Techno econmic Feasibility and Engineering application study to establishment of corn processing(glucose) plant in Ethiopia

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ABSTRACT

Glucose in its different form is used as a constituent of foods, medicine, and other applications in the tanning and dyeing. Hence, the demand for glucose depends mainly on the growth of the manufacturing sector particularly the food and pharmaceuticals. Considering the growth of population and the increasing number of food and pharmaceutical manufacturing enterprises demand is projected by applying a 10% annual growth rate(Source:Ethiopian Revenues and Customs Authority). The key success an drisk factors for amanufacturerin the glucose from corn starch and allied productsindustry are raw material costs, plant location, manufacturing efficiency, secure supply of corn, quality standards, access to suitable human resources, infrastructure facilities, adequate distribution, macroeconomic environment, currency fluctuations, government regulations and policies, etc. The consultant recommends the implementation of this project taking into account the promoters decision related to the associated risk factors. By all measures, the project is found to be economically viable to implement. According to the projected income statement, the project will start generating profit in the first year of operation. Important ratios such as profit to total sales, net profit to equity (Return on equity) and net profit plus interest on total investment (return on total investment) show an increasing trend during the life-time of the project. The income statement and the other indicators of profitability show that the project is viable. The project can create such employment. Inaddition to supply of the domestic needs,the project will generatehundred of *million at full capacity operation in terms of tax revenue. The establishment of such factory will have a foreign exchange saving effect to the country by substituting the current imports and future potential of export of the products. Waterfall 1.1 base-case scenario shows profit after tax and sensitivity analysis for the worst conditions of raw material cost increase and/or product price decrease as much as 10% do not change the viability of the project.*

Key words: *Corn, Processing****,*** *Technoengineering, application,* economic feasibility.

INTRODUCTION

Amount of import glucose has been increasing steady in Ethiopia. Imported glucose can serve as a raw material in different industries such as in pharmaceutical, food, textile, paper and many other industries. Especially, in pharmaceutical industry glucose have versitile use in developing different drugs and relief feed supplements. This study will reduce the gap of production of glucose from corn domestically and will provide opportunity for different industries which will use glucose as raw material. In order to alleviate less utilization of different crops industrially much attention is given in exploitation of different agricultural commodities for industrial usage. The key success an drisk factors for amanufacturerin the glucose from corn starch and allied products industry are raw material costs, plant location, manufacturing efficiency, secure supply of corn, quality standards, access to suitable human resources, infrastructure facilities, adequate distribution, macroeconomic environment, currency fluctuations, government regulations and policies, etc. The consultant recommends the implementation of this project taking into account the promoters decision related to the associated risk factors. By all measures, the project is found to be economically viable to implement. Therefore objective of this study was to indicate an idiea sector of economic feseability analysis and engineering principal application of corn processing for such production particularly glucose processing in Ethiopia .

MATERIALS AND METHODS

The viability of a corn processing plant depends upon the availability and uninterrupted supply of raw material to the unit. Hence, the availability of raw material is one of the important considerations in deciding the location of corn processing unit. The plant will be able to procure major portion of its raw material requirement within the radius of 300 km. The whole facility has four distinct plants namely corn starch manufacturing, corn oil extraction and refining, starch and dextrin modification, and glucose production. The materials and inputs required by these four sections of the integrated plant comprise basic raw materials, auxiliary raw materials and utilities. The basic raw material is corn grain which can be made readily available from the market through cooperatives or farmers . The basic materials for corn oil extraction and refining are dry germ from the main line and hexane. The auxiliary raw materials required by the corn starch plant include sulfur and lime. The auxiliary raw materials required by the glucose plant are HCl, soda ash and activated carbon. The utilities required by the envisaged corn processing are water, electricity, compressed air, and steam (fuel oil).

MATERIAL BALANCE

Material quantities, as they pass through processing operations, can be described by material balances. Such balances are statements on the conservation of mass. If there is no accumulation, what goes into a process must come out. This is true for batch operation. It is equally true for continuous operation over any chosen time interval. The law of conservation of mass leads to what is called a mass or a material balance. Mass In = Mass Out + Mass Stored. Just as mass is conserved, so is energy conserved in food-processing operations.

Assumption: 1kg of corn seed generate 655g of starch powder, those 67.6% of starch is generated from 1kg of corn seed. 450g of starch powder was used, Liquid glucse from 450g of starch, 2.025litter of liquid glucose were exracted

The specific gravity of glucose $= 1.54*10^{-3}$

Mass of produced glucose = $\rho * V = 1.54$g/ ml * 225ml = 346.5gm

If the initial input 1kg is scaled up to 20,000kg/day of corn.

Amount of corn = 6,000tons corn per year plant capacity = 13520litter/day (starch slurry)

Working day per year =300days

Working hour per day= 3shift*8hrs=24hrs

Starch powder with 3% moister content loose.

A. Mass Balance on mesh after milling operation (sample preparation)

Suppose: 4% loss due to the mesh size of the sieves

From conservation of mass: Massin=Massout+Massstored+MassLoss

Mass in (M_1) = Massout+MassLoss

Mass out = Mass in–Mass Loss, Mloss=4% of M in

=Mass in– 0.04*Mass in=20,000-20,000*0.04= 19200kg/day

B. Mass balance on liquefaction unit

Weight of Starch slurry= 0.676*20000kg/day = 13520kg/day (M_2)

From the conservation of mass : Mass in = Mass out+Mstored

$M_1+M_4= M_2 +M_3$

$M_3 = M_1$ - M2 +M_4= (19200 – 13520)kg/day +19200 kg=24880kg/day

C. Mass Balance on dryer

Thus , mass of starch out after drying will be calculated from the conservation of mass;

Massin = Massout + mass stored+Massloss Massin=massout+loss

Massout = Massin(M_1)–Mass loss (M_2); M_{loss} =3% *M_1

Mout =13520-13520*0.03=13114.4kg starch powder/day

ENERGY BALANCE

A. Energy balance on disk

The energy requirement of disk mill to crush the corn is calculated from bonds law:-

$$E/W = \sqrt{100/d2} - \sqrt{100/d1}$$

WhereW=bondworkindex (4,000–8,000J/kg)

D1 (m) =diameter of sieve aperturethatallows80%ofthemassoffeed to pass.

D2 (m) =diameter of sieve aperturethatallows80%ofthematerialtopass.

D1=2mm=2*10^{-6}m and d2 =1mm=1*10^{-6}m

Take bond workindex, w=5000J/kg from the range of given above

E/W=√100/1*10^{-6}–√100/2*10-6

E=W*[√100/1*10^{-6}–√100/2*10^{-6}]

=5000J/kg*(10000–7071)=14645000J/kg=14645000J/kg*40,000kg/day

E=585,800kJ/day is energy that required to mill 20,000kg/day of corn

B. Energy balance on dryer

The rotary drier that choose for the plant has been capabilityof removing about 60% of the water entering the feed. The drier is a countercurrent drier, with air as the heating medium. The RH(humidity ratio) of the air entering is assumed to be 10%.If the air entering is heated to a temperature of 160^{o}C,the material fed from liquefy tank into the drier at a temperature of 80^{o}C because from the literature liquefying with activator is held mixing atatemperature 80-90^{o}c.

Moisture Solid in the feed =13520kg/day, Waterinthefeed =13520kg/day water Feed to dryer

Water removed by the drier=0.60*13520=8112kg/day, because

dryer have capacity to remove 60% water

Water Content in final Product=0.03*(13520+13520–8112)

=567.84kg/day

The material fed to dryer tank is at room temperature 90–120^{o}c, assume 90% of water add for dryer is removed.

Heat required raising the product to discharge temperature.

Q=sensible heat of water+sensible heat of starch at reference tempreture of T_1=25^{o}c

Q =$M_1Cp_w(T_2–T_1)$ +$M_2Cp_s(T_1–T_2)$, where M_1=Mass of water, M_2 = Mass starch,

cp_w=4.18j/kg^{o}c, cp_s=3.7j/kg^{O}c

Q=13520*4.18(90–25) +13520*3.7(90–25)=6924944watt=6924.944kw

Heat required removing water

$Q_2=MCp_w((T_2–T_1)$=13520Kg/s*4.18(90–25)

Total Heat=3673.384kw

Energy balance on autoclave

Q=sensible heat of water +sensible heat of corn

$Q=M\ CP_w + MCP_s = MCP_w(t_2-t_1) + MCP_s(t_2-t_1)$

=13520*4.181(120-25) + 13520*3.9(120-25)=1,284,495kw

SIZING ON MAJOR EQUIPMENTS

Equipment specification typically includes the determination of vessel dimensions and description of other internal parts of the equipment. It also involves the determination of parameters like speed, power and any other operating parameters pertaining to the particular equipment. Specification of equipment can be approached from a duty specification viewpoint.

Assumptions

- 1kg=1litter
- 10% allowance for each equipment
- The volume of sulpheric acid and sodium hydroxide after solution prepared

A. Corn starch storage tank (blender thank)

Starch demand annually needed =3,934,320tone /annual =13114.4kg/day

Density of corn starch = 0.3526kg/m^3

V= m/ρ=13114.4kg/0.3526kg/m=37193.4m^3/day

Storage volume for daily with 10% allowance

V= 37193.4+ (37193.4*0.1) =40912.7m^3/day

B. Sizing on sulfuric acid storage tank

60ml of H_2SO_4 is used for each 50g of starch

Thus,the annually required (needed) H_2SO_4will be calculated as;

H_2SO_4 needed annually is =9734400 litter /yr=32448litter /day

Take 1kg= 1litter

Density of H_2SO_4= 1840kg/m^3 = 32448kg/1840kg/m^3

V=17.6348m^3/day

Storage volume for daily with 10% allowance

V=17.6348+ (17.6348*0.1)=19.4m^3/day

C. Sizing on sodium hydroxide storage tank

NaOH need for annually= 9734400litter/year =32448litter /day =32448kg /day

Density of sodium hydroxide = 2130kg/m^3

$V = m/\rho$=32448kg/2130kg/m^3 V=15.233m^3/day

Storage volume with 10% allowance

V=15.233m^3 + (15.233*0.1)=16.76m^3/day

D. **Sizing on dryer**

Mixture of starch and water into dryer =(13520+ 13520) kg/day=27040kg/day

Sizing on water tank

Water needed annually =20,000*300*0.67=4056000litter/year =13520litter/day

$V=\frac{m}{\rho}$=13520/1000 = 13.52m^3/day

Volume with 10% allowance =13.52+ (13.52*0.1)=14.872m^3/day

Total volume of dryer= (volume of water + Storagevolume of starch) with 10% allowance

=14.872m^3 + 37193.4m^3=37208.272m^3

E. Sizing on water tank

Water needed annually =4056000litter/day

For production =13520litter/day

The storage volume of water,V is calculated as;

V= 13520/1000 = 13.52m^3/day

Volume with 10% allowance =13.52 + (13.52*0.1)=14.872m^3/day

PLANT COST ESTIMATION

Total capital investment estimation

Table: 3- Purchased equipment cost

No	Type of Equipment	Required capacity with 10% allowance,m^3	Number of Equipment	Unit Cost of the Equipment(Birr)	Total Cost of the Equipment(Birr)
1	Sulfuric acid tank	19.4	1	46000	46,000
2	Blender/mixer(slurry preparation tank)	40912.7	1	480000	48,000

3	Hydrolysis tank(converter)	40,946	1	58000	58,000
4	Wooden neutralization vat	40,963.7	2	48000	96000
5	Filter		1	88000	88,000
6	Centrifuge	80.56	1	116000	116,000
7	Dryer	372008.27	1	220000	220000
8	Cooling tower	55.4	2	212000	424,000
9	Vessels and tank	223	10	2900000	2900000
10	Boiler		1	122000	122,000
11	Pumps		6	84000	504,000
	Purchased Equipment Cost				4,622,000

The purchased equipment cost is 40% of fixed capital investment.

4622000 = 0.4 * FCI

FCI = 11,555,000

Purchased delivered cost is (15-40%) FCI, taking the average, 20%FCI

Purchased equipment instaltion,6-14%FCI, 10%FCI

Instrumentation (installed), 2-8%FCI, 5%FCI

Piping(installed), 3-20%FCI, 10%FCI

Electrical (installed),2-10%FCI, 6%FCI

Yard improvement,.2-5%FCI, 3.5%FCI

Service facilities(installed),.8-20%FCI, 14%FCI

Land,1-2%FCI, 1.5%FCI

Engineering and supervision,4-21%FCI, 12.5%FCI

Construction expense,4-16%FCI, 10%FCI

Contractors fee,.2-6%FCI, 4%FCI

Contingency ,5-15%FCI, 10%FCI

Estimation of working capital (WC)

Working capital is 10-20% of total capital investment

Taking 20%

TCI= WC + FCI

Table: 4 Total capital investment estimated result

Items	Cost(Birr)
1 Direct Costs	
Purchased equipment cost delivered	2311000
Purchased equipment installation	1155500
Instrumentation and controls (installed)	577750
Piping (installed)	1155500
Electrical (installed)	693300
Building (including service)	166560
Yard improvements	346650
Service facilities (installed)	1617700
Land (if purchase is required)	173325
Total direct costs	8197285
2 Indirect Costs	
Engineering and super vision	1386600
Construction expense	1155500
Contractor's fee	462200
Contingency	1155500
Total indirect costs	4159800
Working capital investment	2888750
Total capital investment =FCI + WC	14,443,750

Total Production Cost Estimation

(I).Manufacturing Cost = Direct production cost + Fixed charges + Plant overhead cost.

(A) Fixed Charges:

I. Depreciation:

Depreciation=10% of FCI

Depreciation=0.1*11555000 birr = 1155500 birr

II. **Local Taxes:** (1-4% of fixed capital investment)

Consider the local taxes = 2% of fixed capital investment

Local taxes = 0.02*11555000 birr =231100 birr

III**. Insurances:** (0.4-1% of fixed capital investment)

Consider the Insurance = 0.6% of fixed capital investment

Insurance=0.006*11555000= 69330 birr

Fixed Charge =Cost of Insurance + Cost of Local Taxes + Depreciation

= 1155500 birr + 231100 birr + 69330 birr= 1455630 birr

(B) Direct Production Cost:

I. Raw Materials:

Assumption:-

The Capacity of the Plant

Amount of corn used per day = 20,000kg/day

Amount of corn = 6,000tons corn per year

plant capacity = 13114.4 litter/day

Working day per year =300days

Working hour per day 3*8

Table: 5- Cost of raw material

Raw material(RM)	Amount	Unit cost of RM	Annualcost of RM
Corn	6000ton/year	6birr/kg	36,000,000 birr
Chemicals	19468800L/Year	100.03birr/L	1947464064 birr

II. Cost of Operating Labor (OL)

Table: 6- Cost of operating labor

No	Equipment	Number Of Operating Labor	Unit Cost Of Labor Per Year (Birr)	Total Cost Of Labor Per Year(Birr)
1	H_2SO_4 tank	1	21600	21600
2	Slurry preparation	2	18000	36,000
3	Converter	1	14400	14400
4	Neutralizer	3	21600	64800
5	Filter	1	14400	14400
6	Centrifuge	2	18000	36000
7	Tower	1	23300	23300
8	Dryer	1	20000	20000
9	Boiler	1	19000	19000
10	Pumpers	1	17000	17,000
	Total	14	187300	266500

III. Direct Supervisory and Clerical Labor (DS & CL): (10-25% of OL)

Direct supervisory and clerical labor cost = 12% of OL

Direct supervisory and clerical labor cost = 0.12*266500Birr = 31980 birr

Iv. Utilities cost

Power cost:-

Daily power cost = 50KWh*24hrs/day*0.75birr/Kwh = 900birr/day

Annual power cost of dryer =900birr/days*300days=270,000birr

Water cost =27040lit/day*0.025birr/lit*300day= 202,800birr

Utilities cost=270000 birr + 202800birr = 472,800birr

V. Maintenance and repairs (M & R): (2-10% of fixed capital investment)

Maintenance and repair cost = 5% of fixed capital investment

Maintenance and repair cost =0.05*11555000 = 577750birr

vI. Operating Supplies: (10-20% of M & R or 0.5-1% of FCI)

Consider the cost of Operating supplies = 15% of M & R

Operating supplies cost = 0.15*577750birr = 86662.5birr

vII. Laboratory Charges: (10-20% of OL)

Laboratory charges = 10% of OL

= 0.1*266500birr

= 26650birr

Direct production cost = raw materials + Cost of Operating Labor (OL) + Direct Supervisory and Clerical Labor + Utilities cost + Maintenance and repairs + Operating Supplies + laboratory charges

Direct production cost =36000000 birr + 266500 + 31980birr +472800birr + 86662.5birr + 577750birr + 26650birr

Direct production cost = 37462342.5 birr

(C) Plant overhead Costs:

Plant overhead cost = (50%)*cost (Operating labor + supervision + maintenance)

Plant overhead cost = 0.5*(2665600+31980+577750) birr = 1637665birr

Manufacturing cost = Direct production cost + Fixed charges + Plant over head Costs

Manufacture cost = 37462342.5 birr+ 1455630birr + 1637665birr

Manufacture cost = 40555637.5 birr

(II) General Expenses: 50-70% total operating labor, supervision and maintenance

General Expenses = 50-70%*cost(operating labor + super vision + maintenance)

= 0.5*(2665600+577750+31980) birr = 1637665birr

Thus, General Expenses =1637665 birr

(III) Total Production cost = Manufacturing cost + General Expenses

Total production cost =40555637.5 birr +1637665 birr = 42193302.5birr

Table :7 - Total production cost estimation

NO	Items	Calculate Cost(birr)
A	Direct production costs	37462342.5
1	raw materials	36,000,000
2	Plant labor cost	266,500
3	Utilities	472800
4	Operating supplies	86662.5
5	Maintenance and repair	577750
6	Direct supervision and clerical	31980
7	Laboratory charge	26650
B	General Expense	1637665
C	Fixed Charge	1455630
10	Depreciation	1155500
9	Insurance and properties	69330
10	Local taxes	231100
	Total production cost	42193302.5

Annual production rate =4,423,200litter/year

Unit production cost per litter= total production cost /annual production rate

=42193302.5/4423200 =9.54 birr/litter (it is cheapes

Sales

Unit selling price of glucose = 20birr/litter

Whole Selling Price of glucose=20birr/L*4423200L/year=88464000birr/year

Selling price of by products = 3birr per Kg *2808000Kg=8424000birr

Total annual sales = 96,888,000birr

Gross profit = annual sales – Total Product Cost= 96,888,000birr – 42193302.5birr

Gross profit=54694697.5 birr

Let the Tax rate be 35%.

Taxes = 35% of Gross profit = 0.35 * 54694697.5birr

=19143144.13birr

Net Profit = Gross profit -Taxes = 54694697.5birr -19143144.13 birr

Net Profit = 35551553.38 birr

A .Rate of Return

I .Rate of return before tax

$$\text{Rate of return} = \frac{\text{gross profit}}{\text{Total capital investment*project life time}} * 100$$

$$= \frac{54694697.5}{14443750*12} * 100$$

Rate of return = 32%

II .Rate of return after tax

$$\text{Rate of return} = \frac{\text{Net profit}}{\text{Total capital investment*project life time}} * 100 = \frac{35551553.5*100}{14443750*12} = 20.5\%$$

B. Payback Period

$$\text{Payback period} = \frac{\text{Fixed capital investment}}{\text{Annual net profit average+ Annual Depreciation}}$$

If the project life time is = 12 years

$$\text{Annual net profit average} = \frac{\text{Net profit}}{12} = \frac{35551553.5}{12} = 2962629.458\text{birr}$$

$$\text{Annual Depreciation} = \frac{1155500}{12} = 96291.67\text{birr}$$

$$\textbf{Payback period} = \frac{14443750}{2962629.458+96291.67} = 4.7 \text{ year}$$

Breaking even point (BP): TO calculate the breakeven point we need unit sale price and minimum unit cost, so calculating of minimum cost is required

Minimum unit cost = total productioncost/Annual produc = 42193302.5/4423,200liter/year =9.53liter, to be profitabel; the unit price must be gerater than minimum unit cost of the product.

Already assumed unit price to be birr20/liter

Annual seels (AS)= FC +over head cost +general expans

AS=1637665+1637665+1455630=4730960birr

Break even point=annual sale+9.53BP=20BP,4730960+20BP=9.53Bp gives BP=4518586.64birr

Annual cash flow(R):

R=Net profit +Depreciation = 1155500+35551553.38=36707053.38birr

Net present worth (NPW):

NPW=P-TCI

$$P=\frac{R\{(1+i)^n-1\}}{\{i(1+i)^n\}}+Recovery(1+i)^{-n}$$

Where,Interest rate(i)=12%

Servise life(n)=12year

Recovery (RE)=working capital +salvage value

Assuming salvge value=0, therefore recovery (RE)=working capital=2888750birr

Recovery=working capital=2888750birr,then from this “p” is:

$$P= 36707053.38*\frac{\{(1+0.12)^{12}-1\}}{\{0.12(1+0.12)^{12}\}}+2888750(1+0.12)^{-12}\ =228120580.5$$

NPW =P-TCI

=2281205805-14443750= 2,266,762,055birr

Since NPW is positive the project is feasible.

Discussion

Technology and Engineering

The technology selection for the main product starch compared two front-end fractionation technologies: dry and wet processes. In general, wet fractionation tends to be relatively costly , however, produces higher-valued coproducts and has less starch loss than dry fractionation. Cleaning, steeping, fiber separation, gluten separation, germ separation and the final starch washing and drying are the major processes of the selected technology. Similarly, modification of the manufactured starch can be done in two process alternatives, namely, enzymatic and acid modification. The plant considers the dry acid process as a primary route for certain applications while the other approach is mainly product and enzyme specific. In a two step process, the dry starch is acid treated and heated to produce dextrins which have different physical properties than raw starch. Glucose plant processes are based on a common, yet modern, approach of enzymatic hydrolysis and evaporation to get dried product. Corn oil extraction technologies are mainly catagorized as mechanical expression, solvent extraction and supercritical fluid extraction of which the second is adopted in this specific plant after a thorough cost benefit analysis..

Organization and human Resource

The selection of structure of the envisaged project is made based on the existing structure of manufacturing plants operating in the country, the capacity, complexity and technology mix of the plant and assuming that the company shall be managed by the Ethiopian government for some period till it is privatized. Organizational structure principles such as specialization, coordination, and departmentalization are also considered for design of structure that best suits the envisaged project.

Location, Site and Land

As the raw material is a key factor in the success of this business, major corn growing zones covering West Gojjam, Jimma, East Wollega, West Shoa, Illubabor and East Shoa has been selected as possible potential locations of the envisaged project by assessing the availability of critical project requirements such as raw material availability, utilities (mainly water and electricity), transport infrastructure, labour, social infrastructure(health center, schools, financial institutions, postal and telecommunication service) and proximity to market centre qualitatively. It has been found West Gojjam can be a better option. Further considering key technical and financial factors in the selected location, sites of major towns in West Gojjam such as Bahirdar, Bure, Adet, Dembecha and Fenoteselam has been evaluted. Therefore based on the qualitative and quantitative stage of location and site selection processes, the consultant proposes Burie which also hosts a proposed industrial park as the site for the envisaged Corn Processing Plant. Thesiteforinstallingtheenvisagedplantisintheagroindustrialparkpreparedwithaccesstoall infrastructuresrequiredbysimilarindustries,whichisabout420kmfromAddisAbaba. Thesite is inside the major producer of corn at the national level that will supply the main raw material sustainably without endangering the local food security with access to the basic infrastructure such as electricity, health center, schools for the plant under study. It is also relatively close to supply markets from Wollega, Shoa and South Gondar. Land requirement of starch and allied products manufacturing is very high, as it requires large area to set up plant and machinery and effluent treatment plant. There should be enough land for disposal of treated waste water. A unit with crushing capacity of 180MT/day or 100 MT/day main product starch should have at least

6.5 hectares of land. However, if available at reasonable price, the facility with its living quarters may acquire up to 10.6 hectares of land to meet future expansion requirements.

Conclusion

The capacity of glucose processing plant from corn complex is determined by considering different technical and financial factors such as market demand, raw material availability and supply reliability, technology and availability of machinery and equipment in the world market with the proposed capacity (economies of scale), investment and skilled labor requirement. The complex consisted of the main starch and related products (animalfeed and gluten)facility integrated with subsidiary plants for corn oil, glucose and modification starches. Use of corn for glucose production is useful for farmers and industries because farmers as row material supplier and industries are users this industry farmer linkage this have a great role for the development of the given country. The profitability of producing glucose from corn starch is feasible. The capacity of glucose processing plant from corn complex is determined by considering different technical and financial factors such as market demand, raw material availability and supply reliability, technology and availability of machinery and equipment in the world market with the proposed capacity (economies of scale), investment and skilled labor requirement. The complex consisted of the main starch andrelated products(animal feed and gluten) facility integrated with subsidiary plants for corn oil, glucose and modification starches.

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