduction of some new varieties giving higher yields and showing higher solids content. The Central Potato Research Station near Simla in the Mountains about 350 km. north east of New Delhi contributes to these improvements. The small size growers growing less than one hectare to a few hectares each makes it hard to effectively reach the individual grower to assist them in adapting new and improved cultural practices and get new and improved potato varieties. Public meetings between growers and agriculture officials do, however, take place, where cultural practices are taken up and discussed including marketing aspects. The practice of producing industrial type potatoes under firm contract, like in Northern Europe, for use in potato processing, does not exist in India. This is almost a must for modern potato processing in order to make it viable and may be somewhat difficult to introduce in India, allthough the growers declares their willingness to enter such a system, provided the economic return is satisfactory.

B Potato Marketing and Price Structure

According to NAFED (National Agricultural Co-operative Marketing Federation of India Ltd., P and D Division) it is estimated, that 18 - 20 percent of the potatoes are retained by the growers for seed and partly for sales locally. It is estimated, that 25 percent of the production is wasted at different stages of marketing due to the potatoes perishable nature and the often adverse handling and storage conditions with very high temperatures the greater portion of the year. Less than 0.5 percent is exported.

The marketing of potatoes almost exclusively takes place through private traders. In Farukhabad the potatoes are brought in bulk to a public auction where they are auctioned away to private traders, who serve as middlemen between the growers and the retailers. The growers only realize a very small part of the retail price and often less than the production price. Some potatoes are stored in cold storage for later marketing, but the present cold storage capacity is only about 400,000 tons in the Farukhabad district. Due to high temperatures most of the year, potatoes can only be stored for a short time without refrigeration depending on the location of the storage area. In shady areas potatoes may still be stored a couple of months without refrigeration according to the agricultural officer in Farukhabad, i. e. after harvest and before the hottest period starts in March-April. Thus the growers are often times forced to flood the market with resulting drastic drops in price. To make the present situation worse, the electric supply in the Farukhabad District is unreliable creating numerable power shortages with resulting fluctuation in the cold storage temperature. This affects the potato quality adversely and brings about premature sprouting of the potatoes. The cold storage operators claim, it is too expensive to have full load coverage by back up electric generators. The present cost for cold storage is Rs.20-25/HK per storage season of about 5 months. (HK=Hecto Kilogram = 100 kg.)

The price range for the potatoes at the Farukhabad auction varies greatly. For the 1984/85 season the following range was given:

Period	Price/HK in Rs.
January - June	30 - 80
June - September	80 - 120

It is thought, that establishment of a potato processing venture in the Farukhabad District will help bring about a higher and more stable farm gate price for the potatoes and thus secure a much needed higher income for the small scale growers. This is the major background for the great interest in implementing an economically viable potato processing industry in the Farukhabad District.

C Present Potato Processing

Very little potato processing is taking place in India, including the Farukhabad District, at present. There are a few potato chip factories in the big cities such as New Delhi and Bombay.
Some cottage type potato dehydration is taking place in the Uttar Pradesh State.
It is only very recently the interest in potato processing has come to light. A major reason for this lack of interest is the very low per capita income in India. This limits the market for snack items including potato chips, shoe string potatoes, potato puffs and also for prepared products such as dried instant potato and frozen french fries. There is a need to save the scarce income for more basic food products.
Still there is a growing market for potato chips in the bigger cities and not least in New Delhi with its more international outlook.
The market potential for potato products is not well known for which reason, it is felt most prudent to start with a smaller scale processing and thus to test the market out before and/if expanding the processing.

III Potential Potato Processing

It is recommended to implement an integrated potato processing venture in the Farukhabad area intially comprising production of potato starch, alcohol and chips. Potato starch and alcohol is recommended in order to find a suitable outlet for the large amount of cull potatoes, which in the Farukhabad area is estimated to comprise about 20 percent of the crop or 250 to 300 thousand tons per year. It appears, it would be beneficial initially as the potatoes are harvested and before they are placed in expensive cold storage to take out the culls through a general grading of the potatoes. The culls, which are potatoes with minor cuts and blemishes but mostly sound of flesh will at this early stage be healthier and thus give a a better yield of finished product (starch and alcohol). In the Farukhabad District, harvesting takes place Nov.-Dec. while planting takes place Sept.-Oct. on the plains of Uttar Pradesh State.

Of potato products, which demand high quality, pleasant tasting and reasonably high solid content potatoes potato chips are chosen initially. Among the reasons for chosing potato chip production is, that is has allready found some market accertance in India and particularely in the larger cities and not least in New Delhi. With dependable well organized cold storage and conditioning facilities (conditioning serves to bring the reducing sugars created during the cold storage period down, so the chips do not come out very dark brown) this activity can be carried out throughout the year, i.e. three shifts 250 days a year. This will make it possible to provide year round employment for most of the workers in the integrated potato processing venture. Potato chip manufacture can be carried out at different levels of sophistication and automation. Here it will be recommended to use a technology, that employes the optimum number of workers but still maintains the highest degree of sanitation, i.e. the product enters the packages with minimum handling by the workers.

A Starch Production from Potatoes

Starch is found in potatoes as intercellular granules. The content of starch in potatoes increases with maturity of the potatoes and varies between 12 and 18 percent in mature potatoes. In northern Europe the starch content in the type of (industrial) potatoes grown for starch production averages to about 17 percent. Manufacturing of potato starch is carried out by cleaning and crushing the potatoes followed by refining of the starch and drying it to about 20 percent moisture content.

Figure I and II shows a potato starch production flow sheet and illustrates a modern potato starch factory respectively. Present potato starch production is mainly carried out in modern factories using continuous flow methods. A brief description of modern potato starch production methods follows.

The potatoes are received in bulk by trucks or tractor trailers, which are weighed in and out. Samples are taken of the potatoes to measure content of impurities and starch, which forms the basis for calculation of how much to pay the grower. Usually the potatoes are dumped into cement lined trenches from where they are flumed into the washer by means of a rapid water flow in the narrow bottom of the trench. This water is mainly recirculated to save on water consumption. A very important part of this initial operation is to separate out stones and other hard items, since these otherwise might damage the crushing equipment. The clean potatoes are then crushed to a fine pulp by various milling procedures. The starch is then separated out by various centrifugal and sieve methods and bleached by means of sulphor dioxide (SO_2). The Sulphor Dioxide may be made by the factory by controlled burning of sulphor or it may be purchased in steel bottles from a manufacturer. The latter is now the most common in the Northern European potato starch plants. The purified starch "milk" is finally dewatered by passing it over a continuous rotating vacuum filter and finally into a dryer which may be a pneumatic hot air dryer with cyclones. Usually the starch is stored in bulk It is sold either bagged or in bulk according to the wish of the buyer.

The pulp produced is usually passed through a continuous screw press conveyor and delivered into a silo at 8 to 10 percent solids content. The potato growers usually takes this back for cattle feed .

The fruit water from the pulping and cleaning operations of the potato starch is usually passed out on leaching beds to dispose of the highly poluting contents of the fruit water without poluting streams or ground water. There are expensive ways of separating out proteins from the fruit water, but this will not be recommended for the initial operation of this potato processing plant, but may be added later if needed. It must, however, be stressed that the fruit water under no circumstances must be passed out into streams or rivers since it will adversely affect the biological life in the water through uptake of oxygen and general polution of the water.

The type of potato starch plant recommended in this report has the essential functions described above, but emphasis is given to use of machinery which is less sensitive and easy to maintain and repair. The process is such, that it can be stopped and restarted without major loss of product and product quality. Also a major portion of the equipment such as boiler, storage tanks and sheet metal work can be done in India by Indians. It is, however felt, that it is essential to establish this plant under a turn key contract, i.e. the factory is guaranteed to function normally when installed by the contractor. This involves that the contractor provides an engineer for about one month to assist in the start-up of the plant, the cost of which is incalculated in the contract.

A detailed description of the recommended plant, its requirements and costs follows.

FIGURE II MODERN STAPCH PRODUCTION FROM POTATOES

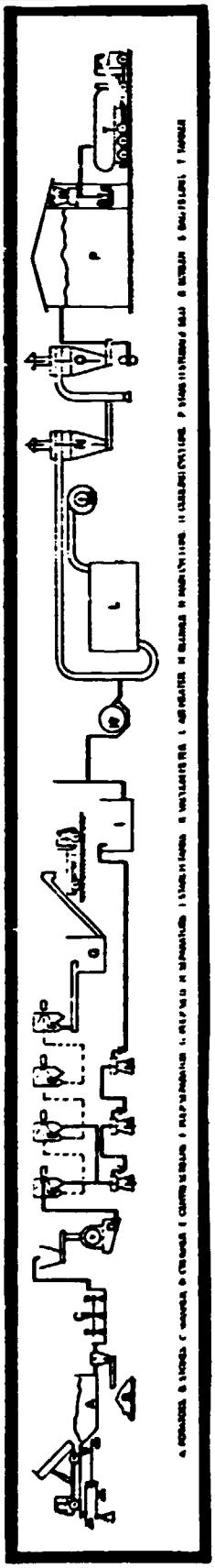
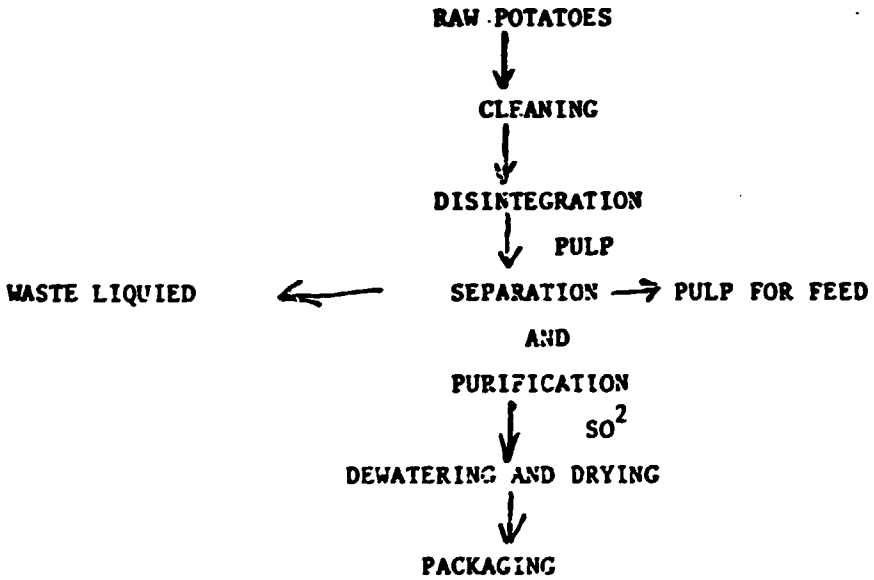


FIGURE I

POTATO STARCH PRODUCTION

FLOW SHEET



4.1 Plant Capacity

In choosing the plant capacity consideration is given to the fact, that India so far has had little experience with potato processing as a whole and non with potato starch production using modern methods. Thus it has been decided to make the initial capacity of the potato starch plant rather small and use it as a training centre for potato processing technicians and management aside from being a commercial plant. This plant is also intended to be part of a multi potato product manufacturing plant with initial starch and alcohol production but possibilities to extend into the manufacture of other potato products such as potato chips, frozen french fries, whole potato flour, etc.. This will allow time to more closely investigate the market for such products in order better to secure the economic feasibility of the venture. The apparent large volume of culls suitable for starch and ethyl alcohol production, which in the Farukhabad District alone is estimated to be between 150 and 200,000 tons per season (approximately 15 to 20 percent of the roughly one million ton per anno potato crop) makes these productions favorable providing an economic source of potatoes.

The recommended plant capacity is 50 tons of raw potatoes per day of 3 eight hour shifts or about 2 tons per hour with an estimated 100 day processing season or 5000 tons of potatoes per season. In Northern Europe the average yield of starch is about 16% which results in a yield of finished starch containing 20 percent moisture of about 20 percent. However, based on information collected in India during the expert's mission in May/June/86 it is estimated, the yield of finished potato starch will be less and this yield is estimated as 16 percent or 900 tons per season. Allthough work has been and is being carried out to develop potato varieties with higher solids and starch content, production of industrial potatoes is not yet common in India, but the growers are open and interested in this to create new outlets for potatoes.

In Denmark the potato starch plants have a capacity between 15 and 40 tons per hour. The capacity of the recommended plant can readely be expanded as the need may occur as it has taken place at the Danish plants through the years.

A.2 Equipment and Buildings

According to his terms of reference, the UNIDO expert consulted various food processing machinery manufacturers to obtain price estimates for the desired processing capacity initially for production of starch and ethyl alcohol from potatoes. He has among others obtained very detailed technical and cost estimates on ethyl alcohol and starch production from potatoes with capacities, which fall within a reasonable initial size. This STAPCOSA turn-key proposal will be presented in the following. The actual potato starch plant layout is shown in Figure III . The cost estimates are presented by processing sections indicated in Table 1.

Table 1 Estimated Cost of a Turn-key Installation of a Potato Starch Plant Processing 50 tons of Potatoes/24 Hrs. Source: STARCOSA A/G, Braunschweig, West Germany, Oct. 30, 1986 •

Location*	No.	Description	Material	Inst. KW.	Kg.	Delivered Price, f.o.b. Hamborg, DM
A,1	1	Pump	Fe	22	300	23,000
A,2	1	Washer	"	5	1000	33,100
A,3	1	Screw Conveyor	"	1.5	300	10,400
A,4	1	Stone Trap	"	5	1000	42,000
A,5	1	Tank 5 m^3	"	-	1500	17,000
Total Section A, Potato Washing				33.5	4100	125,500
B,1	1	Variable Feed	"	2.2	460	12,200
B,2	1	Potato mill	"	15	1200	116,000
	1	Spare Drum				-
	5000	Spare Blades				-
B,3	1	Pulp Silo	Cement	-	-	-
B,4	1	Centrifuge	SS	2.2	200	10,800
B,5	1	Separator	SS	7.5	560	77,800
B,6	1	Chute 0.5 m^3	SS	-	150	7,200
B,7	1	Mono Pump	SS	3	160	11,500
B,8	1	Mono Pump	SS	4	170	13,300
B,9	1	Separator	SS	7.5	560	77,800
B,10	1	Chute 0.5 m^3	SS	-	150	7,200
B,11	1	Mono Pump	SS	3	160	11,500
B,12	1	Mono Pump	SS	4	170	13,700
B,13	1	Separator	SS	7.5	560	77,800
B,14	1	Mono Pump	SS	4	170	13,300
Total Section B, Milling, and Separation and purification				59.9	5410	449,700
C,1	1	*Silo+Agitator	SS	1.5	430	22,600
C,2	1	Mono Pump	SS	4	170	13,300
C,3	1	Separator	SS	30	4800	252,000
C,4	1	Mono Pump	SS	4	150	13,300
C,5	1	Sieve	SS	0.5	170	25,200
C,6	1	Mono Pump	SS	3	160	11,500
C,7	1	Mono Pump	SS	4	170	13,300
C,8	1	*Silo+Agitator	SS	1.5	430	22,600
C,9	1	Mono Pump	SS	4	170	13,300
C,10	1	H_2O Cyclones	SS	13.5	1500	93,600
C,11	1	*Silo+Agitator	SS	1.5	430	22,600
C,12	1	Mono Pump	SS	2.2	150	8,400
C,13	1	Sieve	SS	0.5	170	25,200
C,14	1	Mono Pump	SS	3	160	11,500
C,15	1	Mono Pump	SS	4	170	13,300
Total Section C, Starch Purification * 8 m^3				77.2	9250	561,700
D,1	1	Vacuum Filter	SS	2.6	1500	137,500
D,2	1	Conveyor	SS	1.1	300	15,100
Total, Section D Filtering				3.7	1800	152,600
E,1	1	Dehydrator	SS	19.8	6000	312,500
E,2	1	Conveyor	SS	1.1	300	10,400
E,3	1	Sieve	Fe	1.5	160	21,600
E,4	1	Elevator	"	1.1	600	14,100
E,5	1	Silo, 10 m^3	"	2.2	900	51,800
E,6	1	Conveyor	"	1.1	300	10,400
E,7	1	Scales	"	-	240	10,500
E,8	1	Sewing Machine		-	10	8,200
Starch Drying and Sifting				26.8	8510	439,500
F,1	1	Waterpump		-	30	8,900
SO_2 Addition to the starch slurry						
G,1	1	Conveyor	Fe	1.1	300	12,000
Pulp transport system in plant						
H,1		Quality Control Sett-up			500	103,700
H,2		Pipes and Fittings			4800	138,200
H,3		Drains			720	25,900
H,4		El. and Light			10000	365,800
H,5		Foundations			5000	36,000
H,6		Isolation Materials			2400	17,300
H,7		Spareparts, 2 years			2500	108,400
Miscellaneous					25920	795,300

* The location here corresponds to those on Figure III

Summation:

Section	Inst. KW.	Kg.	D.Mark Delivered f.o.b.Hamborg
A Washing	33.5	4.100	125,500
B Milling+Refining	59.9	5.410	449,700
C Starch Milk Refining.	77.2	9.250	561,700
D Starch Milk Concentration	3.7	1.800	152,600
E Starch Drying and Sifting	26.8	8.510	439,500
F SO_2 Addition	-	30	8,900
G Pulp Handling	1.1	300	12,000
F. Miscellaneous		25.920	795,300
Total Starcosa	202.2	55.320	2.545,200 DM

Equipment Purchased in India

1 Steam Generator, 650,000Rs.	180,000
1 Stand-by Diesel Bi-Generator, Rs.780,000	120,000
Total Machinery and Equipment	DM.765,200
Freight Hamburg-Bombay	100,000
Freight Bombay-Farukhabad	20,000
Total Freight	120,000
Processing area 40x20=800=m^2 each Rs.1600=Rs.1,280,000	196,923
Storage area 15x25=375 m^2 each Rs.1400=Rs.525,000	80,769
Total Processing and Storage bldg.	277,692
Total Machinery, Equipment, Freight and Buildings	3,162,892

Montage (Installation Costs)

1 Engineer 3 man months each 25 work days = 75 work days each DM DM650	48,750
5 local assistants 3 man months each 25 work days (5x3x25=375) each Rs20=375x20=Rs7500 each DM6.5	1.154
Daily allowance for expatriate Engineer DM66 per day for 92 days	6,072
Travel in India for above Rs.1000/week=Rs12,000 (=Farukhabad-Delhi weekly)	1,846
Food + Lodging for above for 92 days each Rs500=Rs.46,000	7,077
Air ticket, business class, Hannover-Frkt.-New Delhi +return	4,272
Total Montage Cost	69,121

Commissioning Cost

1 Engineer one man month of 25 work days each 12 hrs., cost per day DM760	19,000
Daily allowance for 31 days each DM66	2,046
Food+Lodging Farukhabad 31 days each Rs500	15,000
Local Travel (4 x Farukhabad to New Delhi and return each Rs.1000=Rs.4000	615
Total Commissioning Cost	36,661

Land and Site Development

5 acres each Rs.80,00 =Rs4 lakhs or Rs.400,000 at DM6.5/Rs.	61,538
Site Development 2 lakhs	30,769
Total Land + Site Development	92,307

Total Cost of Montage, Commissioning, Land and Site Development 198,089

A.3 Estimated Management Requirements

Allthough listed under potato starch production these costs will be shared by all three production departments (potato starch, alcohol and chips) equally. This in order to economize on the comparative expensive management costs and make better use of the rather scarce availability of management talent.

Also transport costs will be listed together with management costs, since they are to a great extent utilized in connection with the common management.

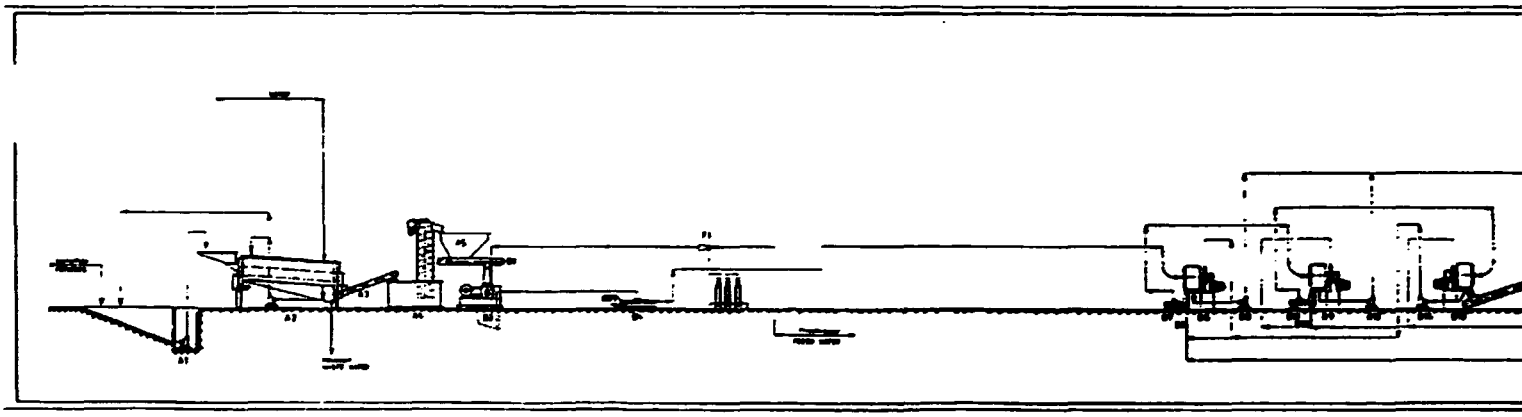
Estimated management and associated costs are listed in Table 2 . These and labor costs were collected by the expert during his mission to India during June-July, 1986. Farukhabad, the recommended area for the plant location is a very rural area, so there will be a great need to have own transport available for the management plus material transports, for which reason it is included here. It is listed on an annual cost basis.

A.4 Estimated Labour Requirements for Potato Starch Production

Estimated labour requirements are listed in Table 3

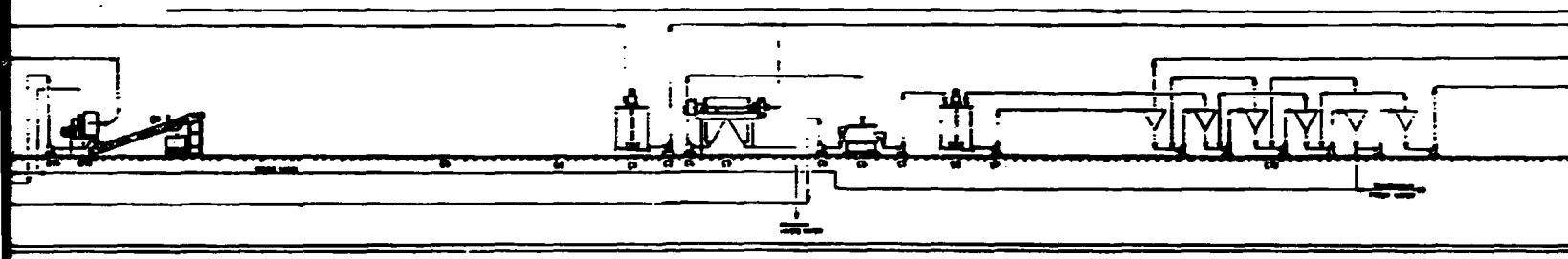
A.5 Estimated Raw Material and other Supply Needs.

In estimating the cost of cull potatoes delivered to the plant it is considered, that cull potatoes generally are considered of far less value than graded, high quality table potatoes and commonly are sold to processing plants for production of such as alcohol or starch in Northern Europe and U.S.A. for a minimal price. It is beneficial to remove these cull potatoes in a preliminary grading before placing the potatoes in cold storage to save the storage cost. Other uses for this inferior grade of potatoes have been as feed for pigs by steaming them, but this is hardly a very promising outlet in India where the majority of the population are vegetarians and pork is far from popular. Normally potatoes for processing are delivered on a contractual basis between the growers and the processor at



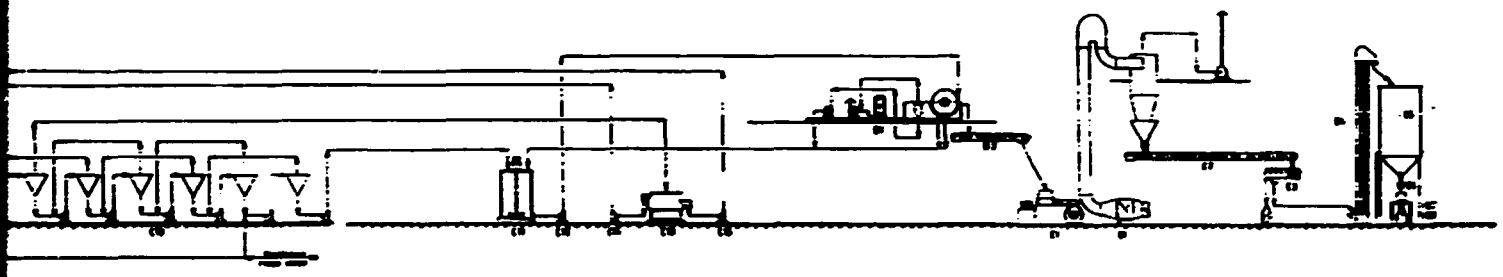
SECTION 1

FIGURE III - POTATO STARCH PLANT LAYOUT



SECTION 2

NT LAYOUT



SECTION 3

an agreed price. Also the type of industrial potatoes grown by the growers is aggreed between the growers and the processor. This concept is new to the Farukhabad District potato growers, but when questioned, they expressed interest in such arrangements during a meeting of growers, interested parties and the expert arranged during his field trip to Farukhabad in July 1986.
Whether the potato starch shall be handled in bulk, as is the case in the Northern potato starch producing factories, is not completely clear yet. A storage building is provided, but the initial volume of product is not large enough to warrent the highly modern silo storage as is shown in Appendix I +II. It also necessitates bulk carriers, which the expert is not sure, India can provide at present. In the meantime the potato starch could be packed into polythene bags or kraft paper laminates with high moisture barrier and tear resistance. Rodent control must be focused on in this connection.
It is considered that the supply of sulphor dioxide must be supplied by the plant itself, since the supply of SO_2 (sulphor dioxide gas in steel cylinders)may not be available or in case it is, it may be too expensive. Here it is calculated, that SO_2 is supplied by burning suitable grade sulphor, which is provided for in machinery cost calculation also.

Table 2 Estimated Management and Office Staff Costs, Rs.

Category	Number	Shifts per Day	Months per Year	Man Months per Year	Cost per Man Month	Cost per Year
Manager	1	1	12	12	3000	36,000
Assistant Manager	1	1	12	12	2000	24,000
Chief Accountant	1	1	12	12	1600	19,200
Assistant "	2	1	12	24	1200	28,800
Clerks	2	1	12	24	1000	24,000
Quality Control, Chief	1	1	12	12	1600	19,200
" ", Assistant	1	3	12	36	1200	43,200
Chief Weigher	1	1	12	12	1000	12,000
Assistant "	1	1	12	12	800	9,600
Storage Controller	1	1	12	12	1000	12,000
Driver	2	1	12	24	600	14,400
Messengers	2	1	12	24	600	14,400
Watchmen	1	3	12	36	600	21,600
Cleaners	2	1	12	24	600	14,400
						292,800
Transportation Cost; Annual Basis						
2 Automobiles, each Rs.60,000						120,000
1 Pick Up, Rs.40,000						40,000
					Total Transportation	160,000
Total Management and Office Staff Costs						Rs.452,800 = DM.69,662*

* This total cost covers the cost for the three integrated potato processing ventures

Table 3 Estimated Labour Requirements for Potato Starch Production

Category	Number	Shifts per Day	Months per Year	Man Months per Year	Cost per Man Month	Cost per Year
Foreman	1	3	12	36	1000	36,000
Potato Receiving	3	3	4	36	600	21,600
Machine Operators	4	3	4	48	800	38,400
Bagging	2	3	4	36	600	21,600
Storage Workers	3	3	4	36	600	21,600
Stokers	1	3	12	36	800	28,800
Sweepers	2	3	4	24	600	14,400
Sweepers	2	3	12	36	600	21,600
Total						Rs.204,000 = DM.31,380

A.6 Operating Costs

A.6.1 Raw Materials

The potatoes will be procured from the local, mostly small scale growers and for the potato starch production initially only cull potatoes will be used. Cull potatoes are potatoes of odd shape and with various superficial bruices and cuts but otherwise healthy flesh. It is estimated, that the potatoes grown in the Farukhabad district contain approximately 20% culls which at the present potato production of approximately one million tons annually amount to roughly two hundred thousand tons. It is generally considered desirable to sort the cull potatoes out after harvest and before the potoes enter storage to upgrade the potatoes and to save the cost of storing these enferior quality potatoes. Cull potatoes are generally processed into starch and/or alcohol, since in these productions the appearance of the potatoes does not matter as long as the flesh is reasonably sound. This is practiced in countries such as U.S.A. and Denmark. The cull potatoes only command a modest price on the market and the expert is proposing a price of Rs.200/ton as reasonable for the grower as well as the processor.

It is envisaged, that there through the present effort of introducing new potato varieties more suitable for processing gradually will be such high yielding, high solids potatoes available for processing. It would be desirable if the growers entered into firm contracts with the processors, price as well as quantity wise to more securely establish potato processing. The processors often times supply some of the grower inputs such as seed potatoes, fertilizer and spraying materials on a credit basis to be paid through the potato deliveries.

Sulphor is needed in the process as sulphor dioxide to bleach the starch and the amount and cost is according to information from the equipment supplier.
Due to the initial small volume production is is considered, that the factory initially must store and market the finished potato starch in polythene bags as indicated in Table 4 . The cost of these and their size has been obtained from a producer of such materials.

A.6.2 Estimated Cost of Utilities

These are shown in Table 5. They are based on information given from the equipment manufacturer about quantities needed and the cost prices were collected by the expert during his visit to India May-June/1986.
It is recommended using coal rather than fuel oil because coal are much cheaper per BTHU in India than fuel oil.

A.6.3 Estimated Management Costs

These are shown in Table 2. They are calculated according to information collected by the expert during his mission to India May-June/1986.

A.6.4 Estimated Labour Costs

These are shown in Table 3. They are likewise calculated according to information collected during the expert's mission to India May-June/1986.

A.6.5 Estimated Property and Inventory Insurance

These are shown in Table 6. The cost of this insurance is according to the expert's information from India

A.6.6 Summary of Estimated Annual Operation and Administration Costs

These costs are given in Table 7.

A.6.7 Estimated Working Capital Requirements

Estimated working capital requirements are calculated according to the expert's previous experience with various projects doing projected profitability and cash flow calculations. Table 9.

A.6.8 Estimated Sales Revenue

This is shown in Table 8.

Table 4 Estimated Raw Material and other Needs

Cull Potatoes, 5000 tons each Rs.200	.000,000
Sulphur 0.2 kg/ton potatoes=1000 kg. each DM.1.2 = DM.1,200	7,800
20,000 polythene bags (600x1100 mm, 150 my thick), each Rs.2.80	55,900
Total	Rs.1,063,700 = DM.163,646

Table 5 Estimated Cost of Utilities

Coal 300 tons each Rs.910	273,000
Electricity 484,800 KW each Rs.1.00	484,800
Total	Rs.757,800 = DM.116,585

Table 6 Estimated Property and Inventory Insurance

Property Values	
Equipment	2,951,200
Buildings	277,690
Inventory	
Coal, 10% of Annual	27,300
Packing Materials, 50% of Annual	27,950
Finished Product, 50% of Annual (710,526DM)	355,263
Total	3,638,403
Insurance, 0.125%	DM.4,549

Table 7 Summary of Estimated Annual Operation and Administration Costs in DM..

Raw Materials	163,646
Utilities	
Coal	42,000
Electricity	74,585
Property and Inventory Insurance	4,549
Management	23,221
Labour	31,380
Depreciation	
Buildings, 4% of 277,692	11,108
Equipment, 10% of 2,951,230	295,123
Maintenance of Equipment, 4%	118,049
Total	DM.763,661

Table 8 Estimated Sales Revenue

900 Tons Starch, each D.Kr. 3000 a.b. Factory (Source Danish Central Potato Starch Organization),
900 x 3000 = 2,700,000= DKr.2,700,000/ 3.8 DM.710,526

Table 9 Estimated Working Capital Requirements

Payroll (10% of Annual Cost of 54,601)	5,460
Raw Materials (50% of Annual Cost)	81,823
Finished Stock(50% of Annual Cost)	355,263
Utilities (50% of Cost)	58,293
Total	500,839

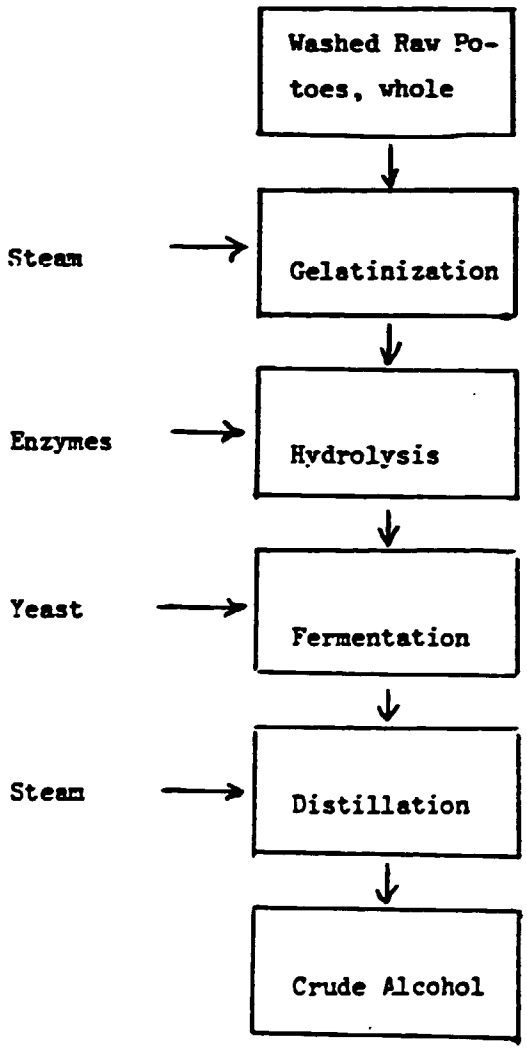
It is obvious, that it would be desirable to operate this plant longer than the stipulated 100 days of three shift. It is possible that there will be supply of cull potatoes for a longer period, provided potatoes taken out of cold storage are properly graded.

B Ethyl Alcohol Production from Potatoes

Production of ethyl alcohol (C_2H_5OH) from potatoes essentially is done by methods very much similar to those used for other starch containing plant materials such as grains, cassava and sugar beets. It is a well established industry and traditional in Northern Europe. Here ethyl alcohol have a traditional use in production of alcoholic beverages such as vodka and snaps containing 40 to 50 percent alcohol by volume. The essential parts of the process is to gelatinize the starch by cooking, brake the gelatinized starch down into fermentable sugars through enzymatic reactions and convert the fermentable sugars (mostly glucose) into ethyl alcohol, distill the ehyl alcohol off and purify the crude alcohol through further distillation to take out socalled "fusel oil" i.e. non ethyl alcohol components. This is called "fine alcohol" and contains about 4 percent water. This can further be dehydrated to produce socalled "absolute alcohol" or 100 percent ethyl alchol. Absolute alcohol is among others suitable as a fuel in cars or an additive to unleaded gasoline to increase the octane (making high test) and also serves as an anti knock ingredient in gasoline. With the increased polution awareness ethyl alcohol as admix to unleaded gasolines plays an increasing important role. Thus the processing technology is varied according to the end use of the ethyl alcohol. It should be pointed out, that ethyl alcohol is by no means only important in the alcoholic beverage industry but is of the greatest importance in medicine and industry. as an antiseptic, solvent, fuel.etc.. The basic flow sheet for ethyl alcohol production from potatoes is shown in Figure IV.

The present industrial methods for ethyl alcohol production from starch containing plant materials including potatoes vary from more basic, batch type processes to highly sophisticated, automated, continuous processes. The capital investment increases greatly with the degree of sophistication of the process. There is also great variation in the degree of refining of the

Figure IV Flow Sheet for Ethyl Alcohol Production from Potatoes



crude alcohol from the initial distillation process from the yeast fermentation process. This will depend on the intended end use of the ethyl alcohol.

The type of process recommended in this report is the batch process, often referred to as the "German Batch Process", because it obtained wide use in Germany. The intended end product is "fine alcohol", highly purified ethyl alcohol with about 4 percent water. This type of process can readily be expanded for greater volume of production and the technology can also be upgraded if desired. It is common for such plants to undergo gradual expansion and sophistification with increased familiarity with the process.

The advantage of producing ethyl alcohol from potatoes is, that secondary quality, but otherwise sound potatoes, having odd shapes and cracks, deep eyes and irregular surface, are perfectly suitable, since it is only the starch content, which is of interest and the whole potato enters the process. This is thus an excellent outlet for cull potatoes from the initial, before storage and final grading operation cull potatoes, which normally only commands a very small price. Removing the culls before marketing and thus upgrading their appearance will usually tend to increase their market price and consumer appeal. For Farukhabad and Uttar Pradesh State as a whole this poses as a highly desirable procedure to introduce in a concerted potato marketing effort. This could be combined with marketing of the graded potatoes in small net or other bags such as 1 kg., 2 kg. and 5 kg. net for the consumer market in the big cities.

On a longer range, one may introduce growing of particularely suited, high starch content, industrial potatoes as used in Northern Europe for potato starch and alcohol production.

The ulteriorpurpose for introduction of potato processing in the Farukhabad district and Uttar Pradesh State as a whole is to secure an outlet for the potatoes produced and thus an income for the growers, who are in great need of increased cash income.

B.1 Plant Capacity

The chosen plant capacity is rather small, namely for the production of about 2,500 liter of fine alcohol per eight hour shift. Normally potatoes contain between 15 and 20 percent starch, when mature. One kg starch yields about 0.65 liter alcohol and considering the potatoes grown in Uttar Pradesh, Farukhabad district are not developed specifically for high starch content but for eating potatoes it is estimated the starch content will be quite low namely about 16 percent as is common for normal eating potatoes (cooking not baking potatoes). Thus it is estimated the yield of fine alcohol will be approximately 100 liter per ton of raw potatoes. This means approximately 25 tons raw potatoes/8 hour or 75 tons per day of three shifts or for a 100 work day season 7,500 tons. The type of plant recommended can, however, utilize other starch containing plant materials such as grains and could thus work throughout the year or about 250 work days of three shifts. It can also readily be expanded if desired.

Furthermore it may serve as an outlet for sound waste potato flesh from other potato processing such as production of potato chips, frozen french fries, whole potato flour, and instant dried potato, etc.. These productions can take place throughout the year, provided dependable cold storage and conditioning storage is available. As a matter of fact this alcohol plant may be highly useful as an outlet for fermentable waste liquids from other potato processes within the complex. The solids left after the alcohol fermentation and alcohol distillation is highly valuable as animal feed and is as such a source of income for the alcohol plants.

Figure V shows the proposed plant layout.

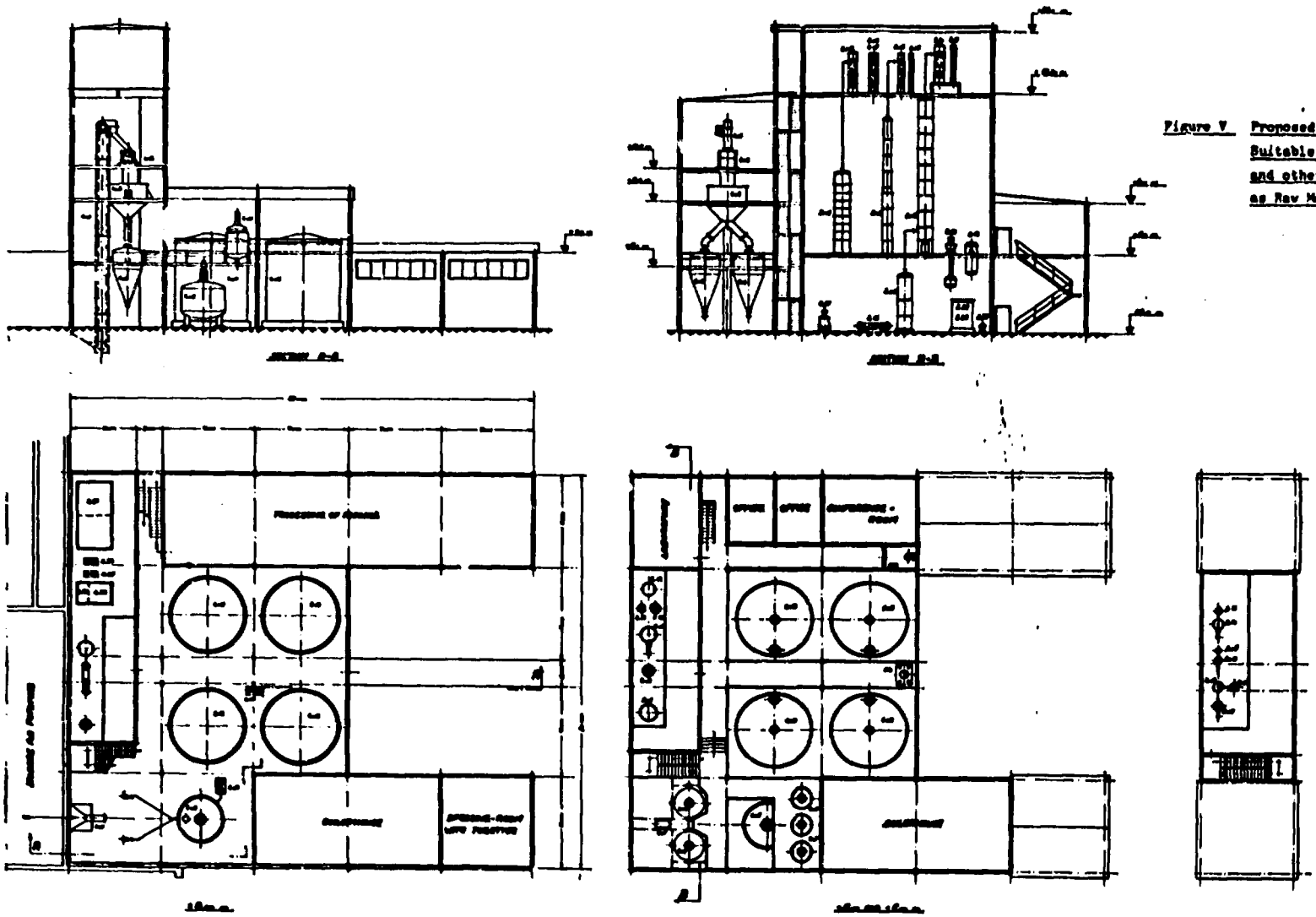


Figure V Proposed Ethanol Plant Layout Suitable for Use of Potatoes and other Starchy Plant Materials as Raw Material.

3.2 Equipment and Buildings

According to his terms of reference the UNIDO expert consulted various food processing machinery manufactures experienced in production of ethyl alcohol from potatoes and other starch containing plant materials. He obtained technical and cost estimates from A/B Alfa Laval, Tomba near Stockholm, Sweden and STAPCOSA, Braunschweig, W. Germany. While Alfa Laval is mainly working with the continuous process, STAPCOSA presented a conventional small scale, batch type(socalled "German Batch Process") proposal, which the expert feels is very appropriate for the situation delt with in this report. The operation of this type of plant is less critical than for a plant using the continuous process. It is easy to expand its capacity and streamline the process if desired. The recommended end product is fine alcohol, containing 4 percent water, but it can be modified to produce 100 percent absolute alcohol suitable for addition to lead free gasoline fuel to increase the octane rating and act as an anti knock agent. With the increased polution concern it is becoming common practice to substitute the lead based anti knock agent with absolute ethyl alcohol using about 10 percent by volume.

The proposed plant can also utilize other starch containing materials such as grain and cassava as a raw material for its ethyl alcohol production. It is thus possible to prolong its processing season to all year processing and thus help make the project more profitable. Various Indian officials pointed out, that there is a preference for using potato based ethyl alcohol as carrier for essential oils in the perfume industry of which there is a great deal in the Farukhabad District of Uttar Pradesh Province. They claim it contains less skin irritants than ethyl alcohol based on other raw materials. There is also a plan to produce Vodka from the potato based ethyl alcohol for which it is claimed to be particularely suitable. The estimated cost of the proposed turn-key plant is shown in Table 10.

Table 10 Estimated Cost for a Turn-key Installation of a Ethyl Alcohol Plant based on Potatoes with a Capacity of about 75 Tons/24 Hrs. producing about 7,500 Liters Ethyl Alcohol per 24 Hours. (Source STARCOSA, Braunschweig)

Item	Number	Decription	Material	Inst. KW.	Delivered Price f.o.b. Hamburg, DM
1	1	Potato Washing Section	Fe	33.5	125,000
2	2	Pressure Cookers	Fe	-	136,000
3	1	Fermenter (15 m^3) with Cooling (40 m^2) + agitator	SS	7.5	130,000
4	1	Mono-Pump 2-8 m^3, variable speed	SS	2.2	10,000
5	1	Still for production of crude ethyl alcohol consisting of;			124,000
		Mash Column	SS		
		Condenser	SS		
		Cooler	SS		
		Pipes, etc..	SS		
6	1	Mono Pump 3-6 m^3, variable speed	SS	2.8	8,000
7	1	Still for production of Fine Alcohol (100% pure alcohol) consisting of;			419,000
		Column	SS		
		Condenser	SS		
		Cooler	SS		
		Pipes, etc.	SS		
8	1	Circulation pump	SS	3.3	12,900
9		Control and testing equipment, pipes			90,000
1		Steam Boiler, Rs.800,000 (per 8Hour 20t(8 bar) steam)	Fe		123,077
10		Drawings for tanks to be made in India;			
	3	40 m^3 tanks each Rs260,000=Rs.780,000	Fe		120,000
	1	Yeast container with agitator, 4 m^3 Rs 227,500.	SS	2.2	35,000
	1	12 m^3 tank with 4 departments, Rs.260,000	Fe		40,000
Sub Total				51.5	1,373,077
		Freight Hamburg - Bombay			50,000
		Freight Bombay - Farukbabad			10,000
		Montage and Commissioning			66,000
					1,499,077
		10 percent Contingenses			149,908
		Total Equipment			1,648,985
		Buildings. 30 x 35 = 1,050 m^2 each Rs.1,600 = Rs.1.680.000			DM.--258.462

B.3 Estimated Management Requirements

The three potato processing operations are under common management and the cost is divided evenly among them and shown in Table 2.

B.4 Estimated Labour Requirements are shown in Table 11. Alcohol production is not very labour intensive, but it needs skilled personnel to operate the equipment and not least the distilling equipment, which is quite sensitive. Also the fermentation processes must be observed closely to obtain the optimum yield of alcohol.

B.5 Estimated Raw Material and other Needs

Table12 shows the estimated raw material and other needs. The amount of cull potatoes needed is calculated from their estimated starch content of 16 percent and assuming, as is common, that 1 kg starch produces about 0.65 liter ethyl alcohol or roughly 100 liter per ton of potatoes.

The amount of enzyme solution used is based on information from STARCOSA in Braunschweig and NOVO near Copenhagen, Denmark.

In calculating amount of yeast to purchase it is assumed, the plant will be able to produce most of its needs from the initial purchased yeast and only occasionally will need new supplies to assure the yeast "milk" remains reasonably pure without foreign infection. The plans provide for a a vessel to grow the yeast in.

There will be a need of purchasing cleaning agents and this has not been estimated here, but will not be a very costly item.

B.6 Operating Costs

B.6.1 Raw Materials

The potato procurement will be undertaken the same way, as it is done for the starch production using mostly or exclusively cull potatoes. It can naturally also take in regular surplus potatoes, if there should be a need to find outlet for surplus potatoes. It could also use other starch containing materials such as grains and cassava if they should be available at a sufficiently low price. It will be a great advantage to have the alchol plant operating year round.

Enzyme solutions must be procured from outside India and the ones mentioned in this report are procured from Denmark from NOVO Industries, near Copenhagen. It would also be possible to use malt made from sprouted Barley, but this is more involved than using the ready made enzyme solutions and the enzymes in malt are also said to be more sensitive to processing conditions, i.e. temperature and pH (acidity). There is, however, a very high, 120 percent duty on these enzyme solutions, which does render them quite expensive. Yeast is manufactured in India and is readily available.

There may be a need to use sulphoric acid in small amounts to adjust the acidity (pH). Also various types of cleaning agents will be needed. According to the machine manufacturer, the cost of these materials will only be very small and they have thus not been listed in the table showing estimated cost of raw materials, Table 12.

Table 11 Estimated Labour Requirements for Ethyl Alcohol Production

Category	Number	Shifts per Day	Months per Year	Man Months per Year	Cost per Man Month	Cost per Year
Foreman	1	3	12	36	1000	36,000
Potato Receiving	3	3	4	36	600	21,600
Equipment Operators	4	3	4	48	800	38,400
Storage Workers	2	3	4	24	600	14,400
Storage Worker	1	1	12	12	600	7,200
Stoker	1	3	4	12	600	7,200
Sweeper	2	3	4	24	600	14,400
Sweeper	1	3	12	36	600	21,600
Total						Rs.160,800 = DM.25,524*

* 1 DM = Rs.6.5

Table12 Estimated Raw Materials and other Needs

		DM
Cull Potatoes, 7,500 tons each Rs.200 = Rs.1,500,000		230,769
Enzyme Solutions assuming 1,200 tons starch/anno		
AMC=0.87 L/ton starch=0.87 x 1200=1,044 L,		
DKr.66/L c.i.f. Farukhabad=1,044x66= DKr.68,904		
Termamyl 0.36 kg/ton starch=0.36x1200=432 kg		
c.i.f. Farukhabad DKr.52/Kg.=52x432= DKr.22,464		
Sub Total	DKr.91,368	
+ 120% import duty	" 109,642	
Total	DKr.201,010	52,897
Yeast Make-Up,six tons/anno each DM.1,316		7,895
Total		DM.291,561

Table 13 Estimated Cost of Utilities

Coal 900 tons each Rs.910=Rs.819,000	126,000
Electricity 123,600 each Rs.1/KW=Rs.123,600	19,015
Total	145,015

Table 14 Estimated Property and Inventory Insurance

Property Values		
Equipment		1,513,600
Buildings		258,462
Inventory		
Coal, 10% of annual		12,600
Finished product, 50% of annual		288,462
Enzyme Solutions, 50% of annual		26,446
Total		2,099,572
Insurance, 0.125 percent =		2,624

Table 15 Summary of Estimated Annual Operation and Administration Costs in DM.

Raw Materials	291,561
Utilities	
Coal	126,000
Electricity	19,015
Management	23,221
Labour	25,524
Insurance	2,624
Depreciation	
Buildings, 4% of 258,462	10,338
Equipment, 10% of 1,648,985	164,899
Maintenance of Equipment, 4%	65,959
Total	DM.729,141

B.6.2 Estimated Cost of Utilities

These are shown in Table 13. They are based on information given by the equipment manufacturer. This process does require a considerable amount of fuel most of which is spent in the distillation processes. Also large quantities of water is needed and not least for cooling. It is estimated 250 m^3 water at 20°C is needed per 8 hour shift. It is not anticipated, there will be any problem providing this amount of water, probably from own bore hole. The FarukKabad area has several rivers with the Ganges river being the largest. The cost of water pump(s) is considered covered under the 10 percent contingencies.

B.6.3 Estimated Management Costs

These are shown in table 2. One third of this cost is attributed to the alcohol production unit.

B.6.4 Estimated Labour Cost

This is shown in Table 11. To operate a distillery is not very labour intensive as shown in this table.

B.6.5 Estimated Property and Inventory Insurance

These are shown in Table 14.

B.6.6 Summary of Estimated Annual Operation and Administration Cost

These are shown in Table 15 for 100 days of plant operation.

B.6.7 Estimated Working Capital Requirements

These are shown in Table 17

B.6.8 Estimated Sales Revenues (Table 16)

In estimating sales revenues it is kept in mind, that there is a particular desire to produce alcohol from potatoes, because it is felt it is better suitable in the perfume industry and in production of vodka for export. The a.b. factory price for industrial alcohol was given as Rs.4.65/L. In this report the price for fine alcohol (highly refined)is estimated as Rs.5.00/L a.b. factory.
It is, however, apparent, that this production cannot be economically viable only operating 100 days per year, but should operate close to a complete working year. The 100 days were suggested, because it would not be required to operate a cold storage in conjunction with the alcohol and starch production, since the potatoes can be kept without this for this period after harvest in Nov.-Dec.. Additional culls can however be procured from the cold storages as they take out table potatoes and grade them prior to marketing. There is a great need to improve the grading of the table potatoes and taking out cull potatoes could be part of this scheme. Also the potato chip operation, which will be year round, will produce some culls during the grading of the raw potatoes.
An additional income from the alcohol production is the sale of the mash residue from the distilling operation.It is estimated, that 10 percent of the solids originally in the potatoes will end up in the mash, which will be relatively dry (approximately 30 percent water). It is highly suitable as animal feed and is estimated to have a value, that is half that of barley which at present sells for about US$140/Ton.
In some larger ethyl alcohol factories also the carbon dioxide gas from the fermentation is cleaned and sold bottled under pressure for such as dry ice production, but this plant described here is considered too small for this.

Table 16 Estimated Sales Revenues for 100 Days of Plant Operation

750,000 liter Fine Ethyl Alcohol each Rs.5[xx], 750,000 x 5 = Rs.3,750,000	DM.576,923
Distilled Mash equal to 10% of 7,500 tons Potatoes = 750 tons Dry Matter = Mash with 30% Water = $\frac{750 \times 100}{70}$ = 1,071 Tons each DM.140 (=half the current price of Barley= DM.280/Ton) = 1,071 x 140 = 149,940	DM.149,940
Total	DM.726,863

Table 17 Estimated Working Capital Requirements

Payroll (10% of Annual Cost of 48,745)	DM.24,373
Raw Materials (50% of annual Cost of 291,561)	" 145,781
Finished Stock (50% of Annual Cost of 726,863	" 363,432
Utilities (50% of Annual Cost of 145,015)	" 72,508
Total	DM.606,094

B.7 Operating Costs Operating 200 Days per year

Due to the the uncomfortable little difference between sales revenue and estimated annual operation costs, it is felt essential to operate the ethanol plant at least 200 days per year. The estimated labour cost for year round operation is shown in Table (the labour force will be kept year round although the calculations are only for 200 plant working days, because there will be periods of clean-up and plant break down, which will prolong the period of operation. Other costs are simply doubled. Table 18 shows summery of estimated annual operation costs.

Table 18 Estimated Annual Operation and Administration Costs in DM.

Raw Materials	593,124
Utilities	290,030
Insurance	3,720
Management	23,221
Labour	54,277
Depreciation	
Buildings, 4%	10,338
Equipment, 10%	151,360
Maintenance of Equipment	60,544
Total	DM.1,186,614

B.8 Estimated Sales Revenue for 200 Day Plant Operation

An estimated sales revenue for 200 days is taken from Table 16 by multiplying with 2 and is DM.1,453,726. It must, however, be pointed out, that losses do take place in processing as well as in sales.

Table 19 Estimated Labour Requirements for Ethyl Alcohol Production Plant operating 200 Days per Year.

Category	Number	Shifts per Day	Months per Year	Man Months per Year	Cost per Man Month	Cost per Year
Foreman	1	3	12	36	1000	36,000
Potato Receiving	3	3	12	108	600	64,800
Equipment Operators	4	3	12	144	800	115,200
Storage Workers	2	3	12	72	600	43,200
Storage Worker	1	1	12	12	600	7,200
Stoker	1	3	12	36	600	21,600
Sweeper	2	3	12	72	600	43,200
Sweeper	1	3	12	36	600	21,600
					Total	352,800 = DM.54,277 *

* 1 DM = Ps.6.5

C Potato Chip Production

Potato Chips have gained World wide consumer acceptance and in particular in U.S.A., which is probably the first country to introduce large scale commercial potato chip production. As a matter of fact, it has a special institute for this industrial activity, called "The American Potato Chip Institute", Cincinnati, Ohio.

The concept to produce potato chips probably originated in France, where it gained popularity among the wealthy as a gourmet food item in the 19'th Century.

Essentially, potato chip production is simple, namely cleaning, peeling, slicing and frying the thin slices in oil or fat, This can be done virtually by any house wife in an ordinary kitchen with very simple tools. However, the picture does change dramatically when producing to present day consumer market, where a uniformly light coloured, high quality, crisp potato chip is demanded. This has created the need for development of particularly suitable high solids content, smooth surface, light skinned high yielding potatoes with good flavour characteristics. Modern potato breeding including genetic engineering methods makes this possible and is being practiced at many potato research stations throughout the World. Also cultivation, handling, storage and processing conditions must be well controlled. To secure year round supply of potatoes, they must be stored in cold storage and before processing into potato chips be conditioned for a few weeks at room temperature (18 - 20°C) to metabolize away the reducing sugars developed during the cold storage. Otherwise the potato chips will develop a very dark brown colour, when finished fried, which does not meet with consumer accentance. Some recently introduced potato varieties develop less reducing sugars during cold storage than other varieties. Also the quality of the frying oil is very important, i.e. it must be highly resistent to break down into free fatty acids and turning rancid during storage of the packed potato chips. Addition of anti oxidants does help delaying the degradation of the oil or fat. Vegetable oils, such as soy bean or maize oil is commonly used. Salt and flavour ingredients must be uniform high quality and evenly sprinkled onto the chips.

C.1 Plant Capacity

For the initial production of potato chips only a small scale plant is recommended. This line will have common management with the two other production lines, the ethanol and starch line. It is recommended initially to process 2,500 tons potatoes per year of 250 working days of three eight hour shifts. A yield of 28 to 30 percent of potato chips containing 30 percent oil or fat is common. Thus at 28 percent yield the annual production of potato chips is 700 tons. It is a must, that only high quality, well graded, light coloured, smooth skinned potatoes of a pleasant flavour is used. Otherwise the yield of finished fried potato chips will be far smaller. Also oil or fat absorbtion increases with lower dry matter content, which is undesirable in view of the general fear of intake of large amounts of oil or fat due their high calorie content.The peeling loss from smooth skinned potatoes is also far less than for potatoes with deep eyes. For suitable potatoes the peeling loss using abrasive peeling by such as carborundum coated rollers is between 5 and 10 percent only, since it is not necessary to peel the potatoes very deeply. Small specs of light coloured skin is hardly visible on the roughly one millimeter thick potato chip. The newly introduced Kufri Badshah potato variety from Shimla appears to be suitable for potato chip production when properly graded.

The marketing aspects were looked into by the expert, as much as his short term input permitted. He visited various market places in New Delhi and had lengthy discussions with Ministry of Industry officials in New Delhi. He also discussed the potato snack marketing prospects with officials in the State Government of Uttar Pradesh. He was given a potato project study by the Consultancy Cell, Department of Food, New Delhi the data of which forms part of his assessment and calculations given in this part of his report. He still feels, that it is necessary to establish a distribution contact for instance in New Delhi to secure an efficient and fast marketing of the po-

tato chips, which in the hot and humid Indian climate have a relatively short shelf life, since elevated temperature, high humidy conditions are adverse to high fat content products. It should also be pointed out, that it is necessary to use packing materials with good humidity and air penetration resistance. Poly propylene, as recommended in this report is suitable, but laminates with aluminum foil for larger institution size packages are even better, but very costly. Also the master cartons in which to transport the packed chips from the factory to the market must have high moisture resistance and be tear resistant also,because the chips are very fragile and their consumer acceptance decreases if they are marketed broken into small peaces. The packages must be marked with date of manufacture in order to have effective quality control. The expert did contact a major specialty food producer and marketer during his May/June, 1986 India mission and discussed distribution of specialty foods such as snack foods, but the planned meeting did unfortunately not take place due to the management beeing on leave during the very hot season.

C.2 Equipment and Buildings

There are numerable manufacturers of potato chip production lines also on a turn key basis. Since this production is not common place in India, it will be necessary to import such a production line, which can be done on short notice and might be combined with procurement and turn-key installation of the potato starch and ethanol production plants. The estimated cost is listed in Table 20.

Figure VI shows a potato chip production flow sheet

Table 20 — Estimated Cost for a Turn-key Installation of a Potato Chip Production and Packing Line with a Capacity of ten Tons of Raw Potatoes per Day of three eight Hour Shifts producing 2.8 Tons of Potato Chips per Day or 700 Tons per Year of two hundred and fifty work Days

1	Potato Chip and Packing Line	Dm. 700,000
	Freight W. Europe - Bombay	50,000
	" Bombay - Farukhabad	10,000
1	Steam Boiler, Indian make, Rs. 300,000	46,154
	Sub Total, Machinery	DM.806,154
	Contingencies, 10%	80,615
	Total Machinery	DM.886,769
	Processing Building, 200 m^2, each Rs.1400 = Rs.280,000	DM. 43,077
	Cold Storage 800 m^2 each Rs.2000 = Rs.1,600,000	" 246,154
	Total Buildings	DM.289,231

Table 22 — Estimated Raw Material and other Needs*

Graded Potatoes, 2,500 Tons each Rs.750 =	Rs.1,875,000	
Salt, 3% of 700 Tons=21 Tons each Rs.6000 = 21 x 6000 = 126,000	Rs. 126,000	
Vegetable Oil = 30% of 700 tons = 210Tons plus 20% Waste = 252 Tons, each Rs.5 000	Rs.1,260,000	
Packing Materials		
Polypropylene Bags packing 100 gr. net = 7,700,000 including 10% waste = 4 bags per meter of 14.5 cm wide tube = 1,925,000 meter at Rs.1,500 per 1000 meter = Rs.1,500 x 1,925	Rs.2,887,500	
Cardboard Boxes (about 46x33x25 cm) each for 5 kg net = 140,000 each Rs.7 = 140,000 x 7	Rs. 980,000	
Total	Rs. 7,128,500	= DM.1,096,690

* The price of packing materials and vegetable oil varies greatly with quantity purchased and for packing materials also with the type of print and the colour of the printed material. Also the price of salt depends on the purity and grade. Aside from salt, one may also use other flavour materials to enhance the taste.

FIGURE VI POTATO CHIP PRODUCTION FLOW SHEET

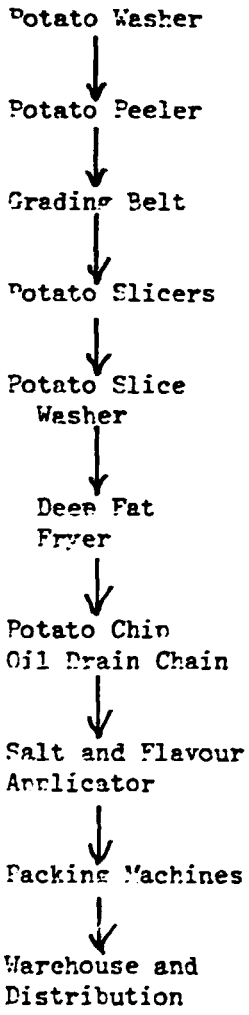


Table 21 Estimated Labour Requirements for Potato Chip Production

Category	Number	Shifts per Day	Months per Year	Man Months per Year	Cost per Man Month	Cost per Year
Foreman	1	3	12	36	1,000	36,000
Potato Receiver	2	3	12	72	600	43,200
Potato Graders	4	3	12	144	600	36,400
Equipment Operators	2	3	12	72	800	57,600
Packing	6	3	12	216	600	129,600
Storage	2	3	12	72	600	43,200
Sweepers	2	3	12	72	600	43,200
Total Labour						Rs.439,200 =
						DM.67,570

C.3 Estimated Management Requirements

The three potato processing operations are under common management and the cost is divided evenly among them and shown in Table 2.

C.4 Estimated Labour Requirements

These are listed in Table 21

C.5 Estimated Raw Material and other Needs

Table 22 shows theestimated raw material and other needs. For this process only high grade potatoes are used. The cost of these materials fluctuate greatly according to market conditions and amounts of material purchased. Card board boxes vary in price according to above and according to the type of print used. The same applies to the platic used for bags for the potato chips. The price for vegetable oil for frying is generally much cheaper, when purchased by the ton in tank cars than when purchased in drums or smaller containers. Prices are usually aggreed on through negotiations according to general produce prices listed on major international markets.

C.6 Operating Costs

C.6.1 Raw Materials

These are shown in Table 22

C.6.2 Estimated Cost for Utilities

These are shown in Table 23

C.6.3 Estimated Cost for Management

This cost is shown in Table 2. One third of this cost is attributed to the potato chip plant.

C.6.4 Estimated Labour Cost

This cost is listed in Table21

C.6.5 Estimated Property and Inventory Insurance

This cost is shown in Table 24

C.6.6 Summary of Estimated Annual Operation and Administration Cost

These are shown in Table 25

C.6.7. Estimated Working Capital Requirements

These are shown in Table 27

C.6.8 Estimated Sales Revenues

In estimating the sales revenues the a.b. factory estimated price per 100 gr. net potato chip bag packed in cartons containing 50 bags each. It will be necessary to explorea manner in which to distribute the potato chips, which possibly might be done through private food product distributers, mostly in the larger cities such as New Delhi, Bombay, etc.. Actually the chips might be marketed in different sizes for different outlets such as larger sizes for the institution trade and smaller for the retail market. 100 gram net is a very popular size in Western Europe including Austria. Here also a 250 gram net bag is commonly marketed in the super markets. There will be a need to feel ones way with this and take a little closer look at the present market before firming up on decisions on what type and size bags to use. The Indian oftentimes very hot and humid climate is adverse to the shelf life of products such as potato chips with their high fat content!

Table 23 Estimated Cost of Utilities

Coal, 400 Tons each Rs.910 = Rs.364,000	DM.56,000
Electricity, 50 KW/hour = 300,000 per year each Rs.1.00 = Rs.300,000	" 46,154
Total	DM.102,154

Table 24 Estimated Property and Inventory Insurance

Property Values	
Equipment	DM.886,769
Buildings	" 289,231
Inventory	
Coal, 10% of Annual	5,600
Packing Materials, 50% of Annual of DM.595,000	" 297,500
Finished Product, 50% of annual with an ab factory price of Rs.3.00 per 100 gram Net Potato Chips Bag (Rs.21,000,000 = DM.3,230,769) = DM.1,615,385	1,615,385
Total	DM.3,094,485
Insurance, 0.125%	DM.3,868

Table 25 Summary of Estimated Annual Operation and Administration Costs in D.M.

Raw Materials	1,096,600
Utilities	
Coal	56,000
Electricity	46,154
Property and Inventory Insurance	3,868
Management	31,380
Labour	67,570
Depreciation	
Buildings, 4% of DM.289,231	11,569
Equipment, 10% of 886,769	88,677
Maintenance, 4% " "	35,471
Total	DM.1,437,379

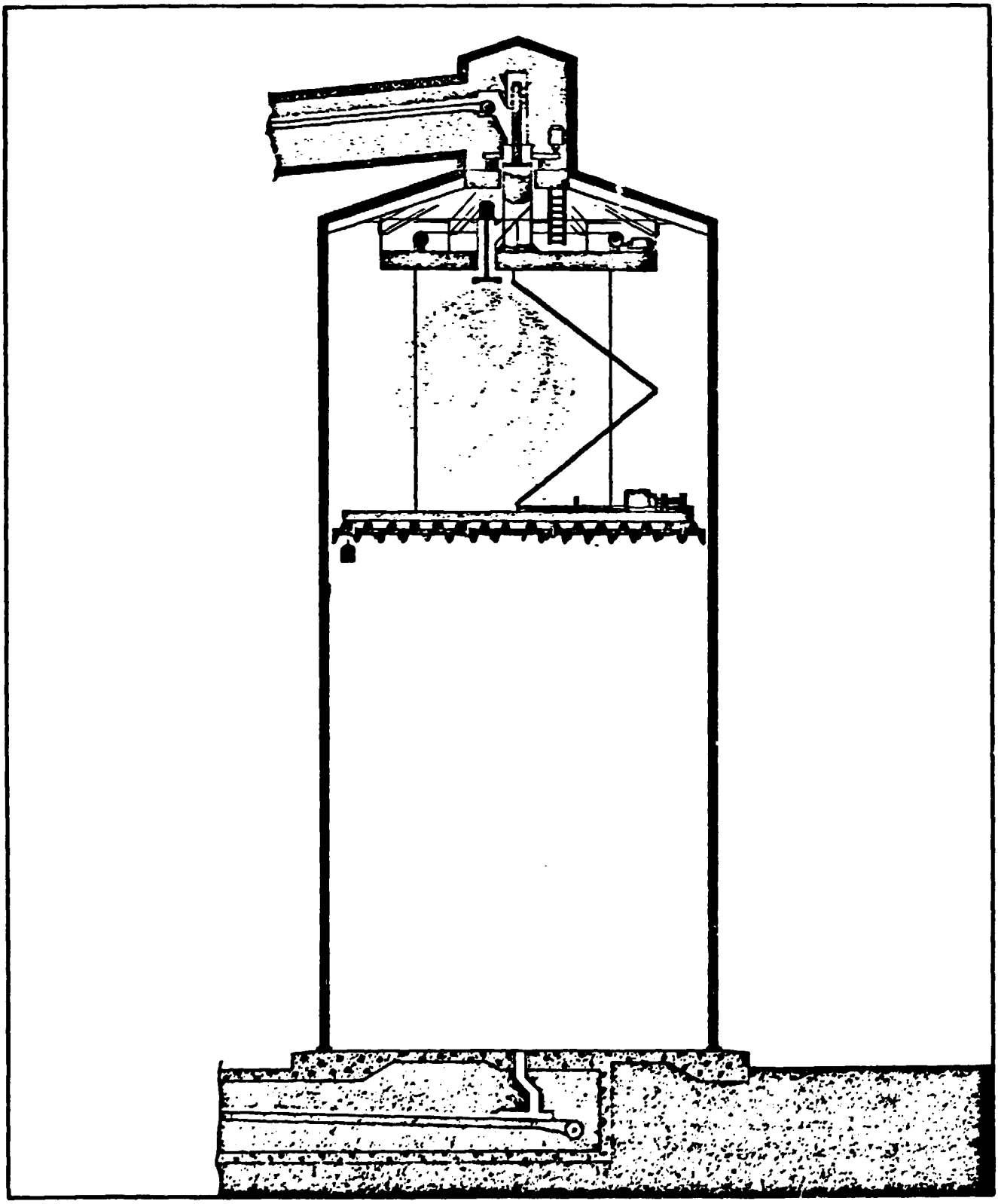
Table 26 Estimated Sales Revenue

7,000,000 100 gram net potato chip bags each Rs.3.00 = Rs.21,000,000 = DM.3,230,769	3,230,769
Sales losses through spoilage and breakage, 20% of above	646,154
Net Sales Revenue	DM. 2,584,615

Table 27 Estimated Working Capital Requirements

Payroll (10% of Annual Cost of 98,950)	9,895
Raw Materials (50% of Annual)	548,345
Finished Stock (50% of Annual)	1,615,385
Utilities (50% of Cost)	51,077
Total	2,224,702

APPENDIX I BULK POTATO STAPCH STORAGE
FOR 5000 to 7000 TONS CAPACITY



APPENDIX II BULK POTATO STARCH STORAGE
FOR 7000 TONS CAPACITY AND UP