

FORECAST OF THE EXPORT OF FRESH STRAWBERRIES FROM THE REPUBLIC OF SERBIA USING THE ARIMA MODEL

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Abstract: Regarding the export of fruit intended for fresh consumption, fresh strawberries are among the leading export products of the Republic of Serbia. The main export market for fresh strawberries is the Russian Federation, where an average of 8,447 tonnes of strawberries were exported in the period from 2016 to 2021, which is about 89% of the total export. In the past five years, the export of strawberries from the Republic of Serbia has halved, as a result of the loss of the dominant Russian Federation market. If this trend continues, the Republic of Serbia will lose \$10.3 million a year in foreign trade, while the drop in exports will increase supply on the domestic market, leading to a drop in prices and negatively affecting the profitability of this production. The aim of this paper is to find a model that best describes future trends in the export of this fruit using the ARIMA model. The long-term monitoring of exports by the Statistical Office of the Republic of Serbia enables the prediction of this parameter in the coming years. The analysis established that, for the period from 2001 to 2022, the ARIMA (3, 1, 6) model is adequate for forecasting future trends in the export of this fruit. Forecasts suggest that exports of fresh strawberries from the Republic of Serbia will continue to decline in the coming years.

Key words: ARIMA models, strawberry export, forecasting, Box-Jenkins modelling strategy, Republic of Serbia.

Introduction

Fruit production has an important place in the economy of the Republic of Serbia. A large number of people are employed in the production, processing, and trade of fruit, as well as in activities that rely on this branch of agriculture (catering, tourism, and the chemical industry). In some parts of Serbia, especially in hilly and mountainous areas, fruit production is the main source of income for many farms (Milić et al., 2013). According to the data from the Statistical Office of the Republic of Serbia, the area of used agricultural land in the Republic of Serbia in 2021 was 3.5 million hectares, of which 182,084 hectares were

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orchards, accounting for only 5.2% of the total usable agricultural land. This is a relatively small area, considering the extremely favourable conditions for growing fruit trees.

In recent years, fruit production in Serbia has expanded significantly. In addition to the increase in orchard area, this growth includes the introduction of modern fruit tree cultivation technologies based on practices from developed fruit growing regions in Europe (Keserović et al., 2016). The natural conditions of the country of Serbia, including climate and soil, are extremely favourable for the successful cultivation of various types of fruit trees, especially strawberries (Dimitrijević et al., 2021).

After the raspberry, the strawberry is the most abundant berry fruit in Serbia. According to the total area under perennial crops, strawberry ranked sixth in 2022 with 7,039 hectares (www.stat.gov.rs). The strawberry is the most important berry fruit, primarily due to its high profitability, the early crop establishment and the very early ripening time (it is the first fruit to ripen in our region after a long winter). Strawberries are suitable for fresh consumption, freezing, and as raw material for industrial processing (Nikolić and Milivojević, 2015).

Strawberry production in Serbia is mainly concentrated in Mačva, the Danube Region, South Serbia, and part of Pomoravlje. According to the 2012 agricultural census, the largest areas under strawberry cultivation were in the following municipalities: Šabac (292 ha), Varvarin (184 ha), Kruševac (160 ha), Grocka (130 ha) and Leskovac (122 ha).

The emergence of new varieties, the introduction of modern technology for growing strawberries, as well as the development of modern cold storage facilities for storing and transporting fruits, have significantly increased the export of fresh strawberries from Serbia, bringing substantial benefits to agricultural producers and the agricultural sector. However, in recent years, the export of this fruit from the Republic of Serbia has declined.

This paper analyses the current state of the most important parameters in the strawberry trade in Serbia. The aim is to use the ARIMA (autoregressive integrated moving average) model and, based on the available data on strawberry exports from 2001 to 2022, to forecast future export trends. This will help create a clearer picture of the future movement of the strawberry exports, enabling the development of possible strategies and reducing the risk for producers. The long-term monitoring of fresh strawberry exports by the Statistical Office of the Republic of Serbia allows for the prediction of this variable in the coming years. Forecasting export trends could provide guidelines to competent institutions for implementing appropriate agricultural policy measures.

Material and Methods

The data for this paper were obtained from the databases of the Statistical Office of the Republic of Serbia, which provided information on the export trends of fresh and frozen strawberries from 2001 to 2022. The databases of the Food and Agriculture Organization (FAO) and the World Bank (WITS) were used to analyse the most important parameters of strawberry production and trade in Serbia and globally. In addition to these sources, numerous domestic and international scientific and professional publications relevant to the research topic were used.

The time series analysis of fresh strawberry exports was carried out using the statistical package "EViews 12 SV". The Box-Jenkins modelling strategy was applied to analyse previous export trends, and to forecast future trends. The goal of the Box-Jenkins modelling strategy is to select an appropriate ARIMA model that satisfactorily describes the tendencies of a particular time series dataset. This approach consists of three phases: model identification, model parameter evaluation and model adequacy verification (Mladenović and Nojković, 2015).

The use of the ARIMA model and the Box-Jenkins modelling strategy has produced reliable results for predicting future trends in the production and turnover of agricultural products, as demonstrated by numerous scientific papers by both domestic and foreign authors. Goyal et al. (2021) forecasted the agricultural sector exports in India, Erlina and Rialdi (2020) forecasted the value of coffee exports in Indonesia, Đoković et al. (2019) forecasted maize yield, Jaiswal and Bhattacharjee (2022) forecasted pork exports, Farooqi (2014) forecasted exports and imports in Pakistan, Paul et al. (2013) also forecasted meat exports, and Melekşen and Eydurhan (2017) predicted a reduction in the area and production of strawberries in Turkey.

Results and Discussion

Analysis of strawberry trade in the Republic of Serbia

After apples and peaches (including nectarines), fresh strawberries rank third in export value among fresh fruit exports (www.stat.gov.rs). According to World Bank data, in 2021, Serbia ranked 15th globally in fresh strawberry exports, with 8,286 tons. When it comes to processed strawberries, Serbia ranked 16th, exporting 6,591 tonnes. The main importers of fresh and processed strawberries from the Republic of Serbia are presented in the following tables (Tables 1 and 2).

For years, the largest importer of fresh Serbian strawberries has been the Russian Federation. From 2016 to 2021, an average of 8,447,077 kg of fresh strawberries were exported to the Russian market annually. Poland ranks second, with 4.97%, while Belarus ranks third (1.71%). Nine other countries together import less than 5% of fresh strawberries from Serbia.

Table 1. The main importers of fresh strawberries from the Republic of Serbia for the period 2016–2021 (average).

No.	Country	Quantity (kg)	Percentage (%)	Export unit price (\$)
1.	Russian Federation	8,447,077	88.96	1.91
2.	Poland	472,000	4.97	1.83
3.	Belarus	162,196	1.71	1.71
4.	Montenegro	82,719	0.87	1.62
5.	Croatia	65,448	0.69	1.97
6.	Romania	58,885	0.62	1.39
7.	Germany	51,980	0.54	1.91
8.	Austria	27,662	0.29	1.86
-	Other countries	126,846	1.34	1.76
Total		9,495,150	100	1.89

Source: Authors' calculations based on the WITS data.[†]

The average export unit price of strawberries in the observed period was \$1.89/kg. Russia imports about 50,000 tonnes of strawberries annually, with Serbia supplying one-fifth of its total needs. The largest exporter of strawberries to the Russian market is Turkey (18,000 t), followed by Serbia (8,000 t), Belarus (5,000 t), Moldova (2,000 t), China (2,000 t), and Egypt (1,800 t) (WITS). A significant increase in Serbian strawberry exports to the Russian market occurred after the European Union had imposed sanctions on Russia in 2014.

Table 2. The main importers of processed strawberries from the Republic of Serbia in the period 2016–2021 (average).

No.	Country	Quantity (kg)	Percentage (%)	Export unit price (\$)
1.	Germany	1,227,018	22.10	1.83
2.	France	945,702	17.03	2.24
3.	Austria	457,418	8.24	1.98
4.	Netherlands	405,992	7.31	2.26
5.	Russia	399,699	7.20	2.06
6.	Belgium	347,126	6.25	3.34
7.	Italy	204,058	3.68	2.32
8.	Sweden	188,972	3.40	2.61
-	Other countries	1,326,245	23.89	2.31
Total		5,552,230	100.00	2.32

Source: Authors' calculations based on the WITS data.

Processed strawberries include any form of cooked or uncooked strawberries, as well as frozen strawberries, regardless of whether they contain sugar or other sweeteners. Based on WITS data, the main importer of processed strawberries from

[†]WITS – “World Integrated Trade Solution” – trade software created by the World Bank that helps in searching various international trade databases.

Serbia is Germany, with France and Austria in second and third place, respectively. The highest export unit price for processed strawberries was achieved in trade with Belgium (\$3.34). In addition to these countries, there are 28 other countries for which there is evidence of imports of some form of processed strawberries from Serbia. Among them, Bosnia and Herzegovina, Switzerland, Croatia, Greece, Slovenia, and Portugal stand out in terms of import volume.

In recent years, starting from 2017 (Figure 1), a decline in the export of fresh strawberries from Serbia has been observed. This is best illustrated by the fact that in 2022, for the first time in 10 years, the export volume of frozen strawberries surpassed that of fresh strawberries. A drastic drop in the export of fresh strawberries occurred in 2022. The main reason for this is the difficulty of exporting strawberries to the Russian market, which is the dominant market, due to the war in Ukraine and the sanctions imposed by other countries against Russia. This made transportation much more difficult and expensive, thereby increasing the selling price of strawberries from Serbia. In addition, one reason is the strengthening of Russian agriculture and the rapid expansion of strawberry cultivation areas. In the past five years alone, strawberry production in Russia has increased by 36,400 tonnes, which, for comparison, is 6,000 tonnes more than the total strawberry production in the Republic of Serbia.

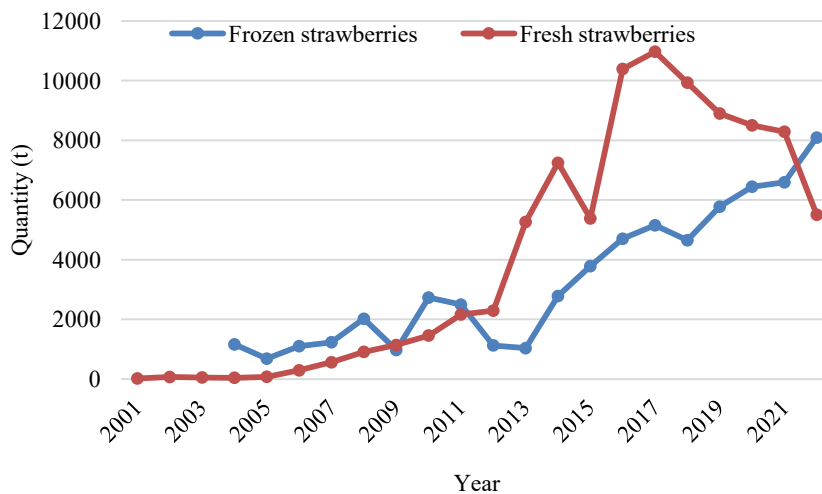


Figure 1. Export of fresh and frozen strawberries from the Republic of Serbia in the period 2001–2022 (in tonnes).

Source: Authors' own preparation.

Considering the greater economic importance of fresh strawberries (due to the higher purchase price for producers), the export trend of fresh strawberries will be

forecast. For comparison, in previous years the price of strawberries for processing ranged from \$0.60 to \$1.00 per kilogram, while the price of fresh strawberries intended for export ranged from \$1.00 to \$2.00 per kilogram.

Forecast of the export of fresh strawberries from Serbia

The first stage of the Box-Jenkinson time series modelling strategy involves analysing a graphical representation of a time series to determine whether the series is stationary or non-stationary. Based on the graphical display, only a rough estimate can be made; therefore, formal statistical testing should also be carried out. Analysing the graphic display (Figure 1), it can be seen that the series had an increasing trend and no pronounced seasonal variations. It can also be observed that the series had no structural break.

By analysing the ordinary and partial autocorrelation (Figure 2), it was established that the time series most likely had an ordinary unit root (the ordinary autocorrelation function decreased constantly and slowly, and the partial autocorrelation was significant only at the first lag).

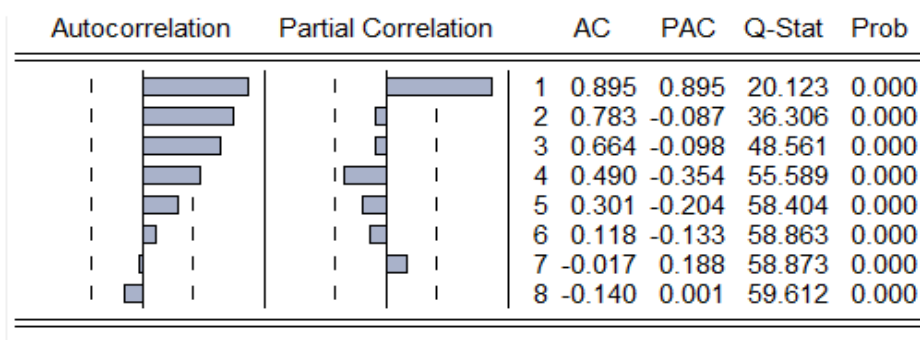


Figure 2. Correlogram of the ordinary and partial autocorrelation functions for the series of fresh strawberry exports during the period 2001–2022.

Source: Authors' own work using the statistical package "EViews 12 SV".

To confirm that the time series had a unit root, the unit root test (Dickey-Fuller test) was performed.

In the first iteration, two hypotheses were proposed:

H_0 : The time series has at least one unit root.

H_1 : The time series is stationary.

The answer to which hypothesis to accept was obtained by comparing the test statistic with the critical value. To compare a test statistic with a critical value, two conditions must be met:

- 1) The last included variable must be statistically significant (except in the zero step), and
- 2) There must be no residual autocorrelation.

Regression of the first difference on a constant found that the constant is not statistically significant. Therefore, to test the null hypothesis mentioned above, the τ_μ test statistic was used. Comparing the test statistic with the critical value gave:

$DF(0) \tau_\mu = -1.138033 > DF\tau_{\mu 5\%}^{crit} = -3.012$, on which basis the hypothesis H_0 was accepted.

Before confirming that a series had a unit root, one must check whether the series might have two unit roots.

In the second iteration, two hypotheses were set:

H_0 : The time series has two unit roots, against the hypothesis.

H_1 : The time series has exactly one unit root.

Comparing the test statistic with the critical value gave:

$DFT\mu(0) = -4.121583 < DFT\mu_{5\%}^{krit} = -3.012363$, on which basis hypothesis H_1 was accepted.

This confirms that the series had exactly one unit root. The first difference of the time series export of fresh strawberries was then modelled and ARIMA (3, 1, 6) was chosen as an adequate model. The estimated parameters of the model are shown in Table 3.

Table 3. Estimated parameters of the ARIMA model (3, 1, 6).

Variable	Coefficient	Std. error	t-statistic	Prob.
AR(3)	0.777835	0.280324	2.774774	0.0135
MA(6)	-0.923048	0.394991	-2.336883	0.0328
R-squared	0.381828	Mean dependent var		303.3889
Adjusted R-squared	0.343192	SD dependent var		1,731,615
SE of regression	1,403,364	Akaike info criterion		17.43557
Sum squared resid	31,510,908	Schwarz criterion		17.53450
Log likelihood	-154.9201	Hannan-Quinn criterion.		17.44921
Durbin-Watson Stat	2.565231			
Inverted AR roots	.92	-.46-.80i	-.46+.80i	
Inverted AR roots	.99	.49+.85i	.49-.85i	-.49-.85i
	-.49+.85i	-.99		

Source: Authors' calculation using the statistical package "EViews 12 SV".

For the model to be adequate for prediction, the residuals of the estimated model should be normally distributed and unautocorrelated. The assumption of

normality of the residuals was checked using the Jarque–Bera test statistic (JB test statistic).

If the calculated value of the JB test statistic is less than the corresponding critical value (5.99 at the 5% significance level), the residuals can be considered normally distributed. In addition to the JB test, standard statistical packages usually provide a p-value in addition to the test statistic value. In practice, the obtained p-value is most often compared with 0.05 or 0.10. To conclude that the residuals do not deviate from the normal distribution, the p-value of the JB statistic must be greater than 0.05 (Mladenović and Nojković, 2015).

The results of the residual normality test (Figure 3) show that the residuals were normally distributed because $JB = 0.205051$ was less than the critical value of 5.99, that is, the corresponding p-value of 0.90255 was greater than the 0.05 significance level.

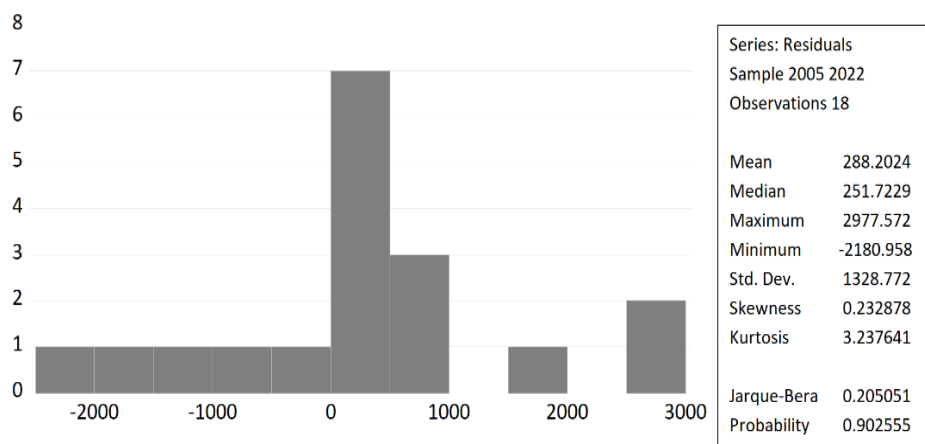


Figure 3. Histogram of residuals from the estimated ARIMA model (3, 1, 6).

Source: Authors' own work using the statistical package "EViews 12 SV".

After the model has been identified, evaluated, and checked for adequacy, a forecast can be made, i.e., forecasting the trend of strawberry exports over the next five years. The forecast of fresh strawberry exports using the ARIMA model (3, 1, 6) for the period from 2023 to 2027 is shown in Table 4.

Table 4. Forecast of trends in the export of fresh strawberries for the period 2023–2027.

Year	Forecast (tonnes)
2023	5,722
2024	5,036
2025	4,886
2026	4,359
2027	4,906

Source: Authors' forecasts based on the ARIMA model.

The forecast indicates a slight increase in exports in 2023 (5,722 t) compared to 2022 (5,505 t), and that the downward trend in exports will continue in the following years, with a slight increase again in 2027 (Figure 5).

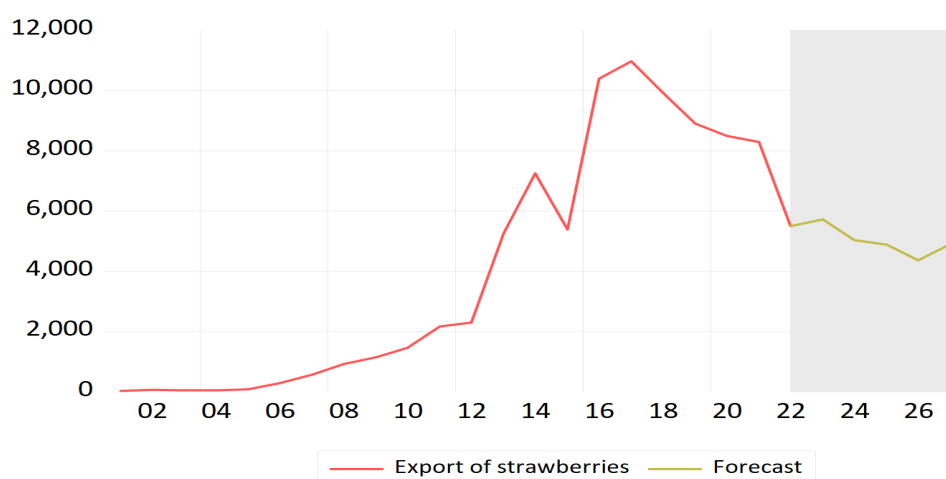


Figure 4. Presentation of fresh strawberry exports in Serbia with export forecasts for the period 2023–2027.

Source: Authors' own work using the statistical package "EViews 12 SV".

Conclusion

Fruit production is characterised by numerous specificities (production takes place in the open field, high dependence on climatic and soil conditions, the specificity of plants that, during their life cycle, experience periods of increasing and decreasing fertility, etc.) which are reflected in regular and stable yields. All this makes agricultural production uncertain and difficult to predict. However, the analysis of time series and the use of the ARIMA model, including the well-known

Box-Jenkins modelling strategy, have shown that it is possible to predict future trends in the production and turnover of agricultural products with relatively small deviations.

In this paper, a forecast was made for the export of fresh strawberries for the period 2023–2027. The projected value for the exported amount of strawberries in 2022 (4,898 t) was slightly lower than the realised value in 2022 (5,505 t). The deviation percentage for the exported quantity of strawberries was 11.02%. Based on the small percentage of deviation, it can be concluded that the chosen model, and therefore the forecast for the next period, could be relatively reliable.

The forecast for strawberry exports for the period 2023–2027 shows a slight increase in exports in 2023 (5,722 t), followed by a continued decline in subsequent years. According to the forecast, a slight increase in exports can be expected in 2027 (4,906 t). Official data from the Statistical Office of the Republic of Serbia indicate that strawberry exports amounted to 4,377 t in 2023 and 2,723 t in 2024, showing that total exports were significantly lower than forecast. The sharp decline in exports can be attributed to the unstable conditions affecting strawberry exports to the Russian market due to the Russia–Ukraine war. Additionally, the introduction of further sanctions packages by the EU against the Russian Federation further complicated strawberry exports. Transportation costs increased substantially due to changes in trade routes, while refrigerated lorries experienced longer delays at border crossings, which also negatively affected the quality of chilled strawberries.

In the past five years, the export of fresh strawberries has halved, decreasing from 10,967 tonnes in 2017 to 5,505 tonnes in 2022.

Considering that the average export unit price of strawberries is \$1.9/kg (WITS), this indicates a loss of the Republic of Serbia of \$10.3 million in foreign trade annually. In addition, the decrease in fresh strawberry exports from Serbia will increase the supply of strawberries on the domestic market, leading to a drop in purchase prices and significantly affecting the profitability of production. Competent institutions should respond to such shocking data by investigating the issue more deeply and, through the implementation of adequate measures and strategies, prevent further declines in exports. One option could be to gradually listen to and adapt to the needs of other markets.

Acknowledgments

The article was developed as part of the research activities conducted under the 2026 Contract on the Implementation and Financing of Scientific Research, concluded between the Faculty of Agriculture, University of Belgrade, and the Ministry of Education of the Republic of Serbia (Contract No. 451-03-34/2026-03/200116).

References

- Dimitrijević, B., Bulatović, B., Rajić, Z., & Zdravković, V. (2021). Economic profitability of Loch Ness blackberry production on a family farm. In S. Jelić, & M. Nedeljković (Eds.), *Proceedings of the scientific conference with international participation "Village and Agriculture"*, (pp. 187–208). University of Bijeljina, Bijeljina.
- Doković, J., Munćan, M., & Paunović, T. (2019). Forecasting maize yield in the Republic of Serbia by using Box-Jenkins methodology. *Agricultural Economics*, 66(2), 525–540. <https://doi.org/10.5937/ekoPolj1902525D>
- Erlina, R., & Rialdi, A. (2020). Forecasting model of agriculture commodity of value export of coffee: application of Arima model. *Journal Teknik Pertanian Lampung*, 9(3), 257–263. <https://doi.org/10.23960/jtep-l.v9i3.257-263>
- Farooqi, A. (2014). ARIMA model building and forecasting on imports and exports of Pakistan. *Pakistan Journal of Statistics and Operations Research*, 10(2), 157–168. <https://doi.org/10.18187/pjsor.v10i2.732>
- Goyal, M., Agarwal, S., Goyal, S. K., & Agarwal, N. (2021). Forecasting of Indian agricultural exports using ARIMA model. *Asian Journal of Research in Business Economics and Management*, 11(8), 11–15. <https://doi.org/10.5958/2249-7307.2021.00010.4>
- Jaiswal, P., & Bhattacharjee, M. (2022). Understanding the potential of livestock market with special reference to the export of pork meat from India: A study of time-series analysis using arima-based forecasting method. *Asian Journal of Dairy and Food Research*, 41(3), 293–297. <https://doi.org/10.18805/ajdfr.DR-1797>
- Keserović, Z., Magazin, N., Milić, B., & Dorić, M. (2016). *Fruit growing and viticulture (part of fruit growing)*. University of Novi Sad, Faculty of Agriculture, Novi Sad.
- Melekšen, A., & Eydurán, S. P. (2017). Forecasting harvest area and production of strawberries using time series analyses. *Journal of Agricultural Faculty of Gaziosmanpaşa University (JAFAG)*, 34(3), 18–26. <https://doi.org/10.13002/jafag4298>
- Milić, D., Kalanović-Bulatović, B., & Veljković, B. (2013). *Management and organization of fruit and viticulture production*. University of Kragujevac, Faculty of Agriculture, Čačak.
- Mladenović, Z., & Nojković, A. (2015). *Applied analysis of time series - second edition*. University of Belgrade, Faculty of Economics, Belgrade.
- Nikolić, M., & Milivojević, J. (2015). *Strawberry fruits - cultivation technology*. University of Belgrade – Faculty of Agriculture, Belgrade.
- Paul, R. K., Panwar, S., Sarkar, S. K., Kumar, A., Singh, K. N., Farooqi, S., & Choudhary, V. K. (2013). Modeling and forecasting of meat exports from India. *Agricultural Economics Research Review*, 26(2), 249–256.
- Statistical Office of the Republic of Serbia (2012). Agriculture Census – Agriculture in the Republic of Serbia, *Fruit Growing*, 41, Statistical Office of the Republic of Serbia, Belgrade. <https://www.stat.gov.rs/> ; Accessed on 15.01.2024.
- <https://wits.worldbank.org/>; Accessed on 01.12.2023.

Received: 13 March 2024

Accepted: 4 February 2026

PROGNOZA IZVOZA SVEŽIH JAGODA IZ REPUBLIKE SRBIJE
PRIMENOM ARIMA MODELA

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R e z i m e

Kada se govori o izvozu voća namenjenog potrošnji u svežem stanju, sveža jagoda predstavlja jedan od vodećih izvoznih proizvoda Republike Srbije. Glavno izvozno područje svežih jagoda je Ruska Federacija, u kojoj se u periodu od 2016. do 2021. godine prosečno izvezilo 8.447 tona jagoda, što je oko 89% ukupnog izvoza. U poslednjih pet godina izvoz jagoda iz Republike Srbije je prepolovljen, što je posledica gubitka dominantnog tržišta Ruske Federacije. Ukoliko se nastavi ovakav trend, Republika Srbija bi u spoljnotrgovinskom prometu gubila 10,3 miliona dolara godišnje, dok bi pad izvoza prouzrokovao rast ponude na domaćem tržištu, što bi izazvalo pad cena i odrazilo se negativno na profitabilnost ove proizvodnje. Osnovni cilj rada je da se primenom ARIMA modela pronađe model koji bi na najbolji način opisao buduća kretanja izvoza ovog voća. Praćenje dugogodišnjeg kretanja izvoza od strane Republičkog zavoda za statistiku daje mogućnost predviđanja ovog parametara u narednim godinama. Analizom je ustanovljeno da je za vremenski period od 2001. do 2022. godine model ARIMA (3, 1, 6) adekvatan za predviđanje budućih kretanja izvoza ovog voća. Prema projekcijama, u narednim godinama očekuje se dalji pad izvoza svežih jagoda iz Republike Srbije.

Ključne reči: ARIMA modeli, izvoz jagoda, predviđanje, Boks-Džekinsova strategija modeliranja, Republika Srbija.

Primljeno: 13. marta 2024.
Odobreno: 4. februara 2026.

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