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A Comprehensive Analysis of Potato Production and Trade: Global Trends and U.S. Production Forecasting

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ABSTRACT

Potato is a globally important crop valued for its high yield potential, nutritional content, and culinary and industrial versatility. This study aimed to analyze U.S. and global potato production trends, explore U.S. trade dynamics, and forecast U.S. production. The analysis was based on secondary production and trade data (2015–2022) collected from FAOSTAT and USDA databases. Different time-series forecasting models were evaluated based on Mean Absolute Deviation (MAD), Mean Squared Deviation (MSD), and Mean Absolute Percentage Error (MAPE) to predict U.S. potato production trends from 2023–2025. The analysis revealed that global potato production exhibited an upward trend, whereas U.S. potato production showed a downward trend. The U.S. potato trade data showed fluctuations, with periods of both trade surpluses and deficits observed during the study period. The Quadratic trend model, identified as the best-fitting forecasting model for this study, projected an accelerated decline in U.S. potato production from 2023–2025. This decreasing trend signaled prevailing challenges in U.S. potato production, highlighting the need for targeted government interventions to stabilize production and enhance the market competitiveness of potatoes.

INTRODUCTION

Potato (*Solanum tuberosum*) is the most important vegetable crop in the world due to its high production potential, remunerative income, and good nutritional value (Koch *et al.*, 2020). Potato belongs to the Solanaceae family and was first domesticated in the Andes mountains of South America around 8,000 years ago. Potatoes were ranked as the third most important crop in the world, after rice and wheat, in terms of human consumption (Birch *et al.*, 2012). It was also identified as the world's fourth most important food crop in production volume after maize, wheat, and rice (Kennedy *et al.*, 2019). Over a billion people worldwide consume potatoes, and 300 million metric tons of potatoes are produced worldwide (International Potato Center, 2024). Potatoes are rich in carbohydrates, provide a good energy source, and contain significant amounts of vitamin C, potassium, and dietary fiber. Besides being an important food source, potatoes are also increasingly used as raw materials for industrial products (Izmirliglu & Demirci, 2015; Jagatee *et al.*, 2015). Beyond direct human consumption, potatoes have several uses in various industries (Xu *et al.*, 2023). Potato starch, a byproduct of potato processing, is highly demanded in textile and paper industries due to its adhesive properties. Potato starch is also used in cosmetics and pharmaceutical sectors, where it is used as a filler and binder in the production of tablets and other products. Additionally, researchers are exploring the potential of potato peels and other waste byproducts as sources of biofuels and biodegradable plastics, offering sustainable solutions to industrial challenges. Another notable use of potatoes is in livestock feed, especially in the form of dehydrated

potato products and waste from processing facilities. The high carbohydrate content of potatoes makes them an energy-dense feed option, particularly for swine and cattle. In biotechnology, the potato has been a subject of genetic modification research, aiming to enhance its nutritional value and resistance to pests and diseases (Khanal *et al.*, 2024).

Potato remains an important agricultural commodity with global reach and significance for food security and economic contributions across various industries (Devaux *et al.*, 2020). There is a need to explore global and national dynamics of potato production, examine trade patterns, and forecast future production trends. This study assessed global and U.S. potato production and analyzed U.S. potato import and export trends. Furthermore, the study forecasted potato production in the U.S. from 2023–2025 using the best-fitted time series model.

LITERATURE REVIEW

Potato is a versatile staple crop, highly adaptable to various farming systems (Kennedy *et al.*, 2019). Potato has a short vegetative cycle and is well-suited for double cropping systems with rice and intercropping with maize and soybeans. Due to the greater adaptability of potatoes in diverse climates, easier cultivation practices, and higher nutritional values, potato production has increased in developing countries (Devaux *et al.*, 2014). Potatoes are less susceptible to the fluctuations of international markets than cereals. Potato is a highly recommended food security crop that can help shield low-income countries from the risks posed by rising international food prices. Potato is also rapidly becoming a valuable

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source of cash income for many small-scale producers. The growing importance of potatoes in urban markets requires new approaches involving new forms of public-private partnerships linked to technological innovation. In addition to being a staple crop for resource-poor communities, potato has the potential to serve as a cash crop for farm households (Thiele *et al.*, 2010).

In the United States, potato production is concentrated in Idaho, Washington, Wisconsin, North Dakota, and Oregon, where favorable climates and rich soils support high yields (World Population Review, 2024). Idaho alone accounts for nearly one-third of U.S. potato production, largely driven by its cool climate and volcanic soils ideal for growing potatoes (NASA Earth Observatory, 2022). A significant portion of the potatoes produced in the U.S. were processed into frozen fries and chips, and dehydrated potatoes were supplied to domestic and international markets (U.S. Department of Agriculture, National Agricultural Statistics Service [USDA NASS], 2019).

Knudson and Miller (2024) noted that, in the United States, potatoes had a substantial economic impact across the food supply chain—production, processing, distribution, and retail. They found that the U.S. potato industries' total economic contribution reached \$100.9 billion, supporting over 714,000 jobs nationwide in 2021. Furthermore, the study also discussed the crucial role of the potato export market, with about 20% of U.S. potatoes grown for export, including fresh, frozen, dehydrated potatoes and potato chips. Despite being bulky and perishable with high transportation costs, the international potato trade saw significant growth, driven by the demand for processed products (Birch *et al.*, 2012). The study also noted that high transportation costs and tariffs on processed potatoes caused major obstacles to the potato trade in the developing world.

Forecasting potato production is crucial for identifying potential challenges, balancing supply and demand, and developing policies and support programs to maintain stable and efficient production. Abid *et al.* (2018) used the exponential growth model to forecast the area and production of potato crops in Pakistan and found that potato production increased with the increase in potato cultivation area. Similarly, Tahir and Habib (2013) forecasted maize production in Pakistan using a Quadratic trend model. They found a positive trend driven by the availability of high-yielding varieties and proper use and availability of input. Moreover, Andaregie and Astatkie (2023) used the Quadratic Trend Model to forecast the cultivated area for wheat and teff, the production levels of wheat, teff, and maize, and the yields of wheat and maize. Their study projected a decline in cultivation areas but an upward trend in the production of wheat, teff, and maize, along with increasing yields for wheat and maize. Several studies have been done to forecast potato production using advanced time series models. Mishra *et al.* (2024a) compared the Autoregressive Integrated Moving Average (ARIMA) and Error-Trend Seasonality (ETS) models to forecast global potato production and

found that the ETS model performed better than the ARIMA model for the selected data. Similarly, Mishra *et al.* (2024b) used ARIMA, State Space, and Extreme Gradient Boosting (XGBoost) to model potato production in major South Asian countries. The study revealed that ARIMA models worked well for Afghanistan, Bangladesh, China, and Myanmar. Conversely, state-space models performed best for India, Nepal, Pakistan, and Sri Lanka, demonstrating that none of the approaches was uniformly best.

MATERIALS AND METHODS

Data Collection and Analysis

Secondary data from the Food and Agriculture Organization's statistical database (FAOSTAT, 2024) and the United States Department of Agriculture (USDA) were used for this study. FAOSTAT data for potatoes were collected to analyze world production trends, the top five potato-producing countries, and trade-related data of the U.S. Moreover, state-level data on potato production were collected from the USDA's National Agricultural Statistics Service (NASS). USDA's press release reports from 2015-2022 were assessed, and the data for the top 3 potato-producing U.S. states were recorded. The datasets were then extracted in spreadsheet format (xls) for further analysis. FAO used metric tons as the unit of measurement for production, whereas USDA employed hundredweights to record production quantities. The unit (hundredweights) used by USDA was converted into metric tons using the standard table on weights, measures, and conversion factors for agricultural commodities and their products provided by the USDA (Bramlett, 1992). Descriptive analysis was applied to report world production, U.S. production, the top 5 potato-producing countries, the top 3 potato-producing states of the U.S., and import and export trends of potatoes in the U.S. The import and export trends were analyzed to track the import and export volume of potatoes in the U.S. and to understand the broader economic impacts of the commodity.

Model Selection to Forecast U.S. Production

The time series data of potato production in the U.S. from 2015–2022 were used for modeling and forecasting U.S. potato production. Among various time series models, four forecasting models—Linear trend, Quadratic trend, Exponential growth, and S-curve, were tested to select the best-fitted model for forecasting potato production in the U.S. from 2023–2025. The equations for the forecasting models proposed by Masood *et al.* (2019) are presented below:

i. Linear Trend Model

$$Y_t = a + bt$$

ii. Quadratic Trend Model

$$Y_t = a + bt + ct^2$$

iii. Exponential Growth Model

$$Y_t = ae^{bt}$$

iv. S-Curve Model

$$Y_t = \text{Exp}(a + b/t)$$

where,

Y_t = Forecasted potato production in year t

a = Initial production level/intercept

b = Regression coefficient (linear, exponential, or S-curve parameters)

c = Quadratic regression coefficient

e = Base of the natural logarithm

t = Time (in years)

Model Accuracy Measures

The reliability of the forecasting methods was assessed using three accuracy measures, also known as forecasting errors: Mean Absolute Deviation (MAD), Mean Squared Deviation (MSD), and Mean Absolute Percentage Error (MAPE). MAD measures accuracy in the original data units, which helps understand the magnitude of the error. MSD is computed with a consistent denominator across models and is more sensitive to large forecast errors than MAD. On the other hand, MAPE evaluates the accuracy of the fitted time series values by expressing the error as a

percentage. The lowest values for all these error measures indicate a well-fitted model with minimal forecasting errors (Karim *et al.*, 2010). The best-fitted model was used to forecast potato production in the U.S. from 2023–2025.

RESULTS AND DISCUSSION

Global and U.S. Potato Production

Global potato production showed a general increasing trend from 2015–2022, with some years experiencing fluctuations. In 2015, the world potato production was 365.06 million metric tons. The production declined by approximately 3.1% in 2016 compared to 2015, reaching 353.62 million metric tons. However, in 2017, global potato production surged to 368.59 million metric tons, an increase of nearly 4.2% from the previous year. In 2018, production slightly declined to 364.02 million metric tons, a modest decrease of 1.2% compared to 2017. Potato production increased consistently from 2018 to 2022 globally, reaching its peak at 374.78 million metric tons in 2022 (Figure 1).

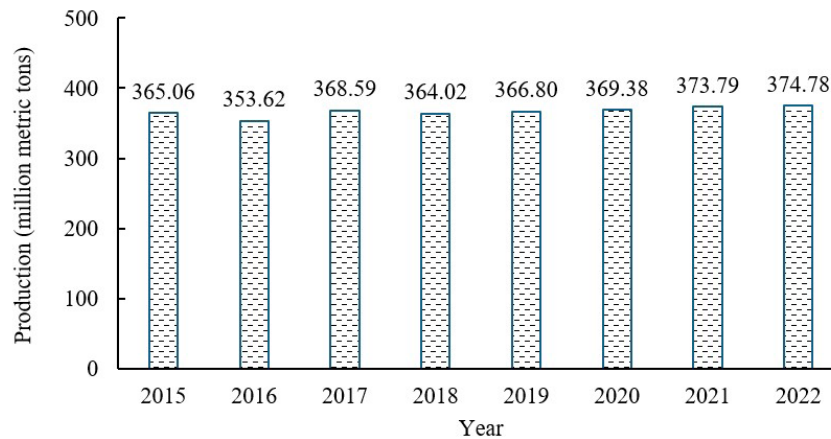


Figure 1: World potato production (2015–2022)

Source: Author's computation based on FAO data, 2024

As shown in Figure 2, U.S. potato production increased slightly from 20.01 million metric tons in 2015 to 20.43 million metric tons in 2016, peaking at 20.45 million metric tons in 2017. However, following the peak, production declined slightly to reach 20.42 million metric tons in

2018, then continuously decreased to 17.79 million metric tons in 2022, a significant drop of 12.88% over a five-year period (2018–2022). Knudson and Miller (2023) noted that U.S. domestic potato production declined primarily due to adverse weather conditions.

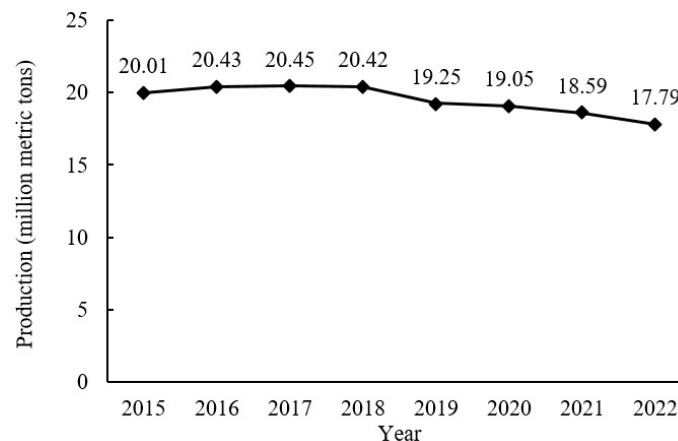


Figure 2: U.S. potato production (2015–2022)

Source: Author's computation based on FAO data, 2024

Top Potato-Producing Countries

China was the top potato-producing country in the world from 2015–2022, and its production far exceeded that of other top-producing countries. China’s potato production increased steadily almost every year, reaching 95.57 million metric tons in 2022 from 82.83 million metric tons in 2015. As outlined by Su and Wang (2019), China’s dominance in potato production is caused by several factors, such as a favorable climate, a short growing period, and government policies to support food security initiatives.

The production data (2015–2022) showed that India was the second-largest potato producer in the world, with production rising from 48.01 million metric tons in 2015 to 56.18 million metric tons in 2022. Scott *et al.* (2019) highlighted that increased potato production in

India was attributed to the availability of improved seeds, improved farming practices, and the desire of customers to diversify their diets. Moreover, potatoes were used as cash and staple crops in India, contributing to the country’s food security and rural economy. In contrast to China and India, the Russian Federation showed a declining trend, with production dropping from 33.65 million metric tons in 2015 to 18.89 million metric tons in 2022. Ukraine’s potato production remained relatively stable between 2015–2022, with minor fluctuations. The production varied from 20.27 million metric tons (2019) to 22.50 million metric tons (2018), showing no significant trends in production. In the case of the U.S., production decreased gradually from 20.01 million metric tons in 2015 to 17.79 million metric tons in 2022 (Table 1).

Table 1: Top five potato-producing countries (2015–2022)

Year	Country	Production (million metric tons)	Year	Country	Production (million metric tons)
2015	China	82.83	2019	China	89.50
	India	48.01		India	50.19
	Russian Federation	33.65		Russian Federation	22.07
	Ukraine	20.84		Ukraine	20.27
	USA	20.01		USA	19.25
2016	China	84.93	2020	China	92.80
	India	43.42		India	48.56
	Russian Federation	22.46		Ukraine	20.84
	Ukraine	21.75		Russian Federation	19.61
	USA	20.43		USA	19.05
2017	China	88.48	2021	China	94.30
	India	48.61		India	54.23
	Ukraine	22.21		Ukraine	21.36
	Russian Federation	21.71		USA	18.59
	USA	20.45		Russian Federation	18.30
2018	China	90.26	2022	China	95.57
	India	51.31		India	56.18
	Ukraine	22.50		Ukraine	20.90
	Russian Federation	22.39		Russian Federation	18.89
	USA	20.42		USA	17.79

Source: Author’s computation based on FAO data, 2024

Top Potato-Producing U.S. States

The United States is amongst the top potato producers worldwide, with Idaho, Washington, and Wisconsin being the top potato-producing states. Idaho was ranked first in U.S. potato production during 2015–2022 (Table 2), with production increasing from 6.52 million metric tons in 2015, reaching its peak at 7.09 million metric tons in 2018, and then gradually declining to 6.04 million metric tons in 2022. Washington, the second-largest potato-producing state, exhibited some fluctuations in its production data. The production increased from 5.02 million metric tons in 2015 to its peak of 5.28 million metric tons in 2016. However, after reaching the highest

recorded production in 2016, Washington’s production dropped to 4.96 million metric tons in 2017, 5.04 million metric tons in 2018, and 5.25 million metric tons in 2019. While 2019 showed a slight recovery compared to 2018, a downward trend continued more sharply in subsequent years, with production falling to 4.77 million metric tons in 2022. Wisconsin consistently ranked third in potato production from 2015–2022. Wisconsin’s production remained steady at 1.39 million metric tons in 2015 and 2016, slightly increasing to reach the highest recorded production of 1.49 million metric tons in 2017. Following the peak, production declined to 1.36 million metric tons in 2018 and rebounded slightly to 1.44 million metric tons

in 2019 and 2020. Then, Wisconsin's potato production reached 1.45 million metric tons in 2021 before declining to 1.33 million metric tons in 2022, the lowest level recorded during the study period (Table 2).

Table 2: Top three potato-producing U.S. states (2015–2022)

Year	State	Production (million metric tons)	Year	State	Production (million metric tons)
2015	Idaho	6.52	2019	Idaho	6.55
	Washington	5.02		Washington	5.25
	Wisconsin	1.39		Wisconsin	1.44
2016	Idaho	6.97	2020	Idaho	6.74
	Washington	5.28		Washington	4.98
	Wisconsin	1.39		Wisconsin	1.44
2017	Idaho	6.74	2021	Idaho	6.60
	Washington	4.96		Washington	4.60
	Wisconsin	1.49		Wisconsin	1.45
2018	Idaho	7.09	2022	Idaho	6.04
	Washington	5.04		Washington	4.77
	Wisconsin	1.36		Wisconsin	1.33

Source: Author's computation based on FAO data, 2024

Import and Export Trends of Potatoes in the U.S.

The trade data in Figure 3 represents potato import and export volumes (in million metric tons) for the U.S. between 2015–2022. The import volume of potatoes increased from 0.40 million metric tons in 2015 to 0.61 million metric tons in 2022, despite some fluctuations. The lowest import volume was recorded in 2015 (0.40 million metric tons). The volume of imported potatoes increased sharply in 2022 with import volume reaching 0.61 million metric tons from 0.47 million metric tons

in 2021. Trade deficits (Imports>Exports) were observed in 2016, 2018, and 2022. In 2022, the U.S. experienced a wider trade deficit of 0.06 million metric tons. Potato exports from the U.S. demonstrated a general increasing trend with some fluctuations. The export trade volume increased from 0.41 million metric tons in 2015 to 0.55 million metric tons in 2022. The highest export volume of potatoes (0.60 million metric tons) was recorded in 2021. Exports exceeded imports in 2015, 2017, 2019, and 2021, indicating trade surpluses in those years.

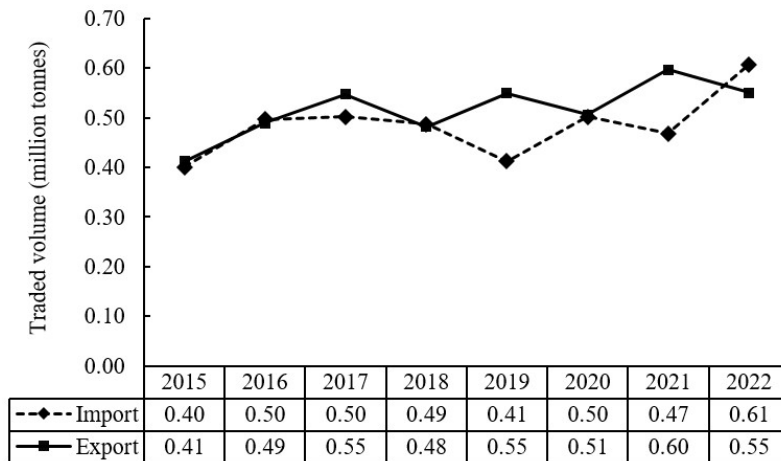


Figure 3: Import and export volumes of potatoes in the U.S. (2015–2022)

Source: Author's computation based on FAO data, 2024

Model Selection and Forecasting Potato Production in the U.S.

The accuracy of the selected forecast models for U.S. potato production was evaluated by assessing the closeness between the predicted values and the observed values. This evaluation was conducted using

the MAD, MSD, and MAPE criteria. The Quadratic trend model was best fitted for forecasting potato production trends. The best-fitted model was selected based on the lowest values of all accuracy measures. The diagnostic measures for selecting the best-fitted model are presented in Table 3.

Table 3: Diagnostic measures for selecting the best forecasting model for potato production in the U.S.

Forecasting models	Model selection criteria		
	MAD	MSD	MAPE
Linear trend	319,667.3	186,743,643,437	1.62
Quadratic trend*	199,996.7	56,466,510,605	1.02
Exponential growth	324,429.5	198,403,112,729	1.65
S-Curve	235,759.2	81,915,423,004	1.19

* Best-fitted model

Source: Author's computation based on FAO data, 2024

The Quadratic trend model was used to forecast potato production in the U.S. from 2023–2025. Production was forecasted to decline from the 2022 production level of 17.79 million metric tons to 16.71 million metric tons in 2023, 15.56 million metric tons in 2024, and 14.26 million metric tons in 2025 (Table 4). The forecasted potato production revealed an accelerated decline over time, with a sharper decrease of 8.35% from 2024–2025 as compared to 6.88% from 2023–2024. This declining trend in U.S. potato production could affect the domestic supply chain, thereby increasing the price of potatoes in the market (Knudson & Miller, 2023).

Table 4: Forecasted potato production in the U.S. (2023–2025)

Year	Forecasted production (million metric tons)
2023	16.71
2024	15.56
2025	14.26

Source: Author's computation based on FAO data, 2024

CONCLUSION

The study analyzed global and U.S. potato production trends from 2015–2022 and forecasted U.S. potato production from 2023–2025. Global potato production steadily increased during the study period, with China leading the production. However, U.S. potato production exhibited a decreasing trend during the same period. China and India demonstrated steadily increased production among the top potato-producing countries, while the Russian Federation and the U.S. experienced declines. Idaho, Washington, and Wisconsin were the major potato-producing states in the U.S. However, all three states experienced slight decreases in production during the study period. The trade data from 2015–2022 revealed fluctuations in U.S. potato export and import volumes. The Quadratic trend model, selected based on minimum MAD, MSD, and MAPE values, forecasted a reduction in U.S. potato production from 2023–2025. The declining trend in the U.S. potato production could lead to a reduced domestic supply, increasing potato prices and potentially impacting the overall agricultural economy. This highlights the importance of formulating suitable policies and strategies to address the underlying factors contributing to a decline in potato production and stabilize production levels.

This study has several limitations. First, potato production could be affected by various factors, such as climate change, disease outbreaks, and market equilibrium changes, which this study did not capture. Second, time series forecasting used in this study is only appropriate for short-term predictions and might result in inaccurate results if used for long-term forecasting. Future studies can explore the use of advanced forecasting models by accounting for various factors affecting potato production, such as climate change impacts, shifts in consumers' preferences, and market dynamics.

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