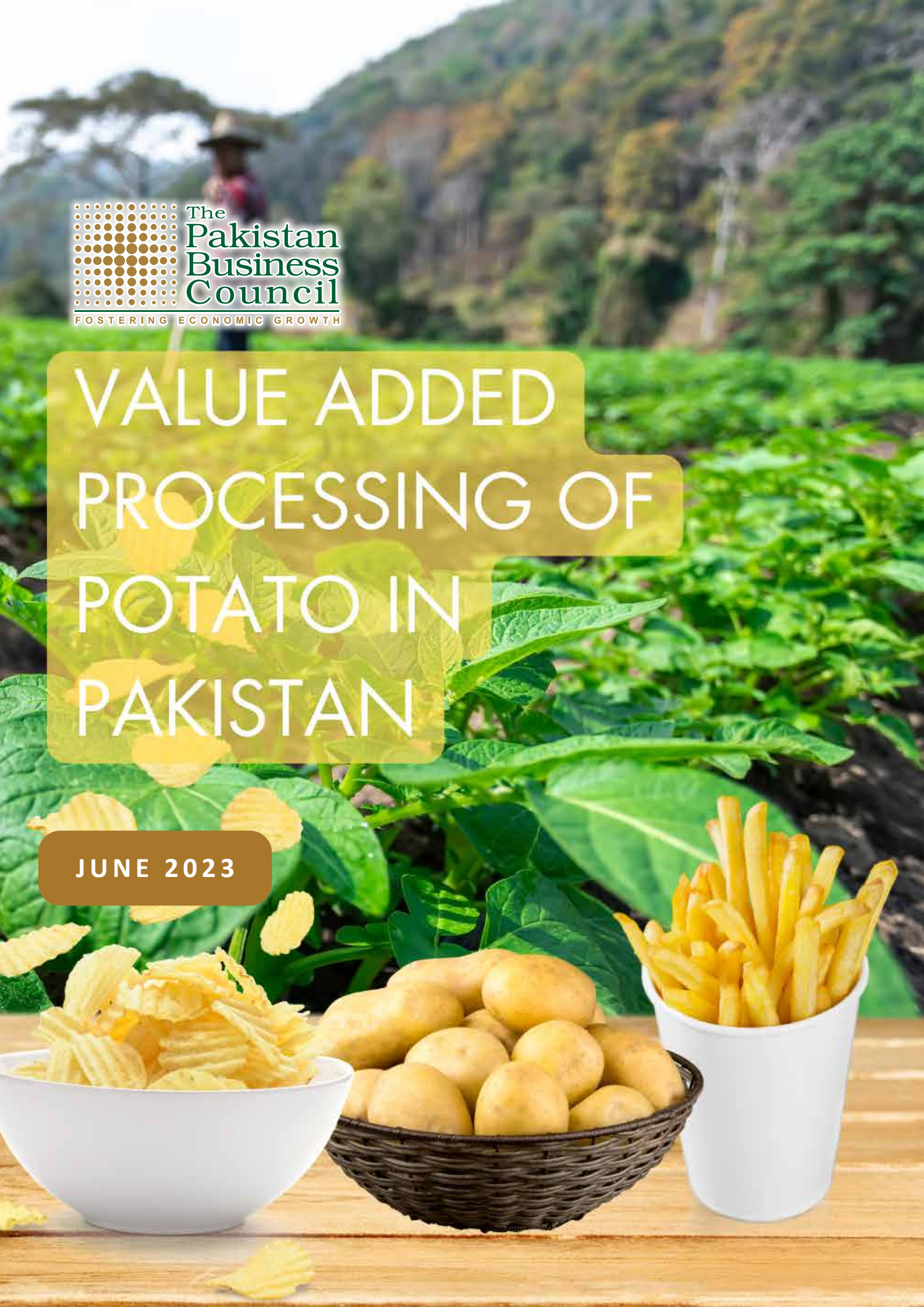

The Pakistan Business Council

FOSTERING ECONOMIC GROWTH

VALUE ADDED PROCESSING OF POTATO IN PAKISTAN

JUNE 2023

VALUE ADDED PROCESSING OF POTATO IN PAKISTAN

The Pakistan Business Council
FOSTERING ECONOMIC GROWTH

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Disclaimer

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The PBC is a pan-industry advocacy group. It is not a trade body nor does it advocate for any specific business sector. Rather, its key advocacy thrust is on easing barriers to allow Pakistani businesses to compete in regional and global arenas. The PBC conducts research and holds conferences and seminars to facilitate the flow of relevant information to all stakeholders in order to help create an informed view on the major issues faced by Pakistan.

The PBC works closely with relevant government departments, ministries, regulators and institutions, as well as other stakeholders including professional bodies, to develop consensus on major issues which impact the conduct of business in and from Pakistan. The PBC has submitted key position papers and recommendations to the government on legislation and other government policies affecting businesses. It also serves on various taskforces and committees of the Government of Pakistan as well as those of the State Bank, the SECP and other regulators with the objective to provide policy assistance on new initiatives and reforms.

The PBC's Founding Objectives

The major objectives of the PBC as stated in its founding documents are:

- To provide for the formation and exchange of views on any question connected with the conduct of business in and from Pakistan.
- To conduct, organize, set up, administer and manage campaigns, surveys, focus groups, workshops, seminars and field works for carrying out research and raising awareness in regard to matters affecting businesses in Pakistan.
- To acquire, collect, compile, analyze, publish and provide statistics, data analysis and other information relating to businesses of any kind, nature or description and on opportunities for such businesses within and outside Pakistan.
- To promote and facilitate the integration of businesses in Pakistan into the World economy and to encourage in the development and growth of Pakistani multinationals.
- To interact with governments in the economic development of Pakistan and to facilitate, foster and further the economic, social and human resource development of Pakistan.

The PBC is a Section 42 not-for-profit Company Limited by Guarantee. Its working is overseen by a Board of Directors. More information on the PBC, its members, and its workings, can be found on its website: www.pbc.org.pk

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Shan

SICPA

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Synthetic Products
Enterprises Limited

Standard
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systems

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LCI Lucky Core Industries

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List of Acronyms

CAGR	Compounded Annual Growth Rate
CPRI	Central Potato Research Institute
DM	Dry Matter
DUS	Distinctness, Uniformity and Stability
FSC&RD	Federal Seed Certification & Registration Department
GB	Gilgit Baltistan
KOPIA	Korea Programme for International Cooperation in Agriculture Technology
LR	Lady Rosetta
MSP	Minimum Support Price
MT	Metric Tons
NARC	National Agriculture Research Center
OPTP	One Potato Two Potato
PBR	Plant Breeder Rights
QSR	Quick Service Restaurants
SAP	Sodium Acid Pryophosphate
SPS	Sanitary and Phytosanitary
USA	United States of America
VCU	Value for Cultivation or Use

Foreword

This study entitled **'Value-Added Processing of Potato in Pakistan'** has been completed by The Pakistan Business Council (PBC) as part of its **"Make-in-Pakistan"** initiative.

What is required is to improve the availability of affordable and high-quality potato seeds and on-farm management by enforcing Plant Breeder Rights Act and improving technology adoption in potato cultivation to improve potato yield and increase investment in the sector.

Pakistan has the potential to utilize surplus of potato produce and manufacture value-added products, increase exports of these products, and create manufacturing jobs. Among all value-added potato products, french fries present an opportunity for Pakistan to increase exports. This is due to the fact that the domestic and the international market of french fries is growing. Moreover, regulatory duties on imports and the devaluation of the Pakistani rupee have created market space for domestic production and export. However, to be globally competitive, local manufacturers need to build a supply chain of potatoes suitable for french fries, adopt high-yielding and disease resistant seed, improve farming practices and work closely with the farmers.

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This sector report is intended to inform Pakistan's overall industrialization policy.

Ehsan A. Malik
CEO, The Pakistan Business Council

Executive Summary

Pakistan's surplus potato crop and its globally competitive price makes it an ideal destination for processing potato-based products. The country has the potential to convert potato into value-added products, increase exports, and create manufacturing jobs. Pakistan primarily produces potato crisps and french fries on a large scale, while manufacturing of potato starch and other value-added potato products is limited. The entry of PepsiCo with Lay's crisps has boosted cultivation and distribution channels for industrial-grade potatoes. French fries present an opportunity for Pakistan to increase exports; as its domestic demand is growing, there is potential to build scale locally, and to cater to the available global demand. The international market for crisps is smaller as compared to french fries, making crisps a less attractive product for export. Pakistan's potential for growth in other value-added potato products like starch, flour, and flakes is limited due to lower returns.

One of the key limitations facing potato processing in Pakistan is the lack of suitable potato varieties. Only a small percentage of potatoes harvested in Pakistan belong to industrial-grade varieties. The suitability of a potato variety for processing depends on factors like dry matter content, color, length and shape. Lady Rosetta (LR) is the most commonly used variety for industrial processing in Pakistan, suitable for making crisps. Because of the lack of demand, knowledge and access to capital, farmers do not grow other industrial varieties. Farmers in Pakistan, other than those who work with reputed processors, rely mainly on seeds sourced from the informal sector, hence resulting in low quality harvests. They also practice flood irrigation, which lowers the output and quality of the produce. Import of potato seeds has increased in recent years, which further accentuates the need for local production of high-quality seeds.

Potato cultivation in Pakistan has seen significant growth over the past decade, with an increase in both production and the total cultivated area. The total production of potatoes in Pakistan has doubled in the last decade, primarily due to increased cultivated area rather than higher yields per acre. Pakistan's yield per acre is lower as compared to countries like Turkey, Iran, and Egypt. To improve output, Pakistan needs to focus on adopting better seed varieties and improving on-farm management. Punjab, the largest province, accounts for over 85 percent of annual potato production, followed by the Gilgit Baltistan region. Punjab's potato clusters contribute a significant share of total potato production and supply crops for domestic consumption, industrial processing, and exports. Gilgit Baltistan provides off-season potatoes for commercial and domestic utilization, and has potential as a seed multiplication region. The availability of fresh potatoes throughout the year is supported by investments in cold storages. A few districts in Sindh like Badin, Sanghar, and Tando Allah Yar also have potential for potato cultivation, especially for varieties suitable for french fries. Investments in new varieties and regions may be important to cater the challenge of rising global temperatures which pose a threat to potato yields.

Pakistan has the potential to position itself as a french fries exporting country. The domestic market for french fries has grown, and companies like Opa and Panda Fries have increased their production capacity. Regulatory duties on imports and the devaluation of the Pakistani rupee have created market space for domestic production. However, to be globally competitive, local manufacturers need to build a supply chain of potatoes suitable for french fries and work with farmers. The global market for french fries has been growing, with increasing demand from developing countries, and the trade volume reached USD 8 billion in 2021. Industrial-grade potatoes are preferred for producing the right size and quality of fries. The global import market for french fries is dominated by developed economies like the United States, France, and the United Kingdom. Pakistan should aim to become a regional supplier of french fries by working with international fast-food brands. Contract farming and local seed production can help overcome the limited availability of suitable potatoes for mass production. With improvements in seed quality, farming practices, and collaborations with international partners, Pakistan can capitalize on its resources and meet the increasing demand for potatoes and french fries both domestically and internationally.

The potato crisps market in Pakistan is primarily dominated by PepsiCo, which holds over 70 percent of the domestic market share with its brand Lay's. The second leading brand is Snack City with about 10 percent market share, followed by Oye Hoye with around 5 percent market share. Other companies such as Triple Em, Lotte Kolson, and Dalda Snacks also have a presence in the market. Additionally, there are smaller companies and cottage industries producing unbranded crisps for local markets and bakeries. The manufacturing process of potato crisps involves slicing the potatoes into thin cuts, frying them at high temperatures, and then seasoning and packaging them. In the global market, the crisps industry has experienced growth, with trade reaching USD 2.76 billion in 2021. The top importing countries for crisps include the United States, France, Germany, Canada, and the Netherlands. These countries also have significant domestic manufacturing capabilities, indicating that the import figures only capture a portion of the market size. Among the top exporting countries are the Netherlands, Belgium, the United States, Poland, and the United Kingdom. Pakistan has limited opportunities for exporting potato crisps due to several factors. The domestic market is primarily served by PepsiCo, and smaller companies struggle to achieve scale and lack the infrastructure and brand power for international expansion. Exporting crisps would require significant investments in manufacturing facilities, packaging, and brand development. The high transportation costs associated with shipping crisps further discourage smaller companies from exporting. The best chance for Pakistan to have significant exports in the crisps segment would be if PepsiCo gears its production in Pakistan for export.

Pakistan currently relies on imports to meet its domestic demand for potato starch. The potential for localized production of potato starch exists, but the opportunities for exporting potato starch are negligible. Potato starch is used as a binding agent and thickener in the food industry and as a binder and adhesive in paper making. Globally, around 60 percent of potato starch is used in the food industry, while the remaining 40 percent is primarily used in the paper and paperboard industry. Pakistan's cheap potato supply presents potential for substituting imports and generating limited exports of potato starch in the future.

By improving the availability of affordable and high-quality potato seed, Pakistan can enhance potato yield and compete with other countries. Currently, most farmers in Pakistan rely on seeds passed down through generations, making their crops susceptible to diseases and blight, resulting in lower overall output. The high cost of procuring certified seeds makes them unaffordable for many farmers, who often opt for cheaper informal seeds. The government's in-vitro labs and seed multiplication centers have limited production capacity and lack commercial viability. Encouraging formal seed multiplication companies and providing a supportive regulatory environment can help meet the local seed demand. Improving technology adoption in potato cultivation, such as implementing drip irrigation to replace suboptimal canal water flooding, can enhance productivity. The government can collaborate with the private sector to develop financing mechanisms that promote the adoption of better technologies and seeds, leading to an increase in farming efficiency and higher potato yields.

Introduction

Pakistan exports over USD 100 million worth of potatoes each year with negligible exports of value-added potato products. The potato surplus that Pakistan exports has the potential to be converted into value-added products, provide sizeable increase in exports from the country and create jobs in the manufacturing sector. One advantage that Pakistan has in manufacturing potato products is the availability of cheap potatoes. The major cost component of value-added potato products. fries and crisps is the cost of potatoes, followed by cost of cooking oil for frying and the type of soil across Pakistan are well suited for production of potatoes, which can provide sufficient raw material for industrial processing by utilizing the right technologies and varieties. Cultivated area of potato has been increasing in Pakistan over the last couple of decades indicating farmers' preference to grow potato. This has resulted in a steady increase in its total production each year. Even though, potato yield has not increased in the last few years, it is nevertheless the only major crop in Pakistan with yield higher than the global average[1].

Potato crisps and french fries are value-added potato products with high domestic and global demand, both of which are produced in Pakistan. Other products such as potato starch, potato flakes, and potato flour and potato dextrins are not produced in sizeable quantities. Pakistan relies on imports of these products to cater to its domestic requirements. In Pakistan's context, substituting these imports and adding value to exports of potato should be given due consideration, given Pakistan has a sizeable production of potatoes. One major limitation in achieving this goal is the lack of availability of potato varieties which are needed to process these products. It is important to overcome this challenge in order for Pakistan to become an exporter of these products. PepsiCo. has been able to overcome part of this problem through its sustained efforts in working with farmers in Pakistan, to manufacture Lays potato crisps.

Pakistan was completely reliant on imports of french fries prior to 2015 for its domestic consumption and since has been able to substitute most of its imports. Domestic companies have able to localize production in the last decade. This has been a promising first step in Pakistan's move towards developing export markets for french fries. With additional capital investments, availability of suitable potato variety and better-quality potatoes, Pakistan is well positioned to enter the global markets Pakistan exports some potato crisps, but generally to niche ethnic markets.

Potato supply chain for manufacturing is critical in order for Pakistan to progress in manufacturing potato products. In order for this, companies have to work will need to work with farmers to introduce better varieties and provide them technical expertise. The government can play a role in ensuring development and implementation of a regulatory environment that facilitates greater manufacturing opportunities in Pakistan.

1 Pakistan's potato yield is 25 tons per hectare, whereas the average global yield is 21 tons per hectare. (Source: FAO)

POTATO SEEDS AND VARIETIES IN PAKISTAN

1. Potato Seeds and Varieties in Pakistan

1.1. Importance of Industrial Varieties

Estimates suggest only 5 percent of total potatoes harvested in Pakistan are industrial grade and used in commercial processing while the rest are table variety potatoes used for household consumption. This is quite low as compared to the international standards. Estimates suggests that globally less than 50 percent of potatoes are consumed fresh.[2] In Canada, around 60 percent of potatoes are utilized by the processing industry.[3] Compared to the industrial economies, the rate of processing in Pakistan is significantly lower.[4] To increase processing of value-added potato products, it is important to first increase the production of potato varieties which are suitable for industrial processing. While process able varieties can be sold to the retail consumer for domestic consumption, the table varieties cannot be used for processing.

Making potato products without the right variety results in poor quality. Without access to the optimal variety of potatoes, companies in Pakistan cannot make products that can compete in the international markets. There are certain characteristics that determine the suitability of a potato variety for processing. The most critical factor is the dry matter content. The general dry matter content needed for crisping and frying is above 20 percent, preferably around 22 percent. Table varieties have dry matter lower than 15 percent.

Potatoes are composed of two key elements, namely water and dry matter (DM). The largest proportion of DM is made up of starch, which is a carbohydrate. DM of potatoes also contains reducing sugars, protein, fiber, ash, proteins and a few vitamins and minerals. The table below shows the average content of the DM in a potato.[5]

Component	Average (g)
Starch	17.5
Sugars	0.5
Crude Fiber	0.71
Nitrogen	0.32
Protein	2
Lipids (fat)	0.12
Ash	1.1
Organic Acids	0.6
Total Dry Matter	22.85

Table 1 - Chemical composition of dry matter in potatoes

2 Potato Facts and Figures." *International Potato Center*, 2 Nov. 2017, cipotato.org/potato/potato-facts-and-figures/.
3 Potatoes and Potato Products, Global Agricultural Information Network, USDA Foreign Agricultural Service, 2018
4 Estimates suggest that India utilizes 7.5 percent of its potato production for processing, only marginally higher than Pakistan, but India has been gearing up its processing industry and exports in the last decade.
5 Sablani, Shyam & Mujumdar, A., Drying of Potato, Sweet Potato, and Other Roots. Handbook of Industrial Drying, Fourth Edition. 2006

Potatoes for crisps and fries both require a high DM content. Potatoes suitable for fries should be long-oblong shape (preferably over 10 centimeters) with low level of reducing sugars. High starch content in potatoes suitable for french fries allow for a fluffy and mealy content in the product. Potatoes for crisps should be medium size, oval and have very low levels of reducing sugar contents.[6] Varieties for processing should also have no asparagine content, low eye depth, smooth surface, an appealing post frying color, and long storage durability.[7]

1.2. Potato Seeds in Pakistan

Most of the seeds used to cultivate potatoes are of low quality and result in below-par quality potato harvest. Despite this, Pakistan's yield for potatoes fares better than the global average. In 2019-20, Pakistan's area under potato cultivation was 166,000 hectares and with an estimated seed requirement of 415,000 metric tons (MT) of which 5,996 MT was imported. The number of seeds provided by the government institutes/ departments is under 50 MT.[8] Based on these estimates, less than 2 percent of seed requirement in Pakistan was met through formal channels in 2019-20.[9] Most of the seeds utilized for potato cultivation in Pakistan are supplied by the informal sector. Farmers use seeds from previous crops or produced by unregistered seed companies. Utilizing informal seeds or those that are of old generation, causes crops to be susceptible to diseases such as late blight and scab.

Pakistan imported potato seed valued at USD 12.4 million in 2021. Over 90 percent of the imported seed was from Netherlands while there were some imports from China, Germany, USA, France and Denmark as well. This is the highest ever recorded seed import in Pakistan which has increased by almost three times compared to seed imports in 2019 which were USD 4.6 million. While Pakistan has been importing potato seed to the tune of USD 5 million since the year 2005, there has been a large increase in its import in the last few years. Some of the increase can be attributed to a higher demand of industrial grade varieties by the processing companies to make fries and crisps. These seeds comprise of less than 5 percent of the total seed demand in Pakistan, which highlights the importance of localizing and supplying high quality seed in Pakistan.

6 Kizito, K.F. et. Al. Quality Attributes of French fries: Factors Affecting Thereon - A Review. University of Alexandria. 2015

7 Exclusive: What Potato Varieties Are Suitable for Chips." Potato Business, 17 Dec. 2018, www.potatobusiness.com/process/exclusive-what-potato-varieties-are-suitable-for-chips

8 IFPRI cites then number at around 10 MT, although the GB department of Agriculture claims to have produced and distributed 30 MT.

9 Rana A.W., Gill S., Akram I,. Seed System of Pakistan: Policy Challenges and Prospects, Pakistan Agricultural Capacity Enhancement Program, International Food Policy Research Institute, 2022

The Federal Seed Certification & Registration Department (FSC&RD) approves seed varieties in Pakistan. The seed goes through a rigorous testing process before it can be certified and provided to the farmers for cultivation. The figure below illustrates the seed approval process.[10]

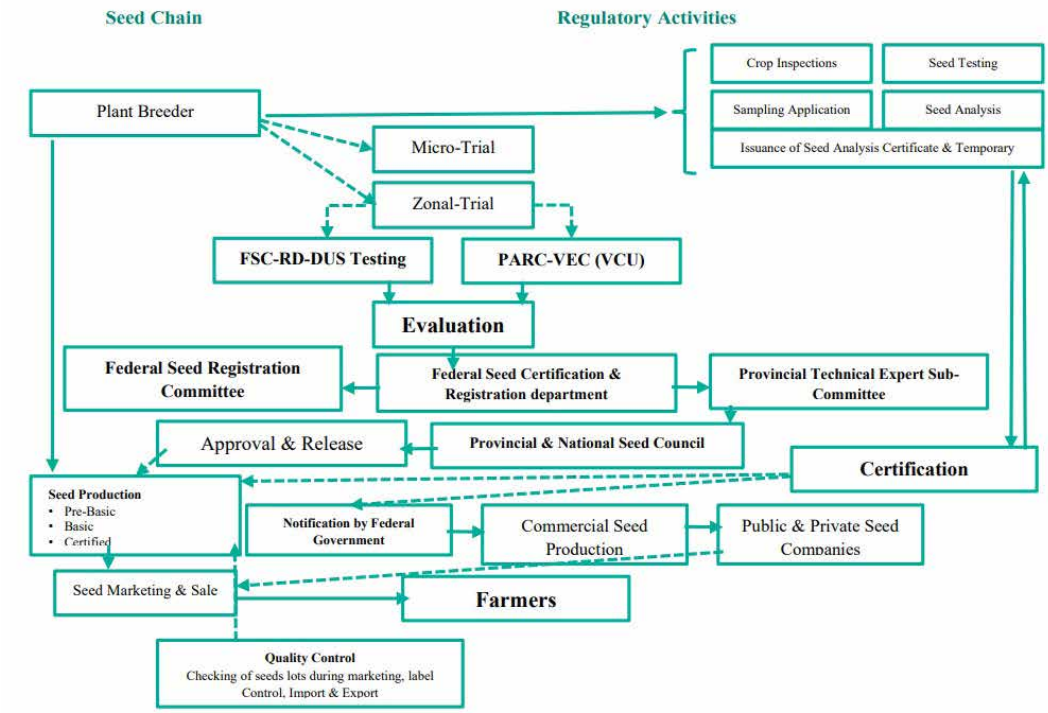


Figure 1 - Seed approval process in Pakistan

Introduction of new varieties is a lengthy process where the seeds go through rigorous trials, primarily Distinctness, Uniformity and Stability (DUS) and Value for Cultivation or Use (VCU) Testing. DUS tests are carried out to ensure that the new variety is distinct from existing varieties that are prevalent in the country. Uniformity of a varieties' characteristics is also established in DUS testing to ensure the crop remains similar and that its characteristics remain stable from one generation to the next. VCU tests are carried out to evaluate agronomic characteristics of seeds such as resistance to diseases and defects. It gets evaluated from federal and provincial registration bodies before it is approved for either domestic production or import. The usual time frame for such approvals is at least three years upon submission of seeds for testing.

Despite the lengthy process of obtaining approvals for new varieties, Pakistan already has approvals for a lot of varieties that are used globally for industrial level potato processing, such as Russet Burbank. While there may be novel varieties with better yields and promising processing results, the focus in Pakistan should be on increasing farmers' exposure to registered and formal seeds and improved farming technologies. There are enough approved varieties available which would cater for industrial requirements in Pakistan. The issue is lack of knowledge and capital to access seeds from formal markets and high reliance on purchase of informal seeds due to lower costs.

10 Rana A.W., Gill S., Akram I,. Seed System of Pakistan: Policy Challenges and Prospects, Pakistan Agricultural Capacity Enhancement Program, International Food Policy Research Institute, 2022

The Government of Pakistan through the National Agriculture Research Center (NARC) is collaborating with Korea Programme for International Cooperation in Agriculture Technology (KOPIA), Government of South Korea to develop local potato seeds in Pakistan through aeroponics technology. Through this technology, potato seeds are grown inside a green house and are provided nutrient solutions through nozzles and mist. This is a soil-less method for producing pre-basic seed and helps tubers grow faster.[11] While this is a promising start, unless the project is scaled in collaboration with the private sector and with other provincial governments, it may not give tangible and productive results in meeting the demand for seeds in Pakistan.

1.3. Potato Varieties in Pakistan

The research institutes in Pakistan have re-engineered some potato varieties, which are compatible with Pakistan's climate. These seed varieties were originally produced in Europe. The re-engineering has given greater tolerance for frost, which is better suited to Pakistan's climate. In Pakistan, frost has an adverse impact on the output of the spring crop harvested in February-March. This phenomenon is more prevalent in Pakistan and not in the European countries since potato is a summer crop in Europe as shown in the table below.[12]

Season	Plant	Harvest
Early	March	June - July
Second Early	March - April	July - August
Main Crop	April	September - October

Table 2 - Cultivation and harvest months of potatoes in Europe

While potato seed varieties have been developed locally, but have not been cultivated by the local companies or used in processing. There is a greater need for interface and coordination between the private sector and the government seed research institutes and departments, to obtain conclusive research. Potato Research Institute, Sahiwal claims that seeds produced in its in vitro labs are more than 10 times cheaper than the imported varieties which make them more feasible for adoption as well. The institute has developed around eleven different varieties, each tailored to different needs such as industrial use, and different region and temperate zones of Pakistan. These are yet to be adopted by any large-scale manufacturer or industrial producer.

The most commonly adopted variety for industrial processing in Pakistan is Lady Rosetta (LR). LR is now commonly grown by many farmers since it has a high demand from processors across the industry. LR was initially propagated by PepsiCo. in Pakistan and is still the most widely used industrial variety in the country. Anecdotal evidence suggests that Hermes was also introduced by PepsiCo. although its adoption was not successful in Pakistan. The Hermes plantations did not provide good yields and were susceptible to local diseases.

11 Ahmed, Amin. "Self-Sufficiency in Potato Seed." DAWN.com, 22 Mar. 2021, www.dawn.com/news/1613799
12 "Potatoes." RHS, www.rhs.org.uk/vegetables/potatoes/grow-your-own. Accessed 25 May 2023

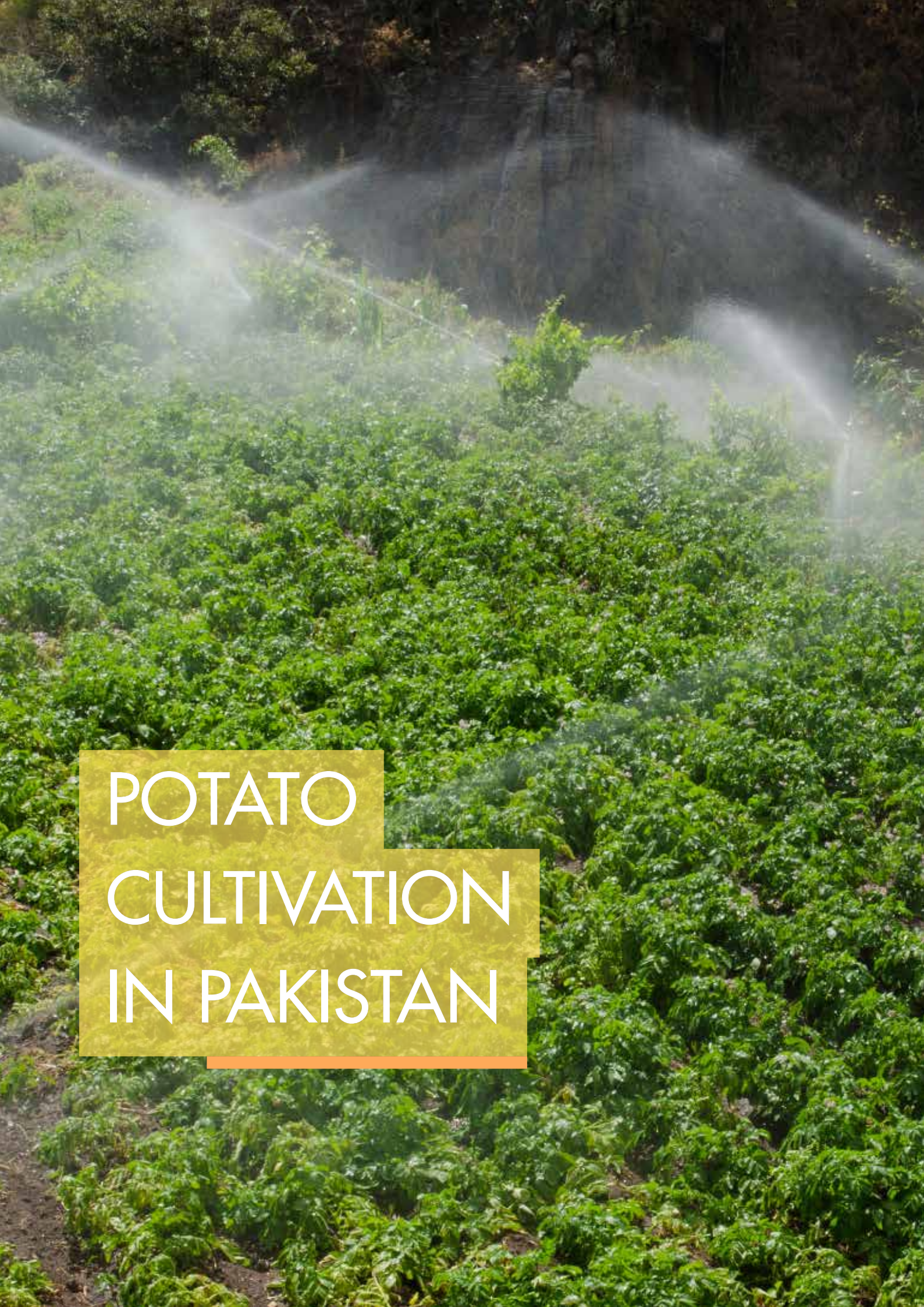
Farmers in Pakistan cultivate the following certified potato varieties which are suitable for crisps:

- Lady Rosetta (red skinned)
- Hermes (white skinned)
- Lady Jo (white skinned)
- Lady Claire (white skinned)

The available certified varieties suitable for french fries are:

- Asterix (Red Skinned)
- Santana (White Skinned)

While LR is most suited for crisps, whereas the lack of industrial varieties suitable for french fries has forced the domestic processors to utilize LR in making french fries. More recently, the domestic fries industry is exploring possibilities to shift to specific french fries varieties as well, such as Santana.



POTATO CULTIVATION IN PAKISTAN

2. Potato Cultivation in Pakistan

Pockets of production in different regions of Pakistan have helped create availability of potatoes throughout the year. Punjab accounts for over 85 percent of the annual potato production in Pakistan. The availability of fresh potatoes domestically has been further aided by investments into cold storages that keep enough stock in store for the whole year.

Temperature is a key factor which regulates phenological growth and development of the potato crop. Potatoes are cultivated during autumn and spring season in the plains and during summer in the hilly areas. This is because potatoes require a frost-free environment and cannot thrive in hot temperatures (above 30'C air temperature) which restricts tuber growth and may cause them to rot. Night time temperature above 20'C and below 10'C are not suitable for potato cultivation. A temperature range of 12°C to 15°C is optimum for tuber production. Rising global temperatures may result in declining yield for potato crop in the future, unless strategies to cope with climate change are not adopted and new varieties are not developed.[13]

2.1. Regions

There are three main potato growing regions, or clusters in Pakistan. The first cluster, located in Punjab, includes the districts of Kasur, Okara, Sahiwal, Pakpattan, Multan, Khanewal and Vehari and contributes up to 70 percent of total potato production. Of this, the highest share of production is in Okara. Since it is the primary region of production, farmers have large scale operations and there are cold storages located across the region. The second cluster, located in Punjab, includes the districts of Chiniot, Jhang, Toba Tek Singh and Faisalabad, and contributes to around 9 percent of total production of potatoes in Pakistan. Both the clusters in Punjab provide crops which are suitable for domestic consumption and also produce potatoes suitable for industrial consumption, mostly in the form of contract farming. Most of the exported produce is also harvested from these regions. One problem in this cluster is that seeds are informally supplied from this region to the rest of the farmers in Pakistan. The smaller cluster in Punjab has relatively smaller land holdings and supplies mostly to the domestic market as compared to the larger cluster.[14]

13 Kalil, T., et. Al, Climate Change and potential distribution of potato crop cultivation in Pakistan using Maxent. AIMS Agriculture and Food. May 2021.

14 Cluster Development Based Agriculture Transformation Plan Vision 2025 – Planning Commission of Pakistan, Ministry of Planning Development & Special Initiatives, February 2020.

The third cluster of production in Pakistan is located in Gilgit Baltistan (GB) spread over ten districts and contributes to 8 percent of total production. GB provides off-season potatoes for commercial and domestic utilization for the rest of the country. The land holdings in GB are significantly smaller than in Punjab, which makes it relatively unsuitable for large scale industrial crop farming. In the absence of cooperatives which work under a joint contract farming mechanism, it will be difficult for companies to be able to source fresh potatoes in bulk from GB. The region is still quite advantageous in providing fresh off-season product to the rest of the country. The farmers in GB are able to get a higher price than farmers in Punjab since there is a large domestic market which prefers fresh produce, rather than cold stored potatoes. Potatoes in cold storage have higher reducing sugars content due to converted starch. Apart from being an off-season supply region, GB also holds potential to be a seed multiplication region for the rest of the country, since it is not affected by the monsoon rains and the aphid virus vector.[15]

Regions in Sindh may be well-suited for potato cultivation, especially varieties for french fries. While, no formal studies have been conducted on the subject, suitable climate and long sunny days during the winter cropping time would make certain districts ideal for potato cultivation such as districts of Badin, Sanghar and Tando Allah Yar. These areas have sandy loam soil which is well suited for potato cultivation and are quite similar to Gujrat in India, which became a major potato production area for french fries in the 1990s.

2.2. Production of Potato in Pakistan

The total production of potatoes in Pakistan has doubled in the last decade. The output in 2013 was approximately 3.8 million tons which increased to 7.9 million tons in 2022. The increase in production cannot be attributed to higher yields per acre, but to the increase in total area under cultivation, which increased from 170,000 hectares to 314,000 hectares. The yield has remained stable at around 25 tons per hectare for the last few years. The yield of potato in Pakistan is slightly better than the global average, but it is still low and can be improved. Similar countries such as Turkey, Iran, and Egypt have yields of 35, 34, and 29 tons per hectare, respectively. This means that Pakistan can improve output by focusing on improving the yield, mainly through application of better seed varieties and improving on-farm management.[16]

15 Ibid.
16 Food and Agriculture Organization of the United Nations. FAOSTAT Statistical Database. [Rome]: FAO, 1997

2.3. Quality Constraints

The main challenge in obtaining good potato harvests in Pakistan is the use of poor-quality seed which results in low quality output. It impacts export prices as well as industrial output. While lower quality produce may suffice for the price sensitive domestic market and household use, it does not serve well for producing for the international market or for industrial processing. Another challenge in obtaining good produce is the impact of climate change. Recent changes in climatic conditions are in particular more dangerous to the potato output. Potatoes are quite sensitive to frost and low temperatures causing their branches to wilt and hindering crop growth, resulting in small size. Lastly, late blight can cause significant damage to potato crop. Caused by the water mold, Phytophthora infestans infects leaves and stems and can quickly spread across the fields if left untreated.[17] Potatoes in Pakistan are also susceptible to various infections caused by viruses, which can be transmitted through aphids, mechanically and through the soil. The most common viruses in Pakistan are potato leaf roll virus, Tobacco Rattle virus, and Potato mop top virus. With better certified seeds, the control of viruses is possible since they have genetic resistance to such viruses. Having genetically stronger seeds is a better method to tackle viruses than chemical application to control them.[18]

17 Schuh, Marissa. "Late Blight of Tomato and Potato." UMN Extension, extension.umn.edu/disease-management/late-blight. Accessed 21 May 2023

18 Arocha, M. and Ali, U. The Agribusiness Project (TAP), Potato Value Chain Competitiveness Assessment. USAID. 2014

POTATO
FRENCH FRIES

3. Potato French Fries

Pakistan has the potential to position itself as a french fries exporting country. A growing domestic market with cheap availability of potatoes has encouraged domestic production of french fries. Domestic companies have started scaling-up production capacity, which will eventually create unused excess installed local capacity over time. With the acquisition of greater technical knowledge and capital investments, local manufacturers of french fries will likely have the opportunity to export.

3.1. An overview of the domestic french fries market

The largest share of Pakistan's french fries market is held by Opa french fries, a subsidiary of Fauji Fertilizer Company. Opa has roughly 68 percent of the domestic market share.[19] Its retail and B2B ratio is around 40 and 60 percent respectively, slightly higher than the global average. Opa has made sizeable investments, to the tune of PKR 600 million, in 2021 for upgrading its processing facility to produce an additional 3 tons of french fries an hour.[20] Apart from Opa, Panda Fries is the second largest processor of fries in Pakistan which is also more than doubling its annual production capacity in 2023 from 1,500 to 3,500 tons per annum. It is pertinent to mention here that these companies have grown their domestic production multiple times since their initiation in 2018, showing a sizeable opportunity for growth. Most french fries were imported prior to 2018. As the figure below highlights, french fries valuing at USD 11.3 million were imported in 2017, before the start of domestic production.

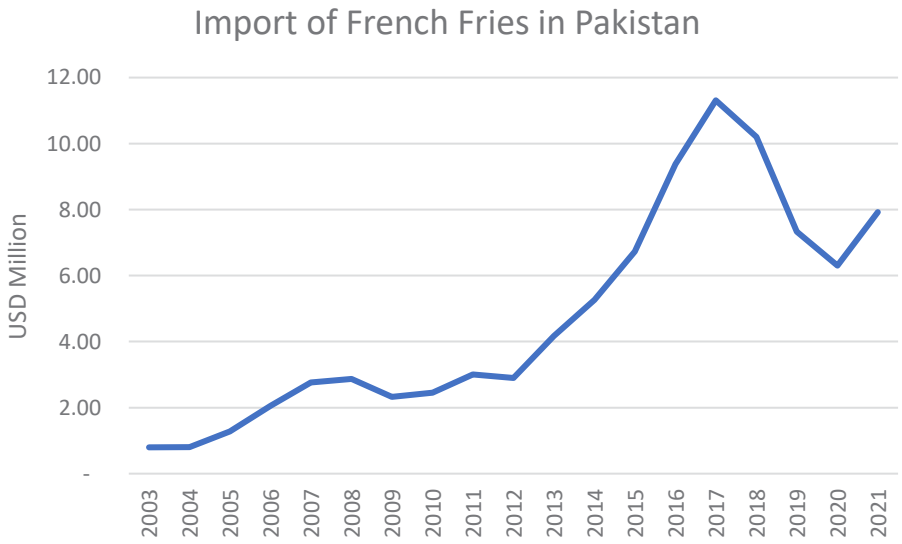


Figure 2 - Import of french fries in Pakistan

Source: ITC Trade Map

19 Annual Integrated Report, 2021, Fauji Fertilizer Company Limited.
20 Ibid.

The devaluation of Pakistani rupee and increased rates of import duties created a market space for domestic production after 2017. It is still important to note that despite import of around USD 8 million of french fries in 2021, domestic companies were able to produce sizeable quantity of fries and scale up their production. Availability of Lady Rosetta, the industrial grade potatoes used for crisps, provided raw material for businesses to process fries. A number of other smaller manufacturing units have established their production in Pakistan with smaller market share such as Golden Brown, Grizzly Fries, Kings Fries, Frozen Hub, etc. Anecdotal evidence suggests that another sizeable investment is being undertaken by the Venus Group to set up a large-scale manufacturing unit of french fries in Pakistan, although, it will take a year or so before it starts manufacturing operations.

Apart from the aforementioned companies, quick-serve fries are being provided to consumers at different locations all over Pakistan. Some businesses operate on a take-away/delivery model to provide quick-serve fries to consumers. The largest multi-store operation in Pakistan is One Potato Two Potato (OPTP) with over sixty outlets across Pakistan. Apart from this, there are thousands of stall/carts/kiosks selling fries all over Pakistan. Most of these small set-ups source local potatoes and use hand cutters to slice and fry fries on site.

The domestic demand for french fries can double by 2030. The production capacity in Pakistan has increased manifold in the last decade. In the absence of imports, Pakistan can increase production and easily cater to the domestic demand for french fries. Since less than 1 percent of total potatoes would be utilized for this purpose, there is more than adequate supply of potatoes available. But, to be globally competitive, local manufacturers will have to work with farmers to build a supply chain of potatoes that are suited for fries in order to be able to cater for export markets. Adoption of PepsiCo’s model for contract farming may help overcome the lack of suitable variety.

3.2. How French Fries are made in Processing Lines

All french fries produced in large scale manufacturing process are par-fried, meaning they are partially fried before they are packaged. End consumers (retail or B2B) fry them again before serving them. The process for manufacturing par-fried french fries is shown in the figure below.[21]

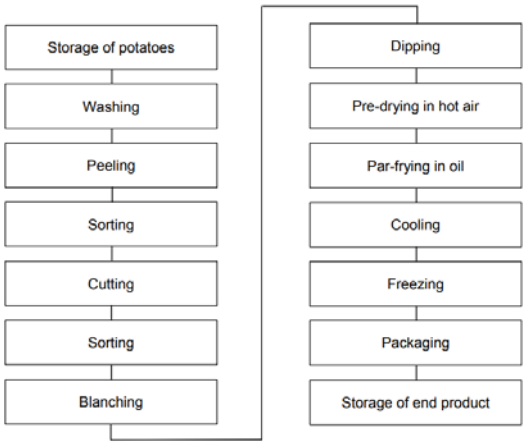


Figure 3 – French fries production process

In manufacturing french fries, utilizing industrial grade potatoes is critical. The correct amount of DM in a potato will provide it with enough carbohydrates to keep it firm, mealy and fluffy during consumption. Long potatoes are preferred to get the right size of fries, ideally above 100 mm. Fries can be sliced to different thickness. Too thin, and they may break up or curl during the frying process. Too thick, and they retain too much moisture without being crisp.[22] The blanching process cooks the fries to remove bacteria and germs on the potato. It kills the enzymatic action within potatoes that preserve the flavor, color and texture of the potato by breakdown of pectin. Furthermore, it develops a surface gelatin that forms a crusty layer during the frying process. It also extracts reducing sugars and amino acid asparagine and reduces acrylamide promoting content in potatoes.[23][24] Getting the correct amount of reducing sugars is also very important in the french-Frying process. High sugar content causes the fries to get limp immediately after final frying. Sugar content below 3 percent is optimal for getting golden crispy french fries. Long haul storage of potatoes results in high sugar content and can result in poor quality of french fries.

21 Loon, Van Wil, Process Innovation and Quality Aspects of French fries, PhD thesis Wageningen University, The Netherlands, 2005

22 Damto, T. Chala G., Effect of Blanching and Frying Time on the Sensory Quality of Fried Sweet Potato Chips, Department of Post-Harvest Management, Jimma University, Food and Nutrition Science Journal

23 "Asparagine is a non-essential amino acid in humans, Asparagine is a beta-amido derivative of aspartic acid and plays an important role in the biosynthesis of glycoproteins and other proteins. A metabolic precursor to aspartate, Asparagine is a nontoxic carrier of residual ammonia to be eliminated from the body."
Definition by National Library of Medicine, National Center for Biotechnology Information.

24 "Acrylamide is a substance that forms through a natural chemical reaction between sugars and asparagine, an amino acid, in plant-based foods – including potato and cereal-grain-based foods. Acrylamide forms during high-temperature cooking, such as frying, roasting, and baking."
Definition by U.S. Food and Drug Administration. Accessed through: https://www.fda.gov/food/process-contaminants-food/acrylamide, Last Accessed: 8th March, 2023

There are a number of pre-frying treatments that can take place. These include dipping fries into a Sodium Acid Pryophosphate (SAP) solution to reduce discoloration after frying. Fries can also be dipped into coating materials such as cellulose derivatives, such as methylcellulose, pectin coatings, whey proteins, starches, gums, etc. to provide a crispier outer layer.[25] After this, fries are dried before entering them into oil to reduce splash and degradation of oil through hydrolysis. After frying, the final stage involves cooling and freezing fries. Once frozen, the fries are packaged, ready for storage and distribution. The fries have to be stored and distributed in temperatures under -18°C.

An alternative method of production is through serving baked French fries, which are not produced in Pakistan and will not be produced in Pakistan for the foreseeable future. Even globally, baked french fries are a very small segment of the total production.

3.3. An outlook of the Global Market

The global imports of french fries have increased by an estimated Compounded Annual Growth Rate (CAGR) of 6.8 percent since 2002 till 2021. There is a likelihood that this trend will continue to increase in the coming decade due to increasing uptake of fast food in the developing countries, which is complemented by french fries. The import of french fries globally in 2021 was USD 8 billion. The figure below illustrates the growth in the global import of french fries.

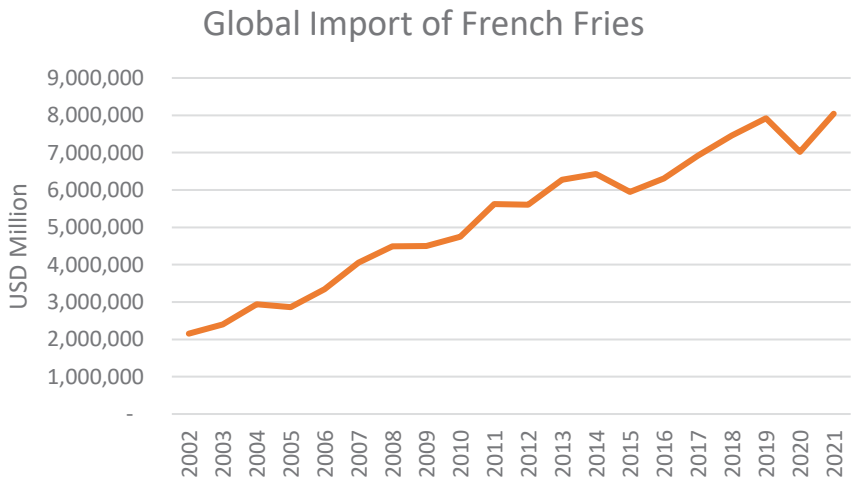


Figure 4 - Global import of french fries

Source: ITC Trade Map

The top french fries importing country is the United States of America (USA). The USA has a sizeable domestic production of french fries as well, showing a high level of consumption of the product within the country. The table below shows the top 10 countries and the import value of french fries in 2021. As evident, most of the french fries are imported by developed economies, showing the high rate of fast-food consumption that takes place in these countries.

25 Kizito, K.F., Youssef, M.M., Abdel-Aal, M.H. & Ragab, M.H.H, Quality Attributes of French fries: Factors Affecting Thereon A Review, Food Science and Technology Dept. Fac. of Agric. University of Alex. El-Shatby, 21545, Alexandria, Egypt, (2015).

Country	Import Value (USD)
United States of America	1,338,856
France	553,344
United Kingdom	511,477
Japan	477,056
Germany	367,870
Brazil	292,567
Italy	289,703
Saudi Arabia	266,280
Netherlands	258,490
Mexico	219,432

Table 3 - Import of french fries (USD) by top 10 countries

Source: ITC Trade Map

Most of the consumption of french fries takes place in quick service restaurants (QSR). Estimations across the globe show that 65 percent french fries are sold at QSR, 20 percent at full-service restaurants and 15 percent at the retail level. Despite the fact that retail market increased during the Covid-19 pandemic by 2 percent, a large share of french fries are still sold through restaurants.[26] In the United States, 90 percent of french fries are sold in QSR. Since a large share of fries are sold without direct brand associations, companies can manufacture and create markets through B2B channels without direct customer interface.[27] In Pakistan, international fast-food chains are collaborating with domestic partners for sourcing of fries. End consumers associate the taste of the final product with the restaurant that they consume fries from and the restaurants can choose their supplier based on multiple criteria, including price.

3.4. Opportunities for Pakistan in the French Fries Segment

Pakistan should aim to work with the international fast-food brands to become a regional supplier of french fries. The biggest challenge to this is limited availability of potatoes suitable for mass production. Contract farming can be an effective method to overcome this issue. PepsiCo. has created an ecosystem whereby local farmers are willing to work with formal companies to provide potatoes suited for industrial processing. While scaling the desired varieties may take time, companies should work with the government to localize the production of seeds for un-patented varieties suited for french fries.[28] Local seed production offers two major advantages. Firstly, it lowers the cost to the farmers significantly, since locally propagated seeds can be around ten times cheaper than imported ones. Secondly, it lowers the import bill and develops domestic capabilities to manufacture and innovate on varieties suited to domestic needs and conditions.

26 Nunes, Keith (2020). QSR demand central to Lamb Weston Outlook, Article retrieved from: https://www.bakingbusiness.com/articles/50691-qsr-demand-central-to-lamb-westons-outlook, Last accessed 7th March, 2023

27 Parikh, Anish A. and Nelson, Douglas C. (2013) "Fat Absorption in Commercial French fries Depending on Oil Type and Coating," Hospitality Review: Vol. 30 : Iss. 2, Article 1.

28 Colloquially referred to as "open varieties", seeds which have over twenty years of patent can be locally sourced and propagated.

Import data of countries importing french fries and export of Pakistan's potatoes is a good marker for gauging potential market for exporting french fries from Pakistan. The table below shows countries that import potatoes from Pakistan and also import french fries from the rest of the world.

Country	Import of Potatoes from Pakistan (USD '000)	Import of french fries (USD '000)
Malaysia	6,709	101,244
Russian Federation	15,390	90,030
United Arab Emirates	18,718	86,484
Singapore	1,016	49,425
Qatar	10,644	21,854
Oman	5,318	18,886
Kazakhstan	1,516	17,779
Bahrain	2,129	13,941
Sri Lanka	19,485	2,038
Afghanistan	29,567	194
Total	**110,492**	**401,681**

Table 4 - Potential export destinations of french fries from Pakistan

Source: ITC Trade Map

Pakistan already exports over USD 110 million worth of potatoes to countries which import over USD 401 million of french fries from across the world. Pakistan can sizably increase its exports by processing and selling fries to these countries. Existing market access to these countries and their distribution channels, will make exporting relatively easier. Investments in higher grade capital equipment and internationally recognized certifications, will also enable Pakistan to export to these markets. Most of these countries have relatively less stringent Sanitary and Phytosanitary (SPS) requirements than developed countries. At the same time, it is unlikely that Pakistan will be able to export to high value markets such as the United States or most European countries due to high quality requirements and sanitary restrictions. In addition, China is the largest producer of potatoes in the world, and an unlikely export destination for Pakistan's potato based products.

POTATO CRISPS

4. Potato Crisps

Pakistan has a large domestic market for potato crisps, but a limited potential for exporting the product. The export of crisps would require significant investments into each market for brand development since consumers only trust and consume potato products they can associate with. Besides, the makers of potato crisps in Pakistan have installed capacity sufficient to cater to the local market, with limited surplus capacity for export.

4.1. Overview of the Potato Crisps Market in Pakistan

Pakistan's crisps market is dominated by PepsiCo. It is the single largest manufacturer of crisps in Pakistan and holds well over 70 percent of the domestic market. PepsiCo produces crisps under the brand name Lay's. The second leading brand is Snack City which holds about 10 percent of the market share and it produces crisps known as Kurleez. The third largest brand in Pakistan is Oye Hoye, which is owned by the company United Snacks and has a market share of around five percent. Apart from these three, the market share is split by companies such as Triple Em, Lotte Kolson, and Dalda Snacks. There are a number of other smaller companies and cottage industries across Pakistan which produce unbranded crisps for local markets and bakeries. The table below provides an estimate of potatoes used for processing by each of the aforementioned companies.

Company	Potatoes Used for Processing (Tons)	Percentage Share
PepsiCo	150,000	71%
Snack City	20,000	9%
United Snacks	10,000	5%
Tripple Im	5,000	2%
Lotte Kolson	3,000	1%
Dalda Snacks	3,000	1%
Others	20,000	9%
Total	**211,000**	

Table 5 - Potatoes used for making crisps in Pakistan during 2017 [29]

As the table above shows, the largest share of production of crisps in Pakistan is by PepsiCo. PepsiCo has recently established a Greenfield project in Multan to produce Lay's and Kurkure. The USD 63 million investment into the plant creates 1,500 direct and indirect jobs. The plant has been established to increase supply to the growing domestic market of Pakistan and have proximity to farmers that it works with.

29 Cluster Development Based Agriculture Transformation Plan Vision – 2025, Planning Commission of Pakistan Ministry of Planning, Development and Special Initiatives.

4.2. Manufacturing of Potato Crisps

The processing of potato crisps is significantly different than that of french fries. A slice of a crisp is between 0.035 and 0.07 inch thick. These cuts can be uniformly cut into straight, grooved, or crinkled surfaces, based on the taste the manufacturer wants to prescribe to the product. The slice of potato crisps is extremely thin, which decreases the moisture content from potatoes significantly during the frying process. After frying, the moisture content in the potato crisp falls below two percent. A high amount of oil is taken up by the crisps during the frying process due to the large surface area of the potato slice. There is around 35 percent oil uptake on the surface of potato crisps during the frying process and it penetrates deep into the microstructure of the crisp during the cooling process. Crisps are fried at temperatures between 160°C-180°C, after which they are ready to be seasoned, packed and served to the consumers.

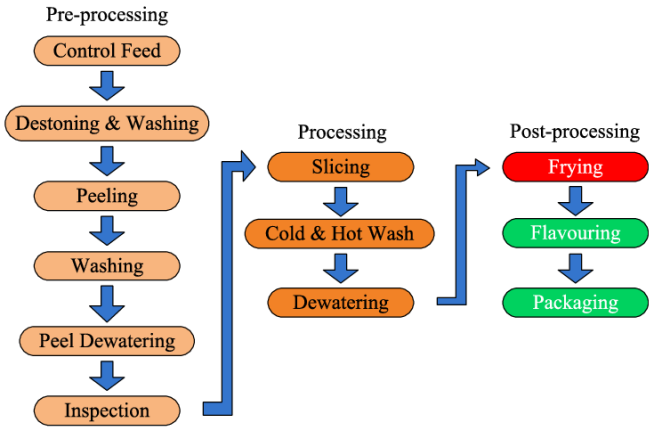


Figure 5 – Manufacturing process of potato crisps

The figure above shows the general process of making crisps. After the chips are washed and peeled, they are dewatered to remove excess moisture on the surface of the crisps. High moisture on the surface leads to oil degradation through hydrolysis of the oil, which lowers its potential yield per liter of use. Once, they are dewatered, crisps are fried and flavored either in salt or various mixes of spices. Following this, they are packaged and ready to deliver to the consumers. Unlike french fries, blanching isn't considered a critical part of the crisping process, although they can be blanched to reduce the starch sticking to the surface and to lower reducing sugars in the potato to avoid browning prior to frying. It is quite important for crisps to have a high level of dry matter, ideally between 20-23 percent and low level of reducing sugars since higher level of sugar content causes unacceptable color formation due to the Maillard reaction during frying.[30]

30 H.P. Beukema and D.E. van der Zaag., Introduction to Potato Processing, Pudoc Wageningen, Centre for Agriculture Publishing and Documentation, 1990.

The color of crisps is associated with what is known as the Maillard reaction and consumers particularly associate quality of crisps with the color of the crisps. The Maillard reaction can be described as the chemical reaction between amino acids and reducing sugars that gives browned foods its flavor. While frying at high temperatures and at low moisture levels, it causes acrylamide to be formed on the surface of potatoes (at over 180°C), it is also considered toxic and risky for human consumption. Studies on laboratory animals have shown exposure to acrylamide can be carcinogenic.[31] Color is amongst the first parameter through which consumers build a taste profile of the product. They tend to associate flavor, nutritional value, safety and storage time with its color. The uniformity in color is related to the quality of oil used as well as the quality of potato tubers used in the manufacturing process, both of which are important in terms of quality and taste profile of the product. High content of reducing sugars, above 2 percent, causes dark brown color to form on the surface of the crisps. Which is why choosing the correct variety of potatoes is essential for the crisping process.

Crisps can be fried using kettle fryers or through continuous fryers. The kettle processed crisps are crunchier and harder since they have a higher fat content and greater blistering on its surface due to presence of starch on the surface. The overall oil and fat content of the product is approximately 35 percent.[32] Chips after frying are exposed to seasonings, while they are hot to improve the application and adherence of the seasonings to the surface. The general range of salt that is on the crisps is between 1-3 percent and other seasonings range from 4-8 percent. Seasonings contain many ingredients and flavors such as cheese, barbecue, sour cream, vinegar, etc.[33]

4.3. An Outlook of the Global Market

The crisps market has grown from USD 0.94 billion in 2003 to USD 2.76 billion in 2021. The figure below shows the increase in trade of crisps during this time period.

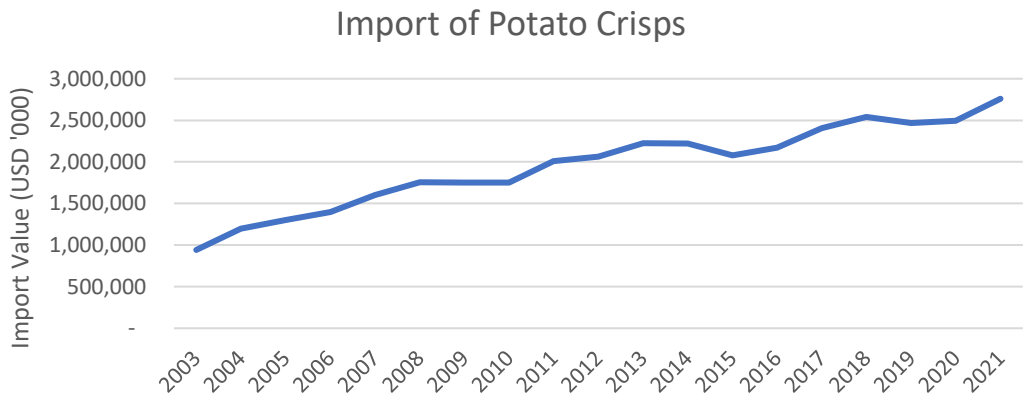


Figure 6 – Global import of potato crisps

Source: ITC Trade Map

31 Borda, D., Alexe, P., Acrylamide levels in food. Romanian Journal of Food Sciences. Official Journal of the Romanian Association of Food Professionals. 2011

32 Riaz, M.N., Snack Foods, Processing. Reference Module in Food Science, 2016.

33 S.O. Serna Saldivar, Snacks Foods: Types and Composition. Encyclopedia of Food and Health, 2016.

The top ten importing countries of crisps are shown in the table below.

Country	Import in 2021 (USD '000)
United States of America	277,663
France	229,399
Germany	188,257
Canada	137,430
Netherlands	132,822
Belgium	84,497
United Kingdom	78,025
Italy	76,185
Spain	73,821
Denmark	73,763
Total	**1,351,862**

Table 6 – Top 10 crisps importing countries in 2021

Source: ITC Trade Map

As the table above shows, around half of the potato crisps were imported by the top ten importing countries. Most of these countries also have a sizeable domestic manufacturing facility, highlighting that the import figures only capture a portion of the total market size. While data on the domestic manufacturing of each of these countries is sparse, estimates would suggest that domestic production in these countries is probably much higher. Interestingly, of the top ten importing countries, seven are also in the top ten exporting countries as seen in the table below.

Country	Export in 2021 (USD '000)
Netherlands	393,329
Belgium	302,272
United States of America	299,607
Poland	178,299
United Kingdom	160,127
Germany	155,904
Spain	153,227
Canada	141,933
Russian Federation	110,501
Mexico	108,356
Total	**2,003,555**

Table 7 - Top ten importing countries of crisps

Source: ITC Trade Map

The market for potato crisps is dependent upon brands and consumers preference of purchasing from a known entity. Unlike french fries, which are largely served in QSR and full-service restaurants, crisps are sold in retail where brand value matters. There seems to be brand awareness of potato crisps manufactured in the top importing and exporting countries. Out of a USD 2.8 billion in export of crisps, over USD 2 billion were by the top ten global exporters, most of whom were among the top ten importers. Regardless, it leaves limited opportunity for companies from developing countries to export crisps to the developed markets, unless they are willing to invest in brand development and establishing retail networks. The added challenge in exporting crisps is that their packaging contains a lot of air. Shipping a high-volume product raises the transportation cost, making it harder to export unless in a different packaging.[34]

4.4. Opportunities for Pakistan in the Potato Crisp Segment

Pakistan has limited chances of entering the export market for crisps in the foreseeable future. With PepsiCo. having the largest market share in Pakistan, smaller companies compete for a share in the domestic market. PepsiCo. is still struggling to fulfill the local domestic demand and on occasions it falls short to source industrial level potatoes for its production needs. Smaller companies scramble to achieve scale in domestic market and do not have the infrastructure, incentive and brand power to expand to international markets. Some companies are able to do modest exports to cater to the diaspora abroad, but are unable to sell to the wider international market.

Exporting potato crisps would require high capital investments in upgradation of manufacturing facilities and accreditations. These are prohibitive investment levels for new entrants or small companies. For instance, exporting would require higher grade multitiered packaging which can maintain product shelf life for over six months. Most small-scale companies in Pakistan have packaging which keeps the product fresh for around three months. Sizeable investments and higher unit costs discourage smaller companies from exporting, as they compete in the price sensitive domestic market. The best possible way for Pakistan to have sizeable exports from this segment is if PepsiCo, or another international brand such as Ruffles, Pringles or Utz, decides to establish production in Pakistan and start to export.

Lay's is amongst the top three crisps brands in the world. Pakistan exported around USD 4 to 6 million worth of potato crisps over the last decade, mostly to Afghanistan, or to US, UK, Canada or Australia where diaspora resides. As the data shows, compared to french fries, the market for crisps in considerably smaller and very concentrated in Western countries.

34 Pringles or Lays Stax have more compact products, although they contain around 40 percent processed dehydrated potatoes, while the rest is starches, flours, salts and seasoning.

POTATO STARCH

5. Potato Starch

Pakistan has the potential to localize its potato starch production to cater to domestic demand, although the potential to export potato starch is negligible. A majority of Pakistan's demand for potato starch is being met by importing the product. Pakistan imported over USD 4 million worth of potato starch in 2021. There are no sizeable domestic production facilities locally for the product. Only sporadic production takes place and there is no manufacturer selling in retail or B2B operations in Pakistan. Given the fact that potatoes are considerably cheap in Pakistan, there is potential to substitute imports and generate limited exports of potato starch from Pakistan in the future.

5.1. Uses and Production of Potato Starch

Potato starch is used in a variety of industries, but there are two main applications of the product. It is used as a binding agent and thickener in food manufacturing and in the non-food category, it is used as binder and adhesive in paper making. General estimates suggest that around 60 percent of potato starch is used in the food industry while out of the remaining 40 percent, most of it is used in paper making. For instance, in the EU, 55 percent is used in the food industry and the remaining 45 percent is used in non-food sector, primarily paper and paper board industry. [35]

5.1.1. Potato Starch in the Food Industry

Potato starch is preferred in many food items due to its silkier mouth feel and gelatinous properties. A majority of products use corn or wheat starches since they are cheaper. Once used in food, they form clear and tasteless pastes and have bland taste. Compared to other starches, potato starch products have a glossier and translucent output. As a downside, it does not hold well to very high temperatures and losses its properties.[36] The table below provides a comparison on the difference between the four main type of starches used in the food industry.

Starch type	Color	Clarity	Texture	Flavor	Gel structure
Corn starch	White	Opaque	Smooth; Very fine	Neutral	Firm
Potato starch	Clear white	Transparent	Pulpy	None	Sticky
Rice starch	Very white	Opaque	Smooth; Very fine	Neutral	Soft and creamy
Wheat starch	White; Off-white	Opaque to Cloudy	Smooth; Fine	Neutral	Soft and creamy

Table 8 –Starch types and their characteristics

35 Braganca, R.M, and F. Paul, Industrial Markets for Starch. The Bio composites Center, University of Wales, Bangor, Gwynedd, 2004.
36 Neeraj et.al, Potato Starch: Novel Ingredient for Food Industry, International Journal of Current Microbiology and Applied Sciences, 2020.

Starch is synthesized by plant cells is made up of two polymers: amylose and amylopectin. Potato starches have larger granules compared to cereal starches and their composition is different. Maize and wheat starch are similar as they contain similar levels of amylose and amylopectin, phosphorus and lipid content. The ratio of amylose to amylopectin in maize and wheat is around 27 to 73 whereas amylose levels in potato starch are 22 to 78 which makes its properties more conducive for specific food needs. The starch content in maize, wheat and potatoes are 60, 52 and 20 percent respectively. Potatoes contain much higher water content compared to the cereals and a lower percentage of starch per kilogram of the commodity. These are specifically potatoes with high dry matter; tableware potatoes will have lower content of starch and may provide output during production but the total yield per kilogram of potato would be correspondingly much lower. Potato starches contain higher levels of phosphorus while it contains less protein, lipid and ash content. The longer amylose and amylopectin chain length with higher phosphate content allows for thicker gel formation and higher viscosity. Although one of the limitations of this starch is its low level of thermal resistance which limits its industrial food applications in its natural or native state. Starches can be modified from their natural state to make them more optimized for use in different industrial applications and change their properties. For instance, a modified potato starch may be able to withstand higher temperatures and diverse pH.[37]

5.1.2. Starch in Paper Making

Potato starch can be used unmodified in its native state, or it can be modified into different forms such as cationic form, dextrinized or derivatized. Potato starch is used as a binding agent in the paper industry in a modified state. Native potato starch is rarely used in the paper industry, except in corrugating process. Modified potato starch have enhanced characteristics that make them well suited for the process of paper making. Modification of starches occurs through various processes such as hydrolysis and oxidation. Starch is the third most used item by weight in the paper making process after cellulose fiber and mineral pigments. Modified starches acts as retention aids, bonding agents, binder for coatings, adhesive in corrugated boards. One type of modification within starch is cationic modification.

Cationic starch is a modified starch that can be used as a wet-end additive. Although native starch can be used as wet-end additive, but cationic starches are preferable. The utilization of cationic starches has been encouraged by recycling of waste paper and has resulted in large scale adoption in the industry. These starches have a positive associated charge on them and can firmly attach themselves with negatively charged cellulose fibers. This provides a very firm attachment and bonding between fiber and filler and increased paper strength. These modified starches also improve water drainage and retention on paper while reduce dusting and linting. This material is non-toxic, renewable and biodegradable making it safe for use as well.

37 Pfister B, Zeeman SC. Formation of starch in plant cells. Cellular and Molecular Life Sciences. 2016

5.1.3. How is Potato Starch Made

The general process of making potatoes requires separation of fiber and proteins from the carbohydrates of the potato. Stored potatoes are washed with water in a flume to remove dirt and foreign matter. This process also removes any stones and dirt attached on the surface of the potatoes. Thereafter, the potatoes are passed through graters or a crusher with a saw blade rasp or a hammer mill. This process disintegrates the potatoes cells and separates the starch from the fiber. During the disintegration process, the oxidation process is inhibited by the addition of sulfur dioxide as opposed to the blanching process undertaken during processing of fries and crisps. This also preserves the color of the mashed potato. The impurities which are water soluble are removed through a washing process. Impurities that are not water soluble are removed through a gravity separation process. Thereafter, the slurry is passed through a centrifugal tunnel through which separates starch content. Mashed potatoes are passed from the centrifuge to a sieve which removes fiber from starch. The fibers can then be used in other markets such as animal feed which is rich in protein. The remaining concentrate is then further distilled and cleaned, thereafter which it forms an aqueous slurry or milk. It is passed into a continuous centrifuge with addition of water to remove other impurities for final purification of the product. This slurry is then dried to remove moisture and water content by vacuum filtration and flash-drying process. The slurry is exposed to heat of above 175'C, which removes all the moisture within the slurry and cakes the product which is further sieved for purification. After this process, the extracted starch is packaged and stored.[38]

5.2. Global Market for Potato Starch

Global imports of potato starch have increased sizably since 2003. They have grown at a faster rate compared to potato crisps and the fries segments, although the overall value is much smaller for potato starch. The total trade of potato starch has increased from USD 319 million in 2003 to USD 952 million in 2021. The total trade volume has increased by around three times during approximately two decades but the overall market size for the product is not as high as potato french fries or crisps.

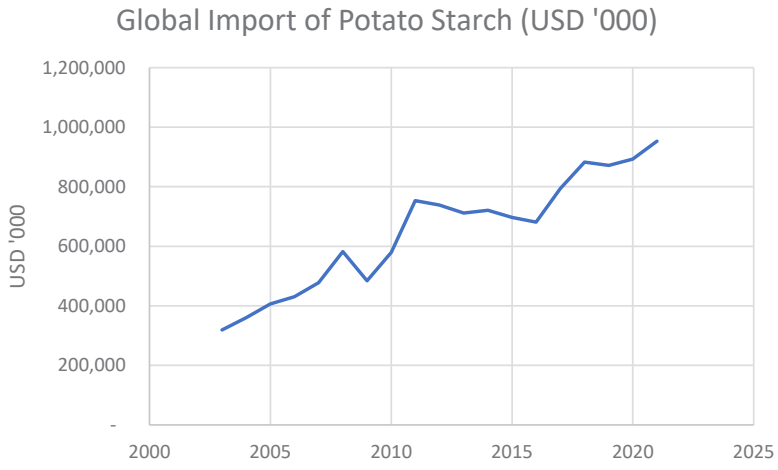


Figure 7 - Global imports of potato starch

Source: ITC Trade Map

38 W.S. Ratnayake, D.S. Jackson, Starch - Sources and Processing, Encyclopedia of Food Sciences and Nutrition (Second Edition), Academic Press, 2003.

The top ten importers of the product, import over 60 percent of potato starch. The largest importing countries of the product are in North America or Europe, although sizeable amounts of the product are imported by Korea, China and Taipei. EU is the largest producer of potato starch and contributes to most of the exports of potato starch globally. Top five EU potato starch exporters constitute over 85 percent of total global export of the product.

Country	Import Value (USD '000)
United States of America	122,865
Netherlands	82,253
Korea, Republic of	68,507
China	66,037
Germany	64,222
Belgium	50,643
United Kingdom	47,461
Taipei, Chinese	34,720
Italy	34,222
Spain	24,440

Table 9 - Top 10 importers of potato starch (2021)

Source: ITC Trade Map

5.3. Potato Starch in Pakistan

Pakistan has started using a sizeable amount of potato starch in the last couple of decades. From almost no use prior to 2003, the import of starch increased from USD 0.35 million by twenty times to USD 7 million in 2018. The imports took a sizeable dip in 2018 due to higher prices, devaluation and demand drop in products, right around the same time import of potato fries also reduced due to import difficulties. Imports have slightly increased after 2020, but they still have not peaked out again. Pakistan imports most of its potato starch from Denmark.

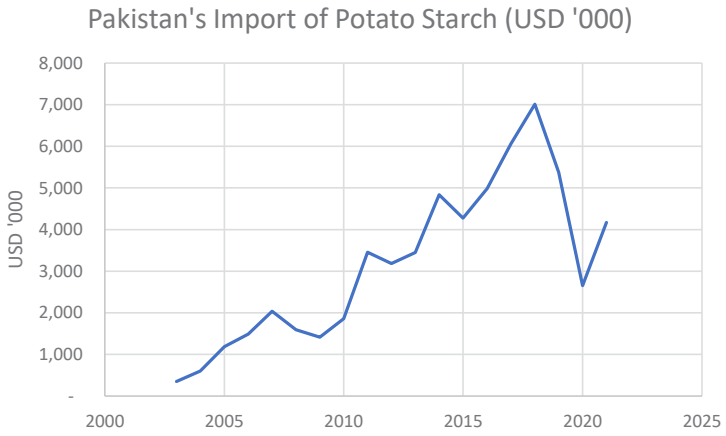


Figure 8 – Pakistan's import of potato starch

Source: ITC Trade Map

There is an opportunity in Pakistan to substitute imports by producing local potato starch, but it will find it highly unlikely to export from the country in the short run. One of the key issues in achieving this will be having the appropriate variety of potatoes available that yield very high starch content that makes the viability of the plant high. As mentioned previously, potatoes have much lower starch content compared to maize, which makes potato starch more expensive than corn starch.

Ingredion is amongst the top ten potato starches producing companies in the world and is the parent company for Rafhan Maize in Pakistan. It would be likely and feasible for an investment to be carried out by a company such as Ingredion in Pakistan, which has domain expertise and market knowledge to carry out these operations. The company also has a domestic and international sales and marketing distribution network which would make it easier to generate revenue channels. Other companies such as Opa or PepsiCO. may invest into manufacturing potato starch in the future in case they install larger capacity production units. In the event that their size increases by a factor of two, it would become feasible for them to produce starch to utilize silvers and smaller potatoes not suitable for manufacturing of french fries.

OTHER POTATO PRODUCTS

6. Other Potato Products

Apart from potato crisps, fries, and starches, other products include flour, meal, powder, flakes, granules and pellets of potatoes, which are all clubbed under the HS Code 1105. The global combined trade of all these products was just under USD 1 billion in 2021 with the largest importers of the products being the USA and the UK. These are niche products which have limited uses and global markets. The scope of manufacturing and exporting them from Pakistan is quite limited. Another important point to note here is that there is not enough disaggregated data for potato based dextrins since all dextrins are classified under the same HS Code 3505.10. Based on total production of corn and potato-based products, there is limited evidence to suggest that the markets for potato dextrins is quite high.

REVIEW OF INDIA'S POTATO PROCESSING INDUSTRY

7. Review of India's Potato Processing Industry

India has only a slightly better food processing proportion for potato than Pakistan, with only 7.5 percent of the total produce is used in processing. Most of the potatoes in India are grown for table and seed purposes. India has been able to improve its production and processing by developing its own indigenous varieties of potato.[39] The Indian Central Potato Research Institute (CPRI) has developed a lot of indigenous varieties which have high dry matter content, low reducing sugars and good chipping and frying characteristics. A few of these varieties include Kufri Chipsona, Kufri Jyoti, Kufri Sinduri, and Kufri Himsona. Different varieties are suitable for various requirements, for instance, Sinduri is more resistant to early blight and can tolerate higher heat stress. Chandramukhi is more suited for processing flakes and chips. Chipsona is a preferred variety in India for processing into french fries. Himsona has a greater tolerance to late blight and frost.

The Indian central and provincial governments play an active role in promoting the development of regional crops and have a number of blanket policies for the sector. One of the key methods in which the Indian government intervenes to increase potato production is by enforcing Minimum Support Prices (MSP). While similar policies are used for wheat and sugar in Pakistan, such polices can have adverse impacts on farming and productivity incentives in the long run. The government in India also promotes contract farming with private companies, such as PepsiCo, which has been readily adopted in West Bengal. Various other schemes are available for food processors in India such as the Scheme for Integrated Development of Food Processing Industry, the Scheme for Technology Upgradation of Food Processing Industry, and the Scheme for Cold Chain, Value Addition and Preservation Infrastructure. These schemes provide financial assistance for infrastructure development, technology upgradation, and quality assurance.[40]

What is particularly interesting is the case of Gujrat becoming a french fries manufacturing hub in India and how McDonalds played a pivotal role in the process.

39 Gupta, V., and Luthra, S. Potato processing varieties: Present status and future thrusts, Conference Paper presented in National Seminar on "Post harvest management and processing potatoes for increasing food security in India", 2014.

40 India |Agricultural Policy Monitoring and Evaluation 2020 | OECD i-Library

7.1. McDonald's Developing French Fries Manufacturing in India

McDonald's pioneered commercial scale french fries production in India. McDonald's opened its first outlet in India in 1996, and started developing a supply chain in the country from 1988 onward. It was not until 2007 that McDonald's was able to produce french fries locally in India. The biggest challenge in producing domestic french fries was the availability of a suitable variety of potato which would meet the quality standard required by McDonald's for its french fries. Since importing fries was very expensive and a slow process, McDonald's had to develop the product locally. India had low technological levels and limited infrastructure and logistics including temperature-controlled warehouses. McDonald's initially helped create a joint venture between Lamb Weston and a domestic partner Tarai Foods. With an investment of USD 10 million in capital equipment, the venture struggled to make high quality fries due to the poor quality of potatoes. The government in India allowed import of fries thereafter with 56 percent duties with two months of shipping lead time. McDonald's was also able to get McCain to import fries into India to cater to its domestic demand in India.

Imports of raw potatoes were not allowed in India, so McDonald's imported germplasm to develop local potato and seed varieties. McCain set up cultivating units in the Himalayan region and invested USD 25 million in establishing a manufacturing unit. They discovered that the province of Gujrat was well-suited for cultivating potatoes for the frying varieties. By partnering with local farmers through contract farming agreements they demonstrated advantages of modern farming techniques and equipment to farmers. By working with farmers to improve their yields, McCain was able to develop potatoes that could be used at commercial scale to produce fries. In 2008, 30 percent of fries were locally manufactured in India and it increased to 75 percent by 2010.[41]

41 Lee H.L., R. Sonali, McDonald's India, Optimizing the French Fries Supply Chain, Stanford Graduate School of Business, 2013.

RECOMMENDATIONS

8. Recommendations

Potato based manufacturing in Pakistan will benefit the most through localizing production of potato seed and making it ubiquitously available at cheaper rates. Constraints in access to the appropriate seed varieties for industrial processing use is the biggest challenge faced by the manufacturers of potato products in Pakistan. With better and cheaper seed, Pakistan can improve the potato yield to match its peers. Virus transmission through aphid, mechanical and soil-based diseases can be curtailed through the development of certified seeds that have genetic resistance to such viruses. Farmers in Pakistan utilize seeds that have been passed on for over ten generations are susceptible to various diseases and blight, which makes crops weak and lowers total output in the country. Procuring seed is the main cost for cultivating potatoes, which causes farmers to prefer cheaper and informal potato seeds. Certified seeds are expensive and unaffordable for farmers. Establishment of local seed options is the best solution to tackle this problem.

The government's in-vitro labs and seed multiplication centers have limited production and aren't commercially viable. There are a number of functioning labs in pockets all over the country, but unless they are upscaled, they will be unable to meet the requirement for local seed. The government needs to encourage formal seed multiplication companies and provide an enabling regulatory environment for them to grow.

Locally developed seeds are better disposed to the local weather, especially to resist damage caused by frost during the winter season. For the spring crop, other varieties can be developed that cater to high soil temperatures. There has been some headway by local researchers to have varieties that cater to some of the domestic needs but without mass scale production, no company will purchase or risk their manufacturing on potatoes drawn from unverified seed. Even with verification, companies tend to stick to a single variety to standardize production.

Enforcing Plant Breeder Rights (PBR) Act will help increase output and yield in Pakistan. While there are numerous unpatented varieties already available in the world, introduction of new and proprietary varieties will help encourage further investment in the sector. It will also build confidence of international investors that their technology patents and intellectual property will not be compromised. There are currently many "open" varieties approved for cultivation in Pakistan which farmers can import and use without having to illegally use patented varieties.

Improving technology adoption in potato cultivation through financing and demonstration schemes will help propel productivity. For instance, fields in Pakistan are often flooded with canal water, which is not optimal for potatoes. Drip irrigation allows for potato tubers to grow with uniform characteristics. The government can work with the private sector to help develop a financing mechanism that would help increase on-farm efficiency and increase yields by adoption of better technologies and seeds.

CONCLUSION

9. Conclusion

Pakistan has the key ingredients needed to become an exporter of value-added potato products. Pakistan is a major producer of potatoes, with an annual production of over seven million tons. However, only a small fraction, under five percent, of these potatoes are processed into value-added products. This is due to a number of factors, including the lack of availability of high-quality potato varieties, low levels of investment in the potato processing industry and outdated farming techniques. With the necessary technological upgrades in farming and processing, Pakistan can substitute imports of the potato products and even aspire to their export. The key focus of the country should be to introduce suitable varieties of industrial grade potatoes for cultivation. This means having varieties with suitable characteristics for each value-added product. And it would also mean having the right variety for the right season and temperate zone. By making cheap and readily available potato seeds available to farmers, processors can source potatoes during different parts of the year to keep production levels high and reduce high storage costs. With better yields through improved farming techniques, both the farmers and companies can benefit through higher outputs and lower costs.

Investments in processing french fries can lead to exports of the product from Pakistan. There is high demand for the product internationally and Pakistan has a comparative advantage in processing french fries domestically. With the availability of the right varieties and processing, Pakistan can access international markets as it already exports potatoes to french fries importing countries. With greater optimization and standardization, companies like Opa can access international markets to export their products. New entrants will also benefit from a developed market place with access to raw material and capital equipment and further propel them in the domestic and export market. Pakistan should aim to localize its production of potato starch and flakes. The demand for these products is low at the moment, but trends show that it might increase in the coming decade and Pakistan can grow high starch varieties to cater to the domestic demand and eventually export these products. There is little possibility of increasing exports of potato crisps in the short term and Pakistan will continue to export limited volumes of these to its diaspora living abroad.

The government can support the sector by focusing on encouraging the registration of new seed varieties and promoting planting of industrial grade varieties. By enabling access to information regarding cutting edge technologies and techniques, the farmers can be incentivized to upgrade their production methods. As PepsiCo. has demonstrated in Pakistan and McDonald's has shown in India, progressive farmers are willing to work on contract farming basis with companies to improve yield and quality of their produce. The government can support these efforts by ensuring that contracts and obligations are fulfilled.

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