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Starch Production, Consumption, Challenges and Investment Potentials in Ethiopia: The Case of Potato Starch

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Abbreviations

ETB	Ethiopian Birr
GDP	Gross Domestic Product
DMC	Dry Matter Content
GTP	Growth and Transformation Plan
Ha	Hectare
IRR	Internal Rate of Return
SC	Starch Content
SY	Starch Yield
t/ha	Tones per hectare
USD	United States Dollar
USA	United States of America

ACKNOWLEDGMENT

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Executive Summary

Since antiquity starch has been used as an important commodity worldwide for various purposes that span as a source of food and nutrition for humans through the non-food areas such as in the textiles, pharmaceuticals, construction materials, paper and pulps, glue and adhesive, confectionary, baking products, packaging and printing, beverages, alternative energy sources and many others. Presently, corn, wheat, cassava and potato are the dominant crops widely in wider utility for the extraction of starches globally mostly based on the availability and economics in a given region. It is estimated that worldwide paper starch consumption consists of 67% corn, 15% potato, 8% tapioca, and 3% waxy maize. Agro-ecological suitability to either of these commodities specified the type of starch produced by the dominant starch producing countries. United State of America dominantly produces corn starch while European countries with very cool environment produce starch mainly from potatoes. Similarly Asians are the hub of tapioca starch. Ethiopia presents wider opportunity for cultivation of various starch source crops owing to its diverse agro-ecologies that permit the production of different crops. Potato starch will probably have the utmost prospect as over 70 percent of the country is situated at an elevation > 1 500 meters above sea level. This has endowed the country with the highest potential for production of voluminous and quality potato among other African countries. This study is then aimed at investigating the current state of starch production in the country, supply and demand factors and growing demand owing to emerging concern for environmentally friendly and bio-degradable products as compared to plastic products, value chain based approach of agricultural development, and potential opportunity for potato starch production to amplify the role of potato industry to the country's GDP. To this end a survey is carried and data were collected from discussion held with managers of different starch using factories and starch extracting firms. Analysis of supply and demand, available technological advances worldwide, potentials for domestic raw materials and starch production, and its sectoral linkage with the country's development target and framework is done. The study result has revealed a rapid growth in starch utilizing factories in Ethiopia, wide gap between the domestic supply and demand for starch, a yearly outlay that worth over 2 million USD (44, 228, 066 birr) for its import, low but improving quality of domestic starch, ample potential for production of starching potato and starch as quantified from suitability map of potato production and therefore make a significant contribution to the horticulture industry strategy target of import substitution and export promotion. Potato starch appears to offer a new market for the potato industry.

1. Background

Starch, a common constituent of higher plants, is the major form in which carbohydrates are stored. It is produced by green plants for energy storage and is synthesized in granular form. Starch is present in most green plants and in practically every type of tissue: leaves, fruits, pollen grains, roots and stems. Starches from reserve organs of many plants are important in commerce. Humans have always eaten starchy foods derived from seeds, roots, and tubers. Although people continue to consume some starch directly from starch-bearing plants, either raw or cooked, their demands for commercially produced starch to be added to foods and beverages have increased significantly. Its use in a broad range of industrial products such as paper, textiles, building materials and alcohol for fuel has also expanded. Starch content in potato tubers, maize endosperm, sweet potato, and roots of cassava and yam varies between 65% and 90% of the total dry weight. Starch granules in storage tissues vary in composition, shape and size, wit shape and size depending on tissue and plant source, there is a range of sizes and shapes in each tissue. Starch is a valuable ingredient for the food industry, being widely used as a thickener, gelling, bulking and water retention agents (Niba et al., 2001; Singh et al., 2003). Starch from all sources has many similar properties. Yet they do also differ in many aspects. Potato starch and its derivatives have special properties, such as low gelatinization temperature and a high past consistency. Potato starch is preferred in the food industry, because its pastes have a good clarity (due to a small amino of lipids and protein) and neutral flavor. In the paper industry, there is also a preference for potato starch. The reason for this due to the fact that potato starch is characterized by large granule size with considerable swelling power, a low glass transition temperature, paste clarity and a reasonably neutral taste. The high molecular weight of its amylose and its good solubility adds to potato starch preference. Cationic potato starches are preferred for internal sizing due to the concurrent presence of phosphate groups. Potato starch dextrins also have an advantage over other starches as an adhesive, because of the good remoistenability and a desirable rheology resulting in a perfect direct tack. Textiles are manufactured better with potato starch due to its film properties, paste penetration depth and adhesive power. Potato starch, tapioca starch and waxy maize starch perform better than other starches in oil drilling, due to their excellent fluid loss properties. The high phosphate content of potato starch is responsible for special flocculation effects in mining and water treatment. Native potato starch, which is used in the food, paper and textile industries, is often not optimal for a particular application. Potato starch and its derivatives have special properties, such as low gelatinization temperature, and a high paste consistency. Potato starch is extensively used in food, chemicals, pharma and other industries. In the food industry potato starch is used as a thickener for sauces and stews, a binding agent in cake mixes, dough, biscuits and ice-cream. Over 40 percent of the potato starch produced in the European Union is used for the non-food purposes that include paper and bio-plastics manufacture, pharmaceuticals and cosmetics, textile and adhesive manufacturing. It is widely used by pharmaceutical, textile, wood and paper industries as an adhesive, binder, texter agent and filler, and by the oil drilling firms to wash boreholes. It is regarded for its neutral taste, good clarity and high binding strength. Potato starch is preferred in the food industry, because its paste has a good clarity (due to small amount of lipids and protein) and neutral flavor. In the paper industry, there is also a preference for potato starch owing to its high molecular weight amylose and its good solubility. Around 15% of the total world paper starch (5 million ton a year, 2005 estimate) of starch comes from potato. Paper mills usually purchase starch in dry powder form and cook it onsite prior to application. Potato starch can be used to improve fabrics and textiles – it can provide abrasion-resistance and smoothness, according to Bayer Crop Science. Potato starch is used in the cosmetics and pharmaceuticals sector in the production of creams, pastes (stick, glue or adhesives) and powders. It can also be used to reduce the need for chemical additives in beauty and pharmaceutical products. Potato starch dextrins also have an advantage over other starches as an adhesive, because of the good remoistenability and a desirable rheology resulting in a perfect direct tack. Textiles are manufactured better with potato starch due to its film properties, paste penetration depth and adhesive power. A key reason for considering the supply of potato starch is its purity and of better quality than cereal starch, as it has the lowest content of fats and protein, with no colour, taste or smell. Potato starch is used as the starting material for biodegradable sugar detergents. Starch's absorbent powers allow it to absorb stains from fabrics better than other cleaning substances.

Potato starch for adhesives

Potato starch as moisturizer

Potato starch as gelling agent

Potato starch as a thickener in sauces

Potato starch to produce yeast

Potato starch for textile processing

Potato starch for paper making

Potato starch for preparing pasta

Native potato starch

2. Scope of the Study

Starch is an important commodity with versatile utility in the food and non-food products. Its future prospect in the non-food products owing to its biodegradability and environmental friendliness characteristic is immense. Thus, the scopes of this study routs through the assessment of existing starch manufacturing and consuming firm's supply and demand balances, challenges associated with production and uptake, import state, and feasibility and opportunities and barriers for planting starch manufacturing factories as away to contribute to the grand GTP target of import substitution and export promotion through competitive exportable product.

3. Objective of the Study

- To assess the present state and trend of starch utilization by various industries; i.e., textile, pharmaceutical, paper, packaging, food complexes, construction materials manufacturing industries, in the country and project future demands;
- To assess the present supply of starches by local starch extraction companies and document problems associated with their production and qualities; and
- To investigate the feasibility of establishing starch extracting companies that can meet the standards demanded by various industries and provide an investment policy briefs.

4. Methodologies followed

The study is carried in the four major National Regional State, Addis Ababa and Dire Dawa cities administration. Basically a long tour is made beginning Tigray Regional State and traversed through Amhara, Oromia, and Southern Nation and Nationalities Regional States and Dire Dawa and Addis Ababa cities administration to collect starch related data from all possible industries distributed across these parts of the country. Accordingly a total of 29 factories, viz., three pharmaceutical, two papers and pulp, five textile, 13 packaging and printing, one construction, and five food complex factories were visited. Moreover, one starch extracting factory located at Dukem is visited.

Data is collected through a one to one interview and two way discussions with the General Managers, Department heads and Technical managers guided by a structured questioner developed in advance. Most factories Managers were very cooperative in providing data on their hands although insufficient due to poor record keeping providing time series data. In contrast three of the food complex factories showed their unwillingness through their various bureaucratic system of extended appointment that runs against our time limit and promise of forwarding the information through Fax. The response of one of the oldest paper factory of the country in Wonji Showa that is known for its large amount of starch use for their both paper and packaging materials production was among the worst experience in a negative way compared with similar other private paper and packaging material producers. Few of the factories were also excluded deliberately from visit owing to their distance. As a result this study did not escape the common problem of augmenting exhaustive data points like any other studies of similar kind as evidenced in various reports. A mismatch between custom authority webpage data and those obtained through interview and discussion is also a problem encountered during data collection time.

The collected data were analyzed using Microsoft Excel program to develop a graphical presentation of the total volume starches used by the different groups of manufacturing industries. Moreover, trend analysis and projection of the future volumes of starch consumption in the country is computed with the assumption of the development triggered needs of starch for the present and the uncommon manufacturing firms in the country, global concern for environmentally friendly and biodegradable materials compared to polyvinyl plastic materials and others not mentioned. Economic analysis or benefits on Profitability, Initial investment cost, Production cost, Profitability, Breakeven analysis, Payback period, Internal Rate of Return (IRR) analysis were also carried to see the feasibility of starch manufacturing firms in the country as a way-out to import substitution, export, investment, and employment promotion in the country.

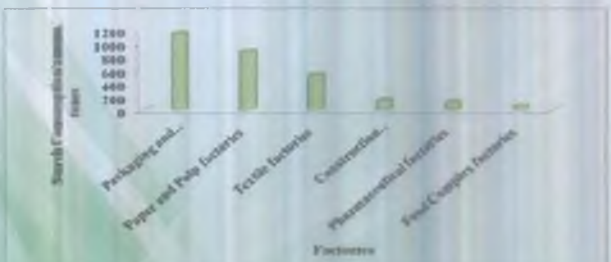
5. Results of the Study

This study result has pointed out that quite very many factories producing different products, i.e., textile, pharmaceutical, packaging and printing, paper and pulp and food complex manufacturing factories, do utilize sizeable amounts of starches at some stages of their manufacturing process. Though not quantified and the scale might be very low laboratory grades of starch such as dextrose and others are presumed to be utilized by different commonest and biotechnological laboratories in the research and higher learning institutions. Obviously, confectionary, gum and other cosmetic manufacturing firms do also make use of starch products of modified nature for their manufactured products. As indicated in the methodological section of this report, it is hardly possible to compile data from each every prospective starch utilizing institutions in the country owing to several limitations, such as time limit and the difficulty of getting each pocket areas, to undertake such kind of study. Thus, as usual the results of this study data were collected from only samples of the overall spectra with special emphasis to large volume consuming factories.

5.1 Current State of Starch Utilization

Starch utilization of the visited and interviewed factories managers expressed the variability of yearly amounts of starch utilized by their respective firms depending on the extent of their yearly manufacturing condition, the factories present and earlier production efficiency, electric energy supply state and others. The collected data also clearly displayed that starch consumption do highly varies with the type of manufactured products and factories producing them. Accordingly, Packaging and printing, Pulp and paper, Textile, Construction, Pharmaceutical and Food Complex factories were found to utilize high to low volume of starch in their order of presentation (Figure 1). The total sum of starches utilized by the surveyed factories during the survey period amounted to 2 900 tons. The type, raw material source, source of purchased starch (local or imported), its price, and countries of import is also known to be different. China and India are found the dominant two countries from which import is made. Likewise, corn starch is the dominant starch type imported by all the different factories.

Figure 1. Volume of starch utilized (tones) by factory type in Ethiopia, 2014



5.2 Starch Production Profile in Ethiopia

In the survey the presence of three starches manufacturing enterprises were identified. Of these Yascai and families starch manufacturing PLC is found to be the main starch extracting PLC providing the lion share of locally produced starch mainly to textile and packaging and printing factories. Mengistu and Solomon starch manufacturing PLCs follow in their order. These PLCs provide close to 40% of the total starch utilizing factories demand in the country. The remaining balance is filled dominantly by starches imported from China and India and some amount from Switzerland and Turkey (Table 1).

5.2.1 Cereal

Currently cereal starches mainly from maize and Sorghum is produced by Mengistu and Solomon starch manufacturing firms. These PLC are found in Kombolcha town of the Amhara Regioanl State and Adwa town in the Tigray Regional. The amount produced and supplied by these two firms are far lower than Yasscai and families starch extracting firm located in Oromia Regional State at Dukum.

5.2.2 Root and Tubers

Starch is produced locally from Roots and Tubers specifically of Cassava and Enset in a larger quantity than the amount produced from cereals. Generally this starch extracting firm is located in Dukum area. Essentially this firm is the biggest locally extracted root and tuber crops starch supplier to many of the textile and medium scale packaging and printing materials manufacturing factories.

6. Supply and Demand of Starch in Ethiopia

The three starch extracting factories located at different parts of the country supplies locally extracted cereals and root and tuber crops starches mainly for textile, packaging and printing and construction materials manufacturing industries. Data collected from the surveyed different factories has clearly pointed out that these local starches extracting PLCs do supply 40 percent of the total starch demanded by the different factories surveyed (Table 1). This clearly shows the greater sum of starch is imported from foreign starch extracting factories and as such substantial amount of hard currency is spent for importing about the remaining 60% of the starch demanded by local industries.

Reasons for such wide gap between the supply and demand is reported to be related to the special grade of starch that high tech equipped large scale Packaging and Printing industries requirement, microbiologically tested and free of heavy metals starch requirement of Pharmaceutical factories as it has an effect on human health, Food Complex factories demands for modified starch and finally some of the Textile factories with latest equipments special need to keep the factory functions safely. Thus, there is a huge imbalance between supply and demand. In general starch is imported from different countries mainly of India and China. This survey result has indicated that nearly 2 700 tones of starch mainly of corn starch brought into Ethiopia during the financial year of 2015, at a value that worth over $ 2.1 million USD or 44, 353, 800 Ethiopian birr. This deficit filling imported starch has accounted for over 60 percent of the local factories demand for starch (Table 1).

Table 1. Starch consumed by the different factories, sources of starch and total cost in Birr.

Names of factories	Consumption/ annum, tones	Price/kg	Total, in Birr	Sources of starch
Burayu Packaging & Printing factory	200	18.00	3, 600, 000	Imported
Minaye Packaging & Printing factory	150	16.50	2, 475, 000	Imported
Ginchi Paper & Pulp factory	180	18.00	3, 240, 000	Imported
Ethio Paper & Pulp factory in Wonji	700	27.50	19, 250, 000	Imported
Unlimited Packaging & Printing fa	150	22.00	3, 300, 000	Imported
Almeda Textile factory	130	44.62	5, 800, 600	Imported
EPHARM Pharmaceuticals factory	30	16.00	480, 000	Imported
East Africa Pharmaceuticals factory	50	18.38	919, 000	Imported
Cadila Pharmaceuticals factory	20	18·77.20	425, 666	Imported
Addis Pharmaceutical	30	19.10	573, 000	Imported
Julfa Pharmaceuticals factory	30	18.38	551, 400	Imported
Grum Biscuit factory	56	31.35	1, 755, 600	Imported
Kality Food Complex factory	6.8	38	258, 400	Imported
Bahir dar Textile factory	100	16.00	1, 600, 000	Imported
Sub Total	**1, 832.8**		**44, 228, 066**	**60.23%**
Nine Packaging factories	448	26.00	16, 848, 000	Local
Hawassa Textile factory	108	28.00	3, 024, 000	Local
Kombolcha Textile factory	150	34.00	5, 100, 000	Local
Dire Dawa Textile factory	10	18.60	186, 000	Local
Chip wood factory	150	27.00	4, 050, 000	Local
Sub Total	**866**		**29208000**	**39.77%**
Grand Total	**2,698.8**		**73, 436, 066**	

7. Projection of Starch Consumption in Ethiopia

The starch has been used in various industries including the manufacturing of textile, paper, and pulp adhesives, pharmaceutical, flower, food complex and so on. Industries use the product mainly as binding, packing, diluting adhesive, water absorber agent, sweetener in their production process. The source of supply of starch is import as well as local, in which production in the country is insignificant. Thus, most of the countries requirement for starch is essentially met through import. There is the sense of a growing demand for starch in the international market and Statistics data illustrates a rising increase of starch imports into Ethiopia. Ethiopia demands 420775 kg starch for Textile factors, 982030.6kg starch for pharmacticuacal factories, 162500kg starch for pulp and paper factories and 62800 starch for food factories. A total of 1768105.6 kg of starch is needed as a total demand for Ethiopia.

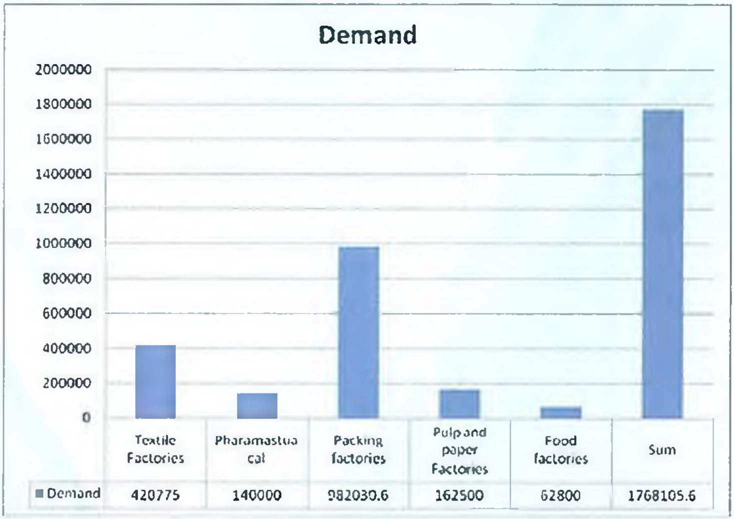
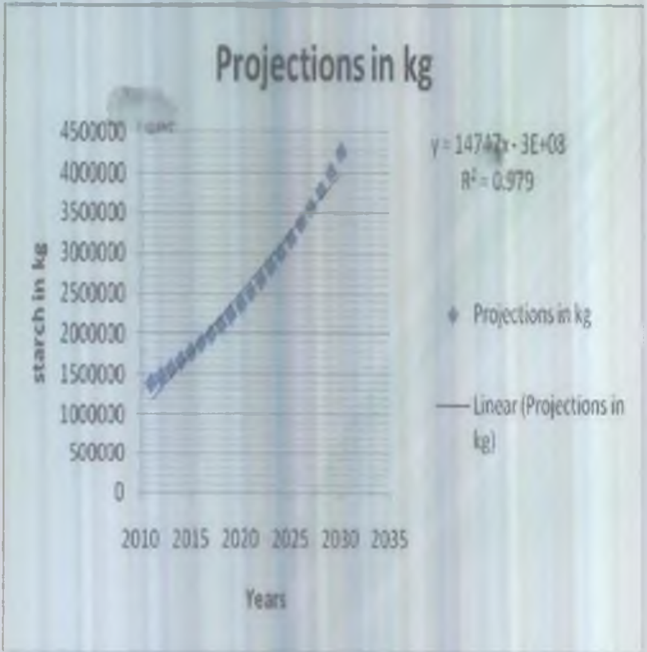


Figure 1: Yearly demand of each factories for starch (in kilograms)

As stated the total starch consumption, a rate of growth of 6% is used in projecting the demand for potato starch. Table 1 depicts the projected demand for the product. As could be seen from Table 1, the demand for starch will grow from 1874191.936 kilograms to 1986643.452 kilograms and 2105842.059 kilograms by the year 2016, 2017 and year 2018, respectively. Furthermore, the demand will reach at a level of 4237367.962 kilograms by the year 2030.

Table 2. Demand projection

Year	Projections in kg
2011	1380446.608
2012	1468560.222
2013	1562298.108
2014	1662019.264
2015	1768105.6
2016	1874191.936
2017	1986643.452
2018	2105842.059
2019	2232192.583
2020	2366124.138
2021	2508091.586
2022	2658577.081
2023	2818091.706
2024	2987177.208
2025	3166407.841
2026	3356392.311
2027	3557775.85
2028	3771242.401
2029	3997516.945
2030	4237367.962



8. Technology Requirement for Potato Starch Production in Ethiopia

8.1 Varietal Requirement

The dry matter content in potatoes is a very important factor. This is mainly determined genetically or by variety. Climate, soil types, maturity at harvest, moisture distribution during the crop growth period and fertilizer do also have an obvious influence on the dry matter content of the tuber. Silty soils and others with good water holding capacity are appropriate for high dry matter accumulation due to the availability of water to the plant. Warm, dry weather is beneficial to high dry matter content, while cold, wet weather tends to reduce it. The availability of potassium may also be relevant. Potato varieties required for starch extraction/isolation different from that used for consumption purposes. The varieties demanded for starch extraction purpose are high in their dry matter or solid portion concentration and are also not tasty for normal table purposes. This however does not necessarily mean other cannot be used for starch extraction purpose as some potato starch producing countries do reclaim starches from other purpose varieties such as those processed from Chips/Crisp and French fries. Culled tubers from table purposes are also used in their starch extraction process. Studies carried on dry matter content (DMC) and starch content (SC) and starch yield (SY) of released/improved varieties and widely grown farmer's cultivars under different agro-ecologies have indicated the prominence of some of these studied varieties over the these qualities. Consequently, DMC and SC values ranging from 17.82 to 26.70 and 9.75 to 17.85%, respectively, while SY ranging from 2.21 to 6.91 t.ha-1 (Tesfaye et al., 2012) are recorded for the varieties studied. This result is a clear indication of the potential present for considering potato as a candidate starch source crop. The starch yield per hectare advantage, multiple productions per annum owing to its short crop cycle, and premium starch quality brings potato top in the list of starch source crop. Potatoes provide a high starch yield per acre. For example, potato starch provides 7 tons of starch compared to 4-5 tons from wheat or corn, according to Bayer Crop Science. Results of dry matter content, and starch content and starch yield per hectare of potato varieties in the country have been evaluated across three major potato growing areas in the Amhara Regional State and the results of these two data are presented in table

Table 3. Mean dry matter content (%) of the 25 varieties in Ethiopia during 2011 cropping season.

Variety	Location		
	Adet	Merawi	Debretabor
Menagesha	18.44^{k}	17.45^{l}	17.05^{l}
Gera	22.06^{ghi}	19.98^{ghijk}	23.80^{ijk}
Challa	26.59	23.25	27.83
CIP-395096.2	21.82	20.85	24.58
Wochecha	23.73	18.65	26.55
Awash	19.99	18.83	22.43
Gorebella	25.09	22.33	29.18
Zengena	23.64	18.50	23.25
Hunde	19.95	18.35	23.75
Agere	24.24	20.70	29.98
Shenkolla	22.82	21.43	26.10
Belete	24.60	23.05	29.00
Ater Abeba	26.93	25.50	27.68
CIP-392640.524	21.76	19.73	26.00
Gudene	24.49	23.43	26.75
Bulle	21.01	20.88	27.33
Gabisa	23.60	19.10	23.65
Tolcha	25.70	20.30	24.93
Aba Adamu	25.42	19.75	25.88
Marachare	21.19	22.58	25.10
Sisay	21.76	21.15	26.15
Ararsa	19.59	20.53	24.25
Jalene	21.97	24.18	26.68
Guasa	23.09	25.85	29.95
CIP-396004.337	23.35	23.28	25.95
Mean	22.91	21.18	25.75
LSD	1.67	2.07	2.12

Source: Tesfaye, *et al.*, 2012.

Table 4. Mean starch content and starch yield of the 25 varieties in Ethiopia during 2011 cropping season.

Variety	Starch content (%)			Starch yield ($t.ha^{-1}$)		
	Adet	Merawi	Debretabor	Adet	Merawi	Debretabor
Menagesha	10.44	8.04	10.76	2.56	2.13	2.76
Gera	13.64	13.84	17.71	3.78	4.43	5.61
Challa	17.25	13.44	18.05	5.60	5.10	5.74
CIP-395096.2	11.60	14.44	17.38	3.26	4.06	5.36
Wochecha	12.05	12.68	11.58	2.45	2.59	2.03
Awash	12.03	13.21	13.14	2.03	2.27	2.33
Gorebella	18.39	14.97	20.12	5.79	6.40	8.04
Zengena	12.40	9.87	15.22	3.30	2.95	4.85
Hunde	18.51	11.44	11.67	4.79	4.52	3.53
Agere	16.98	13.48	14.30	3.82	3.37	3.86
Shenkolla	13.77	13.12	14.76	3.73	4.02	4.73
Belete	17.98	16.66	16.68	6.47	8.01	6.26
Ater Abeba	16.07	15.92	18.42	4.35	5.34	5.67
CIP-392640.524	16.27	13.44	14.44	4.23	3.76	3.37
Gudene	16.82	14.14	16.83	4.43	3.76	4.58
Bulle	12.73	12.17	16.31	2.89	2.99	3.96
Gabisa	17.96	11.72	17.92	4.53	3.71	6.20
Tolcha	17.82	10.89	15.27	3.68^{d}	1.62	3.08
Aba Adamu	16.93	12.74	14.92	4.71	3.72	4.03
Marachare	15.49	13.24	13.19	5.03	5.10	4.08
Sisay	16.58	13.13	14.94	4.35	3.36	4.60
Ararsa	11.64	12.29	13.22	3.00	3.56	3.56
Jalene	16.73	15.04	16.17	5.21	5.74	5.95
Guasa	17.12	12.81	18.06	6.60	5.55	6.34
CIP-396004.337	17.31	15.18	18.63	5.50	4.97^{c}	6.42
Mean	15.38	13.11	15.58	4.24	4.12	4.68
LSD	0.25	0.02	0.12	1.08	1.06	1.02

Source: Tesfaye, *et al.*, 2012

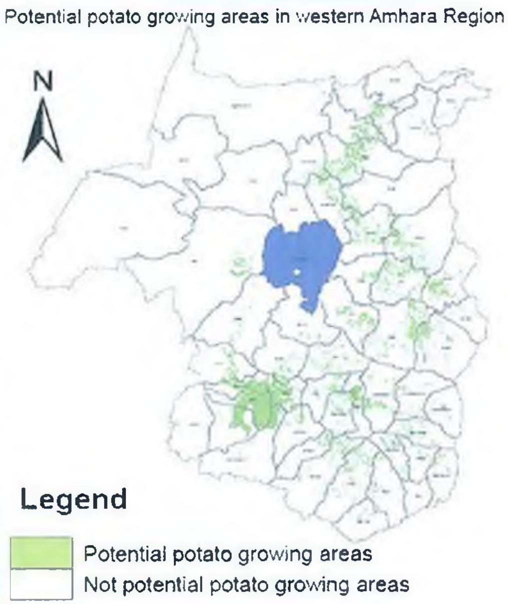
8.2 Location Profile

Globally starch extraction firms are established in areas closer to the raw materials. Besides, presence of good infrastructure to transport the raw material to the extraction factory, dependable power, and plentiful supply of potable water sources, reasonably priced industrial land presence are vital. This could be well learnt from the distribution of the corn starch extraction manufacturing factories in the USA and the potato starch manufacturing firms in The Netherlands. In the USA these firms are located at the three major corn growing States of America while in The Netherlands they are situated at the

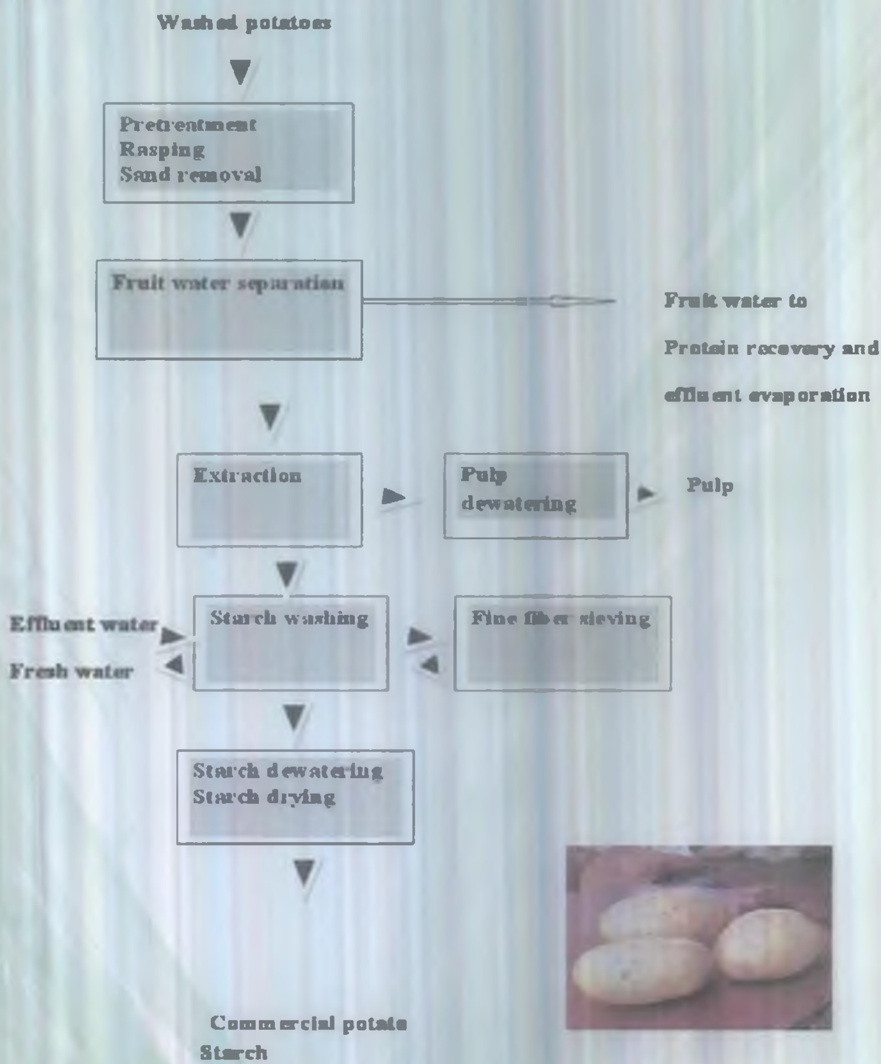
Northern parts of the country where the soil and the climate is ideal for better starch potato production. This is a strategic thought to help reduce the production costs mainly related to high transportation costs.

The agro-ecological suitability profile of major potato growing centers in Ethiopia, the Northwest, Central, Southeastern and Southern areas, at large and in Amhara Region in particular are known for their appropriateness for high tuber yield and quality potato production owing to the position of over 70% of the agricultural areas at an altitudes above 1500 meters above sea level (Figure 2). The climate, soil types except for their low fertility level due to long history of cultivation, weather condition and moisture distribution during the cropping season and presence of irrigable area and infrastructures for such production system are all conducive to ensure sustainable raw material supply that will enable that factory operate longer periods of the year. GIS based suitability map for potato production for the Western Amhara is done using optimum environmental conditions to grow potato such as temperature, rainfall, slope, and soil type.

It is important to note that potato starch processing is entirely different to other types of starch processing such as maize. Therefore potato starch is usually produced in different processing plants. Potatoes have a significantly higher starch yield per hectare compared to cereal. Essentially potatoes have high water content and it is not profitable to transport them any great distance in its raw state. Equally important is that they cannot be stored for a long period of time as the potato starch content decreases during storage. Thus, processing potato into other forms is a way-out to amplify the economic contribution of potato growers to the major potato growers in the highland areas.



8.3. Equipment and Buildings

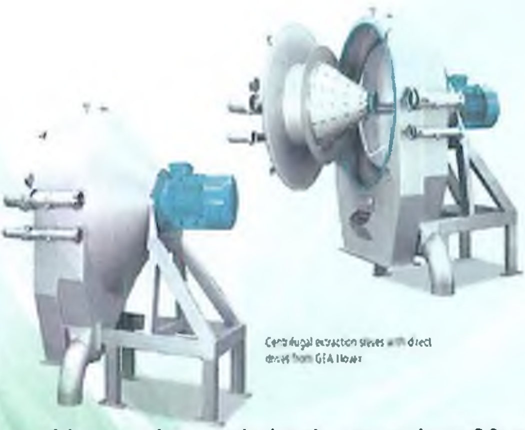


Process overview for production of potato starch

De-sanding cyclone **Rasper**

These machines are used to create a pulp containing fibers and as much free starch as possible.

Decanter: A machine to separate the potato protein from the starch and pulp for additional value such for animal feed in the fattening program



These are machines used to maximize the separation of free potato starch from the pulp and fibers by centrifugal seiving.

STEPS OF PRODUCTION PROCESS

Protein dewatering

9. Financial Analysis

The financial model for the potato starch production is built on a set of assumptions and parameters. All deterministic outcomes (net present value, internal rate of return, debt coverage ratios etc.) are calculated based on the key assumptions specified in the table of parameters. The potato starch production project has a 10 year project evaluation period which begins in 2016 with a construction period of one year. Project operations are assumed to commence and end in 2017 and 2023 respectively. All project assets are assumed to be duly liquidated in 2024 following the cessation of operations. The total investment cost for the potato starch project is 21 m ETB. The cost of the plant & equipments of 17 mil ETB accounts for 87% of the total investment cost whiles the cost of the buildings and civil works/land constitute as low as 8% and 5% respectively. This is due to the expensive and sophisticated nature of the machineries. The machinery possesses unique characteristics that accelerates the extraction of starch from the fresh triturated potato (slurry starch) and ensures the production of high quality starch free from any form of impurities. The plant and equipments used in the processing of potato starch include the dual-purpose mechanical washer, rotator cylinders, hydro-cyclones, centrifugal decanter and flash dryer. In other to adjust for any unexpected costs incurred in excess of budgeted amounts as a result an underestimation of the actual investment cost during cost estimation, an investment cost over-run factor is included in the financial analysis and initial fixed at 0%.

Investment Cost	**Amount**
Land/Civil work	1941174
Building	2411761
Plant & Equipment	17604891
Total	21957826
Investment cost over-run factor	0%

The total investment cost of the potato starch project is financed through equity and debt. 51.5% of the total investment cost is financed by loan while the remaining 48.5% is financed by the government who is the equity holder. The loan will be provided by Ethiopia Development Bank (BRD) depending on the investor interest and agreement on the at a nominal interest rate of 17% with a loan tenor of 8 years. Loan repayment will be made in 7 equal installments with one year moratorium starting from 2016 to 2022.

Loan repayment profile	choice	Equal Principal Repayment
Choice	1	
Loan disbursement	date	2016
Loan tenor	year	8
Grace period	year	1
Number of installments	year	7
Real interest rate	%	10%
Risk premium	%	0%
Loan repayment start date	date	2017
Loan repayment end date	date	2022

The loan repayment profile in the financial analysis is modeled to be dynamic and flexible in order to accommodate or handle different loan repayment structures such as the equal principal repayment structure and debt sculpturing. The equal principal repayment structure is such that, the project makes equal principal repayments of 14% annually whereas annual interest payment decreases. With regards to the loan sculpturing option, the annual debt is sculptured to match the annual net cash flows such that a certain percentage of the total principal amount is paid annually by the project depending on the net cash flows available for debt service and to satisfy the ADSCR benchmark of 1.5 times.

Table 7. Loan Repayment Profile YEAR

Principal Repayment Profile	UNIT	SUM	2016	2017	2018	2019	2020	2021	2022
Active	%	100%	0%	10%	26%	40%	17%	7%	0%
Equal Principal Repayment	%	100%	14%	14%	14%	14%	14%	14%	14%
Sculpturing	%	100%	0%	10%	26%	40%	17%	7%	0%

9.1. Production and Sales of Potato Starch

The potato starch plant begins production with a production capacity utilization of 100% representing one-8 hour shift in 2015. It is assumed that production capacity utilization will grow at a constant rate of 20% per year for a period of five years from 2016 until it reaches 200% in 2020, representing two-8 hour shifts. Afterwards, production capacity utilization will remain constant at 200% till the end of the project operations in 2023. The 8-hour output capacity of the potato plant is 8000 metric tonnes of starch per year. It is assumed that a minimum quantity of 8000 metric tonnes and maximum quantity of 16000 metric tonnes will be produced in 2016 and 2022 respectively. Output inventory constitutes 10% of annual total production quantity. It is however assumed that, all project output will be sold in the last year of operations in 2022; hence, no output inventory is carried forward to the next year.

Table 8. Production of starch

Production	Unit	Amount
Potato starch production	MT/year	8,000
Production capacity utilization during construction period	%	0%
Initial production capacity utilization	%	100%
Production capacity utilization growth rate	% / year	20%
Growth of capacity utilization beginning year	Year	2016
Production capacity utilization growing period	Year	5
Growth of capacity utilization ending year	Year	2030
Production capacity utilization	%	
Proportion of output exported	%	30%
Proportion of output traded domestically	%	70%

The deterministic analysis assumes no shortages of raw material supplies. The potato tubers or roots supplied by potato farmers are assumed to be sufficient to ensure sustainable production throughout the operational life of the project. The impact of shortages of raw materials on the project's feasibility will be discussed in details in the risk analysis. Provisions for plant technicians and support systems are made available to address any technical difficulties or contingencies that may arise during the plant operations to prevent disruptions in production. It is expected that 70% of the total output produced will be exported to industries in the East African regional member countries.

The remaining 30% of the out produced will be sold domestically. Domestically, potato starch is expected to play two important roles.

9.3. Operating Expenses

The operating costs of the project are classified into variable and fixed costs. The project's variable cost such as the cost of raw materials (fresh potato tubers) is a function the production capacity utilization and varies with respect to changes in the production capacity utilization. Nonetheless, the fixed costs including fixed electricity consumption, general and administrative expenses are independent of the production capacity utilization and hence remain constant regardless of changes in it. The operating expenses are initially computed in real terms and then converted to nominal terms using the domestic price index for the preparation of the cash flow statement. The average variable and fixed costs per metric tonne are 8946 ETB and 609 ETB respectively. Therefore, the average total cost per metric of potato starch production is 9576 ETB.

9.4. Price of Potato Starch

The domestic price of potato starch is fixed at 6080 ETB per metric tonne in 2015 prices. The price of potato starch varies from one country to another as the various potato starch processing companies strive to be competitive in the international starch market. The International Starch Institute (ISI) has created a platform that allows direct trade between suppliers and buyers of starch products. The trade platform created by ISI allows all potato manufacturing companies to advertise their products to prospective buyers at their own fixed prices. A similar platform is also created for buyers to find suppliers of starch products with an attached list of prices that the various buyers are willing to offer in exchange for a particular starch product. The price of potato starch varies across countries with a minimum of US$ 240 priced by Brazil and maximum of US$ 998 priced by Nigeria. The average price of potato starch considering the set of prices supply prices above is US$ 582. Considering the production cost per metric tone of potato starch of US$ 456, the FOB price of potato starch produced by the project is assumed to be US$ 664 per metric tone in order to stay competitive in the international market for potato starch. In the financial analysis, it is assumed that there is a 0% change in real price of potato starch over the anticipated life of the project. However, both the domestic and FOB price of potato starch will adjust to account for the change in domestic and foreign inflation rates.

10. Sectoral Linkage of Starch Production with other

By products from potato starch processing are disposal problems for the processor but a source of feed for livestock. Approximately 35% by weight of potatoes received for processing are usually separated and sold as cattle feed. Potatoes and potato byproduct are high in energy and low in protein. Composition of potato starch byproduct is quite variable depending on the processor, the type of waste, the length of time spent in the clarifier tanks, the amount of sediment in wash water entering the settling tanks and the amount of peeling byproduct included. Feeding potato byproduct to beef cattle requires good feed management and certain precautions. Nutrient losses occur as starch is broken down to simple sugars which in turn are used for bacterial growth. This produces acids and quantities of carbon dioxide which escape into the air. The micronora of fresh filter cake is highly variable. Total bacterial counts of fresh filter cake range from 10 to 100 million/ g, generally divided about equally between those that require air and those that do not. Mold counts range from 1 to 10 million! g in fresh samples and multiply rapidly on the surface areas during storage. Certain species of bacteria and molds produce toxins during growth that will cause problems in cattle fed the filter cake. Other species are pathogenic to animals when present in large enough numbers. Generally, numbers of pathogens are low in fresh filter cake but occasionally storage conditions develop which favor one species at the expense of others. If the favored species is a pathogen, the result could be sick or dead cattle in the feedlot. Acidosis in cattle can also result from the acidity caused by bacterial growth during storage of filter cake Filter cake is handled as slurry. For feeding, it is usually mixed with the ration's dry ingredients which absorb the excess moisture from the potato waste. The complete ration can then be augured into feeders.

Lye Peeling Waste is the residue from potato peeling operations which use a sodium hydroxide (lye) dip followed by mechanical action to remove the peel from potatoes. Lye peel contains about 14% solids. Starch content ranges from 50 to 65% of dry matter and is gelatinized due to the concentrated alkali and heat used in the peeling process. Average crude protein is 5.6%, fiber 7.6%, ash 6.9% and fat less than 1.0% of dry matter. Lye peel is very alkaline (pH 12 to 14) and must be neutralized before it can be fed. When stored by itself, lye
peel is quite stable microbiologically and has little loss of feeding value as long as the pH remains high. When 10 to 20% of chopped potatoes filter cake or beet pulp are mixed with lye peel, pH drops rapidly.

Microbial counts in lye peel are much lower than in filter cake but numbers build up rapidly when the two are mixed (Table 3). Bacterial numbers remain essentially static when lye peel is stored without mixing with other products. The high pH of lye peel prevents bacterial multiplication but some survive. The survivors include a high proportion of spore-forming bacteria. Some species of anaerobic spore forming bacteria produce potent toxins which cause cattle to go off feed and can cause death losses. Most cattle feeders store lye peel in pits with filter cake or other potato waste products. The lower pH resulting from this mixing allows bacterial fermentation to take place. During the fermentation process, starch is broken down and goes off into the air as carbon dioxide, thereby reducing the feeding value of the potato waste. Screening Waste and CulJ Potatoes Screening waste consists of cull or whole potatoes discarded because of size and small amounts of peeling. Screening waste has about 20% dry matter. This material can be handled like cull potatoes for feeding and storage. Cull potatoes can be fed fresh or ensiled by mixing with chopped hay to absorb excess moisture. However, they should not be left in piles where they can freeze during winter Feeders should crush cull potatoes before feeding so cattle will not choke on them. Dried Potato Products Variable quantities of dried waste are produced by processors of dried potato products (potato flakes, granules etc.). These potato wastes can generally be included in beef cattle rations without difficulty. Feeding Potato Waste When feeding potato waste to cattle, remember:

1. Potato waste is a highly variable feed ingredient. Variability is usually caused by the condition and time of storage.
2. Large amounts of potato waste can be fed to beef cattle after cattle have been adapted to such rations. University of Idaho research has indicated that 50% potato waste in finishing rations resulted in acceptable performance of beef steers.
3. Potato waste is valuable principally as a source of energy. Open pit storage may greatly reduce the starch content in a short time, thus reducing its feeding value. Inventory of potato waste should be rapidly turned over to reduce losses due to fermentation in storage.
4. While the price per ton of potato waste may be low, remember that you are buying and hauling between 80 and 90% water. On a dry matter basis, fresh potato waste has about the same energy value as barley
5. Consideration must also be given to protein and mineral content.

11. Conclusions and Recommendations

A key reason for the continued supply of potato starch is that it is known to be purer and of better quality than cereal starch, as it has the lowest content of fats and protein, with no colour, taste or smell. The possibility and present experience of year round production of potato, owing to its short crop cycle, that guarantee uninterrupted supply of raw material for full capacity operation of the factory is the other critical points considered. This paper presents the findings from discussions held with technical and managerial personnel from the processing sector to ascertain if there is an opportunity for Ethiopia to become involved in the production of potato starch. Research has occurred with regards to the National situation, supported by economic data and information obtained from different sources to verify what is currently occurring, providing a background for further investigation. This study envisages the establishment of a plant for the production of potato starch with a capacity of 1768 tones per annum. The present demand for the proposed product is estimated at 1768 tones per annum. The demand is expected to reach at 4000 tones by the year 2030. The plant will create employment opportunities and the total investment requirement is estimated at about Birr 21 million, out of which Birr 17 million is required for plant and machinery. However, a detail feasibility study should be carried to clearly examine the access of raw materials on a regular basis throughout the year, arrangements on the supply of the raw material from grower to manufacturing firm, price from its profitability point of view, access to sufficient money especially hard currency for importing the plan, provision of land for placing the plant and other relevant points.

12. References

1. Tesfaye, A., S. Wongchaochant, T. Taychasinpitak and O. Leelapon. 2012. Dry a matter content, starch content and starch yield variability and stability of potato varieties in Amhara Region of Ethiopia. Kasetsart J. (Natural Sci.) 46(5): 671–683.
2. Evaluation of Common Agricultural Policy measures applied to the Starch Sector. Final report. Agrosynergie. November 2010.
3. Kara Fawcett, 2011. Strategic Research Analyst, New Zealand Trade and Enterprise.
4. Global Starch Industry, May 2010. http://www.reportlinker.com/p090565-summary/World-Starch-Market.html
5. Trends and Prospects in International Trade in Potato Starch, September 2011 http://marketpublishers.com/report/consumers_goods/food_beverage/trends_and_prospects_4_ world_trade_in_potato_starch.html

6. Potato Starch: European Union Market Outlook 2011 and Forecast till 2016.
7. James BeMiller and Roy Whistler. 2009. Starch: Chemistry and Technology. Academic Press. 3rd Edition. Food Science and Technology. International Series. Amesterdam. 879 pp.