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PREFACE

The purpose of this monograph, entitled "The State and Forecast of Fruit Production and Processing in Serbia", is to forecast trends in the production of major fruit species and key semi-processed and finished fruit products in Serbia, using quantitative methods and time series analysis. The monograph is designed as a reference book for students, researchers and experts alike.

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Finally, the author assumes full responsibility for the accuracy of all facts and quotations as cited in this book.

Associate Professor Mirjana Lukač Bulatović, PhD

Novi Sad, 2020

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1. THEORETICAL AND METHODLOGICAL FRAMEWORKS OF THE RESEARCH

As a distinctive branch of agriculture, fruit growing has been gaining increased prominence in the production of fruits of high biological quality and associated fruit products. Its enhanced importance is primarily favoured by industrial development, higher standards of living and changes in the social and economic structure of consumers. Growing demands for both fresh and processed fruits exert positive effects on the development and expansion of fruit production capacities.

The expansion of fruit production capacities necessitates contemporary means and methods of planning and integral modelling. Modern high-performance technologies should be used for the efficient planning and establishment of orchards. The orchards of such design could foster the introduction of labour division and the application of modern management practices to fruit production and processing, as well as fresh and processed fruit marketing.

Processed fruit production can be a highly profitable industry provided it meets market demands. However, the existing industrial processing facilities in Serbia should be better equipped, modernised and specialised in order to produce high-quality products which would meet the demands of particular markets. In addition to production capacity and raw materials, product branding is also an important constituent of successful fruit product marketing. Product assortment analyses have indicated that the Serbian processed fruit production does not have a leading market product, relative to both quality and quantity, in contrast to a number of countries such as Greece (where peach compote dominates the market), Hungary (apricot products), Switzerland (apple juice), Italy (tomato products), etc.

Although the need for the integration of fruit production and processing is often emphasised, there is no universal or generally accepted consensus on the extent of their vertical integration. However, it is an empirical fact that intensive fruit production cannot be achieved without modern and highly equipped fruit processing capacities *(Lukač Bulatović, 2014).* The modernization of fruit processing capacities greatly facilitates the improvement of fruit production. Accordingly, fruit processing capacities should be closely interconnected with the raw material base due to their high requirements for a safe and continuous raw material supply.

Fruit processors express keen interest in both specific fruit cultivars and requisite cultural practices because these two factors, in addition to natural conditions (namely climate and soil features), ultimately influence not only the yield and productivity of fruit crops but also the quality and consistency of fruits.

As fruit production provides the raw material base for the fruit processing industry, the primary purpose of this research is to assess the state of and development trends in fruit production and processing in Serbia. The research examines changes in the production capacity of major fruit species in Serbia in the period 1960-2018 and key semi-processed and finished fruit products in the period 1980-2017. On the basis of the data obtained in the period under consideration, a forecast of fruit production and processing in Serbia was made up to 2023. Furthermore, the nutritional and utility values of major fruit species in Serbia were displayed alongside the suitability of some raw materials (namely fruit varieties and cultivars) for processing and the assortment of semi-processed and processed fruit products.

An analysis of the principal parameter values of and trends in fruit production and processing in Serbia was based on the published and internal data of the Statistical Office of the Republic of Serbia for the period under consideration. The following descriptive statistics methods were used for data processing: the arithmetic mean, the interval of variation and the coefficient of variation. The assessment of relative parameter value changes was done using the average annual rate of change computed by the following exponential trend:

$$\hat{Y} = a \cdot b^{x}$$

In the exponential trend: $\hat{Y}$ is the value of the dependent variable, x is the independent variable, a and b are the parameters of the exponential trend.

Provided a time series analysis is used for forecasting, a time series model is developed and assessed on the basis of the available historical data, and subsequently used for estimating the future values. Furthermore, a series of statistical tests and criteria are simultaneously utilised in verifying the goodness of fit of the model assessed.

For the analysing and forecasting in this research, the autoregressive–moving-average (ARMA(p,q)) model was employed. The ARMA model is a combination of the autoregressive (AR) part, which involves regressing the variable on its own legged (past) values, and the moving average (MA) part, which entails modelling the error term as a linear

combination of error terms occurring at the same and different times in the past.

The ARMA(*p,q*) model is of the following form:

$$X_t - \phi_1 X_{t-1} - ... - \phi_p X_{t-p} = \xi + \varepsilon_t - \theta_1 \varepsilon_{t-1} - ... \theta_q \varepsilon_{t-q},$$

where ε_t denotes the independent random variables with an estimated value of 0 and a variance of σ^2, $\phi_1, \phi_2, ..., \phi_p$ are the autoregressive parameters, $\theta_1, \theta_2, ..., \theta_q$ are the moving average parameters and ξ is a constant which indicates the presence of a deterministic trend

$$(\xi = \mu(1 - \phi_1 - ... - \phi_p), \mu = E(X_t)).$$

Provided a time series is not stationary, the autoregressive–moving-average model for an integrated time series (ARIMA(*p,d,q*)) is used with an integrated (differential) time series $(1-L)^d = \Delta^d$, where *d* is the smallest number of differentiations required for reaching stationarity.

The ARIMA*(p,d,q)* model can be expressed in the following form:

$$\Delta^d X_t = \xi + \phi_1 \Delta^d X_{t-1} + ... + \phi_p \Delta^d X_{t-p} + \varepsilon_t + \xi - \theta_1 \varepsilon_{t-1} - ... \theta_q \varepsilon_q.$$

The instance of d=1 most commonly occurs in the form $(1-L)X_t = \Delta X_t = X_t - X_{t-1}$ as ξ denotes a linear trend parameter in the time series X_t.

The Statistica 13.3 software package was used for data analysis. The program displays (in tables and plots) the chosen model, parameter estimates, root-mean-square error, mean absolute error, maximum absolute percentage error and maximum absolute error by exploring the residual autocorrelation function (ACF), partial autocorrelation function (PACF) and Ljung-Box statistics.

The present research determines the adequate models for forecasting the number of productive fruit trees and the volume of fruit production and processing in Serbia. It also provides a statistical analysis of the production features of major fruit species in Serbia, as well as key semi-processed and finished fruit products.

1.1. Theoretical basis of the research

In an effort to elucidate different aspects of the fruit production and processing in Serbia, previous research results can be collated into three distinct categories.

The first result category embraces studies on the fruit production in Serbia, i.e. trends in the fruit production in Serbia, the prevalence of specific fruit crops in the Serbian fruit production, the utility value of fruit species, the suitability of certain fruit varieties and cultivars for processing, etc. Therefore, the remainder of this chapter will outline the arguments and considerations of the most prominent authors dealing with the issues stated above

As one of the most salient areas of plant production, fruit production has excellent development prospects in Serbia due to both favourable natural conditions for cultivating most of the continental fruit crops and the growing demand for fruits in domestic and foreign markets. However, modern fruit production is increasingly complex on account of the enormous demands for high-quality fruits and high-quality production processes *(Milić, Vukoje, 2008)*. The fruit production in Serbia is still underdeveloped, characterised by poor-quality fruits and low, irregular yields. Therefore, the industrial value of Serbian fruit production is considerably lower than its potential value (considering highly favourable natural conditions for fruit growing in the country).

In the period 1980-2011, downward trends were recorded in the number of productive fruit trees and the orchard areas in Serbia (whereas such trends were opposite in Vojvodina). Although the orchard areas and the number of productive fruit trees in Serbia are decreasing at average annual rates of change of -0.40% and -0.24% respectively, the actual fruit production is still increasing (at a rate of change of 0.38%). Consequently, it can be argued that the fruit production in Serbia is intensifying with higher investments per unit area *(Lukač Bulatović et al., 2013; Lukač Bulatović, 2014).* The share of orchard areas in the total arable land in Serbia is rather small, indicating a slightly increasing trend *(Milić et al., 2005)* attributable to a sharper decrease in the total arable land than that recorded in orchard areas.

Similar downward trends were observed in the number of productive fruit trees and the actual production of specific fruit species (*Milić, Lukać Bulatović, 2005)*. The most marked decrease in the number of productive fruit trees was recorded in the Serbian pear and plum production (at rates of change of -2.93% and -0.90% respectively), whereas the most

significant reductions in volume were recorded in the Serbian pear and apple production (at rates of change of -3.99% and -1.83% respectively).

Plums are the predominant fruit crop in the Serbian fruit production structure (according to both the number of productive trees and the volume of actual production), followed by apples and sour cherries *(Lukač Bulatović, 2005)*. However, apples are the predominant fruit crop in the Autonomous Province of Vojvodina. The share of apples in the Vojvodinian fruit plantation structure increased in 2004, compared to 1980, followed by plums and sour cherries.

In the total European plum production Serbia participates with 426,846 tonnes (15.41%) and immediately follows Romania, which is the leading plum producer in Europe with the annual plum production of 624,884 t. Furthermore, Serbia also significantly participates in the total European production of raspberries (21.43%), sour cherries (9.08%), and walnuts (6.54%). The Serbian share in the European production of the other analysed fruit species is below 2.92% *(Lukač Bulatović, 2012).*

A number of authors argue the importance of primary fruit production for obtaining high-quality semi-processed and processed fruit products. The fruit production structure should incorporate an increasing share of fruit varieties and cultivars featuring high processing usability. Fruit concentrate production should be based on raw materials with high dry matter contents and a harmonious relationship between sugars and acids. In addition to the proper size of fruits, cultivars suitable for freezing are required to yield fruits of consistent and intense colour such as the following raspberry cultivars: 'Willamette', 'Lloyd George', 'Malling Promise' and 'Podgorina'.

Raspberry fruits are an important raw material in the fruit processing industry. Over the past decades, a share exceeding 90% of the total raspberry production in Serbia has been frozen (in cold storages) or processed into semi-processed products (namely rolend raspberries, raspberry groats and block raspberries). A 7-8% share of mostly second-class raspberries has been processed in hot processing facilities, whereas only 2-3% of raspberries produced have been used fresh or processed for both domestic and industrial purposes (such as flavouring sweets and chocolates in the hospitality and confectionery industries, etc.) *(Petrović, Milošević, 2002)*.

Veličković (2006) recommends the following raspberry cultivars for different processing procedures (especially freezing): 'Norfolk Giant', 'Puyallup', 'Willamette', 'Scina', 'Lloyd George', 'Malling Exploit', 'Malling Jewel', 'Malling Promise' and 'Podgorina'. Raspberry cultivars yielding aromatic and intensely coloured fruits (namely 'Norfolk Giant',

'Lloyd George', 'Jelička', 'Valjevka', 'Kopaoničarka', 'Zaječarka', etc.) are suitable for producing juices, concentrates, syrups and jams. Furthermore, raspberry cultivars with fruits which retain their distinctive colour and aroma after hot processing (e.g. blanching) are favoured in compote and thin preserve production.

According to biological and industrial criteria, *Paunović (1974)* distinguishes the following strawberry cultivars: early and mass-produced strawberry cultivars, strawberry cultivars for fresh consumption and/or processing, strawberry cultivars of excellent and/or poor quality for freezing, and strawberry cultivars of different maturity dates and economic importance. The author regards the following strawberry cultivars as suitable for processing: 'Suprize des Holles', 'Red Gauntlet', 'Gorella', 'Wadenswil 7', 'Senga Sengana' and 'Wadenswil 8'.

A number of plant breeding centres around the world seek to produce novel strawberry varieties for universal use, which would be equally suitable for both fresh consumption and processing *(Mišić, Nikolić, 2003)*.

All cultivated and edible wild varieties of raspberries can be used for hot and cold processing. However, there are significant varietal differences relative to their suitability for different uses and processing procedures *(Mišić, 1988)*. In addition to wild raspberries, the following raspberry cultivars are suitable for fresh consumption: 'Malling Exploit', 'Willamette', 'Gradina', 'Krupna dvorodna', 'Jelička', 'Lloyd George', 'Newburgh', 'Rubin', 'Malling Promise' and 'Malling Jewel'. The following raspberry cultivars are suitable for freezing: 'Malling Jewel', 'Malling Exploit', 'Gradina', 'Newburgh', 'Lloyd George', 'Valjevska', 'Cuthbert' and 'Fairveiw'. If not frozen or consumed fresh, raspberries can be processed into various products such as pulps, juices, syrups, jams, compotes, etc.

According to *Nikšić et al. (1985)*, the following plum cultivars are highly suitable for drying: 'Požegača', 'Čačanska rodna', 'Agen 707' and 'Stanley'. *Ogašanović (1990)* argues the advantages of the 'Valjevka' plum cultivar over the 'Požegača' plum cultivar, which is the standard plum cultivar for drying in Serbia. When dried, the 'Valjevka' plum cultivar produces fruits which are approximately 65% bigger than those of the 'Požegača' plum cultivar.

In addition to indigenous plum cultivars used for brewing, 'Požegača' is the predominant plum cultivar in the Serbian plum cultivar assortment. The distribution area of the 'Stanley' plum cultivar is rapidly expanding, claiming a share of 50-60% of the plum nursery production in Serbia. However, new plum cultivars produced at the Fruit Research Institute in Čačak have been attracting increasing interest, especially

'Čačanska rodna', 'Valjevka' and 'Čačanska lepotica' (*Nikšić et al., 1985)*.

In Serbia, plums are mostly used for plum brandy production (approximately 65%), fresh consumption (8%), dried plum production (4%) and *pekmez* preserve production (less than 2%). The remainder, including all other plum products, account for 21% of the use of plums in Serbia *(Vlahović, 2003)*.

Sweet and sour cherry fruits are of great and diverse technological value, often and extensively used (especially sour cherry) as raw materials for various canning and processing procedures *(Nikolić et al., 1993)*. The following industrial sour cherry cultivars are used for processing: 'Heimanns Konservenweichel', 'Kelleris 14', 'Šumadinka', 'Oblačinska', 'North Star', 'Ujfehertoi Fürtos Meteor Korai' and 'Kelleris 16'.

The industrial processing of sour cherries produces numerous semi-processed and finished products: sour cherry pulps, sour cherry compotes, sour cherry-flavoured dairy products (namely desserts, ice cream, yoghurt, kefir, whey, etc.), sour cherry brandies and sour cherry liqueurs *(Gvozdenović, 1995).* The author also lists the most renowned sour cherry products of the domestic processing industry such as sour cherry compotes, thin preserves, juices, syrups, jellies, *pekmez* preserves, jams, marmalades, candied fruits, brandies, liqueurs and *ratafia* liqueurs.

Sweet cherry fruits are a highly valued and, at present, precious industrial raw material particularly in compote, thin preserve and jam production. Owing to a high content of anthocyanins, black sweet cherries are used for colouring juices and other fruit products *(Stanković, 1980)*.

According to *Mišić et al. (1993)*, the following sweet cherry cultivars are regarded as most important in Serbia: 'Burlat', 'Van', 'Stella', 'Stark Hardy Giant' and 'Bing'. These high-yielding cultivars produce fruits of high quality and enormous utility value.

The same authors recommend the assortment of most favourable apple cultivars relative to the existing growing conditions in Serbia: apple cultivars for industrial plantations and production, apple cultivars for local-scale production, apple cultivars of great production potential, and apple cultivar for producing fruits of high biological quality such as 'Prima', 'Freedom', 'Liberty', 'Champion', 'Krstovača', 'Budimka' and 'Šumatovka'.

Jovanović et al. (1994) highlighted the poor quality of apples for industrial processing in Serbia. Such apples are mostly fruits originally intended for fresh consumption, but showing mechanical *damage*, moulds or even rot. Only in recent years have the first steps been taken towards

producing (i.e. breeding) apple cultivars for specific industrial processing procedures, using special plant breeding techniques.

Upon analyzing the physical (fruit mass and size), organoleptic (fruit epidermis colour) and chemical (contents of dry matter, sugars and acids) properties of apple fruits, *Nenadović-Mratinić, Milatović (1994)* argued that the following apple cultivars were of the greatest technological value: 'Crvenkorka' (having medium-sized, coloured fruits with high contents of dry matter (19.40%), sugars (11.90%) and acids (0.90%)), 'Krupnoplodna Šumatovka' (having medium-sized, coloured fruits with high contents of dry matter (18.90%), sugars (10.80%) and acids (0.88%)), 'Dunjka' (having large-sized, colourless fruits with high contents of dry matter (18.80%), sugars (11.00%) and acids (0.85%)), 'Kiseljaja I' (having medium-sized, colourless fruits with a high content of dry matter (16.76%) and an extremely high content of acids (1.68%) and 'Drenjaja' (having medium-sized, faintly coloured fruits with high contents of dry matter (15.96%) and sugars (10,60%), as well as an extremely high content of acids (1.74%). Therefore, apple cultivars suitable for processing are characterized by high contents of and a harmonious relationship between sugars, organic acids, tannins, aromatic compounds, vitamins, enzymes and mineral substances *(Mišić, 2003).*

Niketić-Aleksić (1988) recommend the following pear cultivars for both industrial processing and producing numerous products of exquisite quality: 'Williams Christ Birne Bartlett', 'Max Red Bartlett', 'Beurre Hardy', 'Conference', 'Beurre Claigeay', 'Doyenne du Comise', 'Šampionka' and 'Curé'. 'Williams Christ Birne Bartlett', 'Trevlek', 'Starking Delicious', 'Santa Maria' and 'Precoce de Trevoux' are highly suitable for pear compote production, whereas 'Williams Christ Birne Bartlett', 'Trevlek', 'Beurre Hardy' and 'Šampionka' are favoured in pear jam, marmalade and brandy production.

As fruits of many fruit varieties and cultivars are not suitable raw materials for high-quality products, especially those produced for international markets, the production of industrial fruits, i.e. fruits for specific processing procedures, should be increased. This entails producing raw materials of great technological value and of uniform and standard quality, which are consequently processed into products of such quality. Moreover, the fruit processing industry in Serbia would thus be continuously supplied with high-quality raw materials at acceptable prices *(Milić, Radojević, 2003).*

A number of industrial pear cultivars are primarily used for processing *(Etienne et al., 2002).* The fundamental difference between pear cultivars for fresh consumption and those used for processing is

reflected in the fact that pear cultivars for processing are regarded as raw materials, thus requiring greater fruit consistency (a fair proportion of the aromatic compounds in pears are lost in processing) and higher yields (to compensate for generally lowers prices of pear cultivars for processing).

Industrial peach cultivars are mostly characterized by high yields, medium-sized fruits, yellow flesh, and pleasant flavour and aroma *(Nikolić, Fotirić-Akšić, 2013)*. In most of the countries in the world, pear cultivar assortments predominantly comprise mid-season pear cultivars native to Italy (namely 'Maria Serena', 'Romea', 'Adriatica', 'Tebana', 'Lamone','Tirrenia', 'Villa Ada', 'Villa Adriana', 'Villa Doria' and 'Villa Giulia') and late-season cultivars native to the USA (namely 'Shasta', 'Carson', 'Vivian', 'Andros', 'Jungerman', 'Babygold 6', 'Babygold 8', 'Babygold 9' and 'Halford'). In addition to Italy and the USA, breeding programmes aimed at producing industrial pear cultivars are also carried out in France, Rumania, Australia, Brazil and South Africa.

The largest amounts of pears produced in Serbia are canned (approximately 40%), whereas frozen, processed (into jams, jellies, brandies and juices) and dried pears account for 5-6%, 2-3% and 1-2% of the total Serbian pear production respectively *(Ognjanov, 2003)*.

Pejkić et al. (1994) argue that industrial pear cultivars (such as 'Loadel', 'Dixon', 'Halford', 'Carolina', 'Klamf', 'Jungerman', 'Andross', 'Babygold 6' and 'Fortuna') are not equally suitable for all types of products. For compote production, the authors recommend the following pear cultivars: 'Loadel', 'Jungerman' and 'Halford'. However, all the pear cultivars stated above should be tested using different processing procedures so as to determine their suitability for specific products.

The second result category encompasses studies on the fruit processing in Serbia (*which is a lesser researched area of the overall Serbian fruit production and processing)*, i.e. the volume of semi-processed and processed fruit production, the assortment of semi-processed and processed (finished) fruit products in Serbia, the utilization of Serbian fruit processing capacities, and the state of and trends in semi-processed and processed fruit production in Serbia. Therefore, the remainder of this chapter will outline the arguments and considerations of the most prominent authors dealing with the issues stated above: *Šulc (1969), Nikšić et al. (1985), Niketić-Aleksić (1988), Rott (1996), Scorza, Hui (1996), Gvozdenović (1997), Zlatković (2000), Paunović (2001), Milanović (2002), Milić, Radojević (2003), Szalay, Penzes (2003), Milić et al. (2005, 2008), Lukač Bulatović (2006, 2009, 2010, 2012, 2014).*

Fruits can be semi-processed (and used for further processing) or processed (into finished products). Therefore, there are two types of fruit products: semi-processed and processed (or finished) fruit products. Semi-processed fruit products include chemically preserved semi-processed fruit products (namely fruit pulps, purees and juices) and pasteurised and/or frozen semi-processed fruit products (namely pasteurised pulps, pasteurised purees and frozen purees). Finished fruit products include compotes, salads, jams, marmalades, jellies, thin preserves, *pekmez* preserves, candied fruits, juices (namely clear, pulpy, cloudy and sparkling juices), concentrated juices (namely pulpy concentrated juices, lemon and orange concentrated juices, fruit syrups, etc.), and dried fruits *(Milić, Radojević, 2003)*. Other fruit products, such as fruit cheese, butter, sauce and cream, are considered minor *(Lovrić, Poližota, 1994)*.

Gvozdenović et al. (1997) list the products of the Serbian fruit processing industry: juices, syrups, concentrates, frozen fruits, dried fruits, compotes and preserves. The authors argue that the production of clear fruit concentrates, compotes, frozen fruits (especially frozen raspberries) and dried fruits (particularly dried plums) is of paramount importance from technological and economic perspectives. To expand the assortment of semi-processed and processed fruit products, mitigate the seasonal character of fruit processing and increase the overall utilization of the existing infrastructure and fruit processing equipment, the Serbian fruit processing technology (first and foremost the fruit drying technology, which is still largely based on plum drying) should be diversified to include other fruit crops such as apricots, peaches, grapes, etc.

On account of the growing demand for semi-processed products in both domestic and foreign markets, particularly concentrated fruit juices, fruit processing has been gaining priority in Serbia. According to different fruit crops, *Šulc (1987)* reports the average raw material consumption per one ton of fruit concentrate produced: 1 t of fruit concentrate requires 10 t of apples, 7 t of sour cherry, 4 t of plums and 5 t of soft fruits.

In the period 2001-2010, the largest volume of production was recorded in Serbian fruit juices (155.012 t) and frozen fruits (24.602 t). With the exception of fruit juice production (which has been increasing at an average annual rate of change of 1.09%), the production of other fruit products has been decreasing in Serbia *(Lukač Bulatović, 2013)*. The most pronounced decrease in production was recorded in dried fruit production (a rate of change of -17.15%) and compote production (a rate of change of -11.61%).

Approximately 60% of the total Serbian fruit juice production is marketed in Serbia. However, apple fruit juice has traditionally claimed the largest share of the Serbian fruit juice export (about 30%). Serbian fruit juices are mostly exported to Germany, Austria, the Russian Federation, Montenegro, and Bosnia and Herzegovina.

The consumption of sparkling juices in Serbia is three times as high as that of fruit juices, resulting from lower retail prices of sparkling juices, aggressive marketing campaigns and the overall recognition of multinational sparkling juice brands.

The Serbian fruit processing is mostly located in the region of Central Serbia. Accordingly, Vojvodina claims approximately a 30% share of the total semi-processed fruit production in Serbia and a 20% share of the total processed fruit production in Serbia (*Lukač Bulatović, 2010).*

In his research, *Zlatković (2000)* suggests that the fruit processing capacities in Serbia are not a limiting factor in the further development of Serbian fruit production. On the contrary, the author stresses that such capacities are facing a lack of raw material supply due to their insufficient integration with the primary Serbian fruit production, which (relative to the actual fruit production structure and intensity in Serbia) leads to the underutilisation of fruit processing capacities, i.e. uncompetitive and high cost prices of finished fruit products.

Nowadays, Serbia has significant fruit processing and refrigeration capacities. However, the Serbian fruit processing and refrigeration facilities should be better equipped, modernised and specialised in order to produce high-quality fruit products which would meet the demand of the consuming public *(Lukač Bulatović, 2014)*.

Sredojević (2011) argues that fruits are processed and stored in more than 180 refrigerated storage facilities in Serbia. The installed capacity of cold processing facilities is 303,315 t, of which a total of 218.368 t are utilized. There are 39 facilities for cold fruit and vegetable processing in Serbia (with less than 50% in a fully operational state), of which only a few have implemented or are in the process of implementing the HACCP and ISO 9001 systems. There are also 20 plants for fruit juice and concentrate production in the country. However, a considerable number of these processing facilities are not fully operational, or are fitted with poor-quality equipment, whereas only a few feature high-performance processing technology. Moreover, a vast majority of the refrigerated storage facilities in Serbia do not employ the ULO (Ultra Low Oxygen) technology, whereas some even have no quality control systems whatsoever.

The author proposes the allocation of public investment funds, under the auspices of the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia and the EU accession programme in Serbia, to the following purposes: the establishment of ULO refrigerated storage facilities (as well as the modernization of the existing cold storage units), the procurement of dryers and the equipment for fruit cleaning, sorting, calibrating and packing, and the implementation of the HACCP and ISO systems for the further advancement of fruit processing and storing in Serbia.

The third result category includes studies on the use of applied quantitative methods for forecasting trends in agriculture production. Therefore, the remainder of this chapter will outline the arguments and considerations of the most prominent authors dealing with such issues: *Azhar et al. (1974), Hamid et al. (1987), Khan (1988), Novković et al. (1992), Muhammad et al. (1992), Nikolić-Djorić et al. (1993), Novković et al. (1994), Novković (2003, 2010), Iqbal et al. (2005), Mutavdžić et al. (2007, 2019), Sher, Ahmad (2008), Badmus, Ariyo (2011), Irfan et al. (2011), Biswa, Bhattacharyya (2013), Tahir, Habib (2013). Abid et al. (2014, 2018), Kilic Topuz et al. (2018). Başer et al. (2018).*

Lukač Bulatović, Djurić (2019) used the Box-Jenkins ARIMA models to forecast the number of productive apple trees and the volume of apple production in Serbia. The authors found that ARIMA(1,1,0) and ARIMA(0,1,1) are the most appropriate models for forecasting the number of productive apple trees and the apple production volume in Serbia, respectively. *Sharma at al. (2014)* used the Box-Jenkins ARIMA models to forecast the distribution of apple areas and the volume of apple production in Himachal Pradesh. *Ilić et al. (2016)* and *Novković et al. (1992)* used the ARIMA models to forecast the corn production in Serbia. *Hamjah (2014)* argues that ARIMA(2,1,3) is the best model for forecasting banana production, whereas ARIMA(1,1,2) is the most adequate model for guava production. *Wankhade et al. (2010)* made a forecast of pigeon pea production in India in the period from 1950-1951 to 2007-2008. *Zakari, Ying (2012)* forecasted the grain production and harvested areas in Niger. *Rahman (2010), Awal, Siddique (2011), Suleman, Sarpong (2012)* and *Hamjah (2014)* used the Box-Jenkins ARIMA models to forecast seasonal rice production.

2. FRUIT PRODUCTION CAPACITIES IN SERBIA

An orchard is a perennial planting of fruit- or nut-producing trees or shrubs characterized by specific inter- and intra-row spacings. A fruit plantation is a large-scale estate of certain shape and size, containing a perennial planting of fruit trees or shrubs arranged in orderly rows. Fruit plantations are contemporary fruit planting designs, which foster sound management practices and facilitate the use of cultivation machinery.

As a branch of plant production, fruit production is characterized by a great many comparative advantages relative to other branches of agriculture. A large number of continental fruit species are favourable for growing at sites with different soil and climatic conditions. Even soils considered unsuitable for cultivation of some crops such as field crops (due to their physical, chemical and biological properties) can be used for fruit growing. Owing to their deep and elaborate root systems, orchards can make use of nutrients unavailable to field crops.

Compared to other branches of plant production, fruit production features a considerably longer land-use duration, which ranges from 5 to 50 years depending on the fruit crop. Therefore, the selection of location, growing methods and cultivar assortments is of crucial importance, which could mark the difference between gains and losses.

Fruit growing is one of the most productive branches of agriculture *(Babović et al., 2005)*, generating the production value 10-20 times as high as that of wheat and corn production. Fruit production employs 20 times more workers per unit area than wheat production *(Milić, Lukač Bulatović, 2017).*

2.1. Orchard areas

2.1.1. Share of orchards in the total utilized agricultural land

The total agricultural land in Serbia averaged 5.36 million hectares in the period under consideration (1960-2018), with annual variations ranging from 3.44 million hectares in 2018 to 5.95 million hectares in 1960 (an absolute variation difference of 2.5 million ha (Table 1)). The decrease in the total Serbian agricultural land in the period under consideration, at an average annual rate of change of -0.74%, is associated with the diminishing agricultural lands in both Central Serbia (an annual rate of change of -1.09%) and Vojvodina (an annual rate of change of -1.16%) in the same period. Vojvodina accounted for 38.61% of the total Serbian agricultural land in the period under consideration.

Table 1. Orchard area in Serbia in the period 1960-2018

Indicators	**Agricultural land (ha)**	**Orchard area (ha)**	**Orchard area share in the total agricultural land in Serbia (%)**
Average 1960-2018	5,363,298	240,023	4.51
Min.	3,438,130	163,310	3.85
Max.	5,949,018	265,817	5.35
Annual Rate of Change (%)	-0.74	-0.35	0.40
Coefficient of Variation (%)	14.24	11.14	7.41

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

The total orchard area in Serbia averaged 240,023 ha in the period 1960-2018, with annual variations ranging from 163,310 ha in 2012 to 265,817 ha in 1983. The total Serbian orchard area decreased at an average annual rate of change of -0.35%, which is attributed to the diminishing orchard area in Central Serbia (at an average annual rate of change of -0.46%) (Table 2). By contrast, the total orchard area in Vojvodina increased at an average annual rate of change of 1.36%. Therefore, the Vojvodinian share in the total Serbian orchard area increased from 2.95% in 1960 to 10.67% in the final year of the period under consideration (Table 3).

Table 2. Orchard area in Central Serbia in the period 1960-2004

Indicators	**Agricultural land (ha)**	**Orchard area (ha)**	**Orchard area share in the total agricultural land in Serbia (%)**
Average 1960-2018	3,545,323	225,007	6.53
Min.	1,863,671	146,445	5.45
Max.	4,077,766	249,871	10.07
Annual Rate of Change (%)	-1.09	-0.46	0.63
Coefficient of Variation (%)	20.28	12.20	15.63

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Observed over shorter periods of time, the total orchard area in Serbia decreased from 262,574 ha (1980-1990) to 254,027 ha (1991-2000), or to 242,045 ha in the period 2001-2008 *(Lukač Bulatović, 2010)*. The most dramatic decrease in the Serbian orchard area was recorded in the period 1991-2000 (at an annual rate of change of -0.50%).

Table 3. Orchard area in Vojvodina in the period 1960-2018

Indicators	**Agricultural land (ha)**	**Orchard area (ha)**	**Orchard area share in the total agricultural land in Serbia (%)**	**Share of Vojvodina in the agricultural land in Serbia (%)**	**Share of Vojvodina in the orchard area in Serbia (%)**
Average 1960-2018	1,817,975	15,016	0.84	38.61	6.39
Min.	1,530,071	6,752	0.36	30.93	2.95
Max.	3,337,447	19,600	1.26	46.17	10.67
Annual Rate of Change (%)	-0.16	1.36	1.52	0.59	1.71
Coefficient of Variation (%)	16.38	22.66	26.97	18.49	30.44

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

The status and importance of fruit production in the Serbian agriculture is reflected in the share of orchard areas in the total agricultural land in Serbia. In the period under consideration (1960-2018), orchard areas claimed a share of 4.51% in the total agricultural land in Serbia, indicating a slightly increasing trend at an average annual rate of change of 0.40%.

Serbia boasts favourable natural conditions for growing most of the continental fruit species and an enduring tradition of fruit production (especially in some fruit-growing regions of the country). However, the full potential of these conditions has been grossly underexploited to date, which is suggested by the underlying trends in the Serbian fruit production volume and capacity utilization over longer periods of time. Owing to its mostly extensive character, the fruit production in Serbia has been stagnant for a considerable period of time, even showing signs of falling. In the period 1980-2004, the orchard area in Serbia averaged 251.841 ha, indicating a downward trend at an average annual rate of change of -0.47% (*Milić et al., 2005*).

The establishment of intensive fruit plantations should, at least, maintain the present distribution of orchard areas in Serbia (approximately 250,000 ha). Moreover, the intensification of fruit production should result in both higher yields per unit area and higher volumes of fruit production. Provided plum yields are increased to 15 t/ha, the current volume of plum production in Serbia could be achieved on a land area of 35,000 to 40,000 ha in contrast to more than 80,000 ha of the presently utilized areas devoted to plums *(Obradović, 2001).*

2.2. Number of productive fruit trees

Changes in the Serbian fruit production structure have been examined relative to trends in the number of productive fruit trees in Serbia. This number has served as one of the indicators for the Serbian fruit production capacity, while taking into account the effect of growing methods on the number of fruit trees per capacity unit.

2.2.1. Analysis and forecast of trends in the total number of productive trees of major fruit species in Serbia

In the period under consideration (1960-2018), the total number of productive fruit trees in Serbia, i.e. of the fruit species considered[1] in the present study, averaged 76 million, indicating a slightly increasing trend (at an annual rate of change of 0.50%). The number of productive fruit trees in Central Serbia increased at an average annual rate of change of 0.32%, whereas such increase was even larger in Vojvodina with an average annual rate of change of 1.69% (Table 4). The share of Vojvodina in the total number of productive fruit trees in Serbia increased at an average annual rate of change of 1.18%).

Observed over shorter periods of time, the number of productive fruit trees in Serbia increased from 65.80 million (in the period 1960-1979) to 83.65 million (in the period 1980-1999), followed by a decrease to 78.68 million in the final subperiod under consideration. The number of productive fruit trees in Vojvodina increased from 6.78 million in the initial subperiod under consideration to 12.01 million in the period 1980-1999, or to 13,00 million in the period 2000-2018. In the period 2000-

[1] The present study included all the fruit species for which official records have been kept by the Statistical Office of the Republic of Serbia since 1960.

2018, the share of Vojvodina in the total number of productive fruit trees in Serbia averaged 16.52%.

Table 4. Trends in the number of productive fruit trees in Serbia in the period 1960-2018

Indicators	Number of productive trees (000)			Share of Vojvodina in the total number of productive fruit trees in Serbia (%)
	Serbia	Central Serbia	Vojvodina	
Average 1960-2018	75,996	65,441	10,555	13.65
Min.	48,631	44,076	4,555	8.82
Max.	86,685	74,014	16,542	20.95
Annual Rate of Change (%)	0.50	0.32	1.69	1.18
Coefficient of Variation (%)	12.11	10.49	29.04	21.98
Average 1980-2017	65,800	59,016	6,784	10.21
Min.	48,631	44,076	4,555	8.82
Max.	78,143	68,630	9,513	12.17
Annual Rate of Change (%)	2.26	2.09	3.75	1.46
Coefficient of Variation (%)	13.00	12.10	21.41	9.09
Average 1980-2017	83,647	71,641	12,006	14.35
Min.	79,536	68,788	9,463	11.90
Max.	86,685	74,014	12,794	15.75
Annual Rate of Change (%)	-0.18	-0.32	0.72	0.89
Coefficient of Variation (%)	2.67	2.75	7.01	6.35
Average 1980-2017	78,675	65,680	12,995	16.52
Min.	76,690	62,400	11,181	14.50
Max.	81,434	69,129	16,542	20.95
Annual Rate of Change (%)	-0.25	-0.25	-0.31	-0.06
Coefficient of Variation (%)	1.99	3.54	13.04	13.22

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

In the period 1960-2018, plums accounted for 55.67% of the total number of productive fruit trees in Serbia (Table 5), followed by apples (17.00%) and sour cherries (9.08%). The remaining fruit crops considered (namely pears, peaches, sweet cherries, apricots, walnuts and quinces) claimed a share of less than 6.43%. Accordingly, plums are the predominant fruit crop in the Serbian fruit production structure. They are grown on a majority of farms primarily because of the long-established tradition of plum brandy production in Serbia (i.e. slivovitz or *šljivovica* production) and their rather extensive cultivation (with minimum cultural practice and natural condition requirements).

In the period 1960-2018, plums and apples were the most prevalent fruit crops in the fruit plantation structure in Central Serbia, claiming shares of 60.82% and 14.09% respectively. The share of all other fruit crops considered in the total number of productive fruit trees in Central Serbia ranged from 0.97% (quinces) to 8.85% (sour cherries). However, apples were the predominant fruit crop in the fruit plantation structure in Vojvodina (34.21%), followed by plums (22.04%), pears (12.16%), sour cherries (11.29%) and peaches (8.39%). The remaining fruit crops considered (namely apricots, sweet cherries, walnuts and quinces) claimed a share of less than 5.11% in the total number of productive fruit trees in Vojvodina. Plums and apples accounted for 56.25% of the total number of productive fruit trees in Vojvodina.

Table 5. Fruit species in Serbia according to the average number of productive trees in the period 1960-2018

Fruits species	**Serbia**	**Central Serbia**	**Vojvodina**
Apples	17.00	14.09	34.21
Pears	6.43	5.56	12.16
Quinces	1.03	0.97	1.55
Plums	55.67	60.82	22.04
Sweet Cherries	2.23	2.16	2.84
Sour cherries	9.05	8.85	11.29
Peaches	4.65	4.09	8.39
Apricots	2.12	1.73	5.11
Walnuts	1.82	1.73	2.41
Total productive trees	100.00	100.00	100.00

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Forecast of the number of productive fruit trees in Serbia - the ARIMA(1,1,0) model was selected for forecasting the total number of

productive fruit trees in the Republic of Serbia using the Statistica 13.3 program.

The parameter estimates are displayed in Tab. 6. Parameter estimates are not statistically significant with the autoregressive part. However, the exclusion of the AR part from the model is not an option in Statistica 13.3.

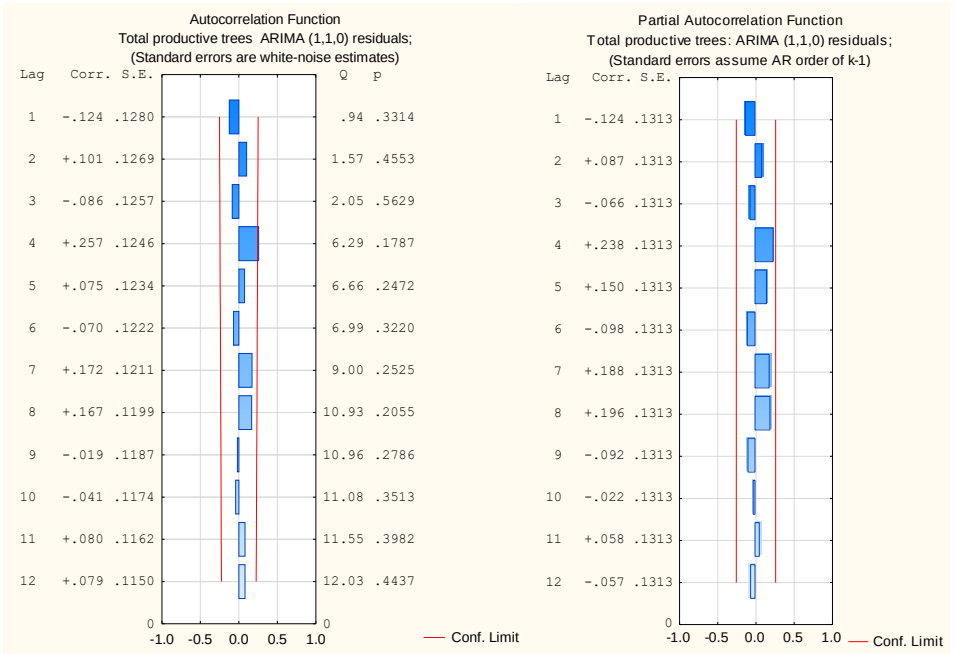
Furthermore, the model was utilised for computing the parameter estimates and the 95% confidence interval. Upon analysing the residual autocorrelation function and partial autocorrelation function of the model assessed, it can be argued that the model is adequate.

Table 6. Model for forecasting the total productive trees in Serbia

Paramet.	Input: Total productive trees (Spreadsheet1 in Workbook1) Transformations: D(1) Model:(1,1,0) MS Residual= 9566E2					
	Param.	Asympt. Std.Err.	Asympt. t(56)	p	Lower 95% Conf	Upper 95% Conf
Constant	676.0325	333.0984	2.029528	0.047167	8.756199	1343.309
p(1)	0.6071	0.1134	5.354531	0.000002	0.379978	0.834

Total productive trees – Residuals:

ACF PACF



The forecast values of the trends in the number of productive trees (Table 7, Fig. 1) indicate an annual increase in the total number of productive fruit trees. In the period 2019-2023, the total number of productive fruit trees will constantly increase up to approximately 83 million.

Table 7**.** The forecast of the total productive trees in Serbia (2019-2023)

Case No.	Forecasts; Model:(1,1,0) Seasonal lag: 12 (Spreadsheet1 in Workbook1) Input: Total productive trees Start of origin: 1 End of origin: 59			
	Forecast	Lower 95.0000%	Upper 95.0000%	Std.Err.
61	80425.95	76717.30	84134.59	1851.324
62	81194.84	75833.98	86555.69	2676.090
63	81927.24	75049.01	88805.47	3433.551
64	82637.50	74376.37	90898.64	4123.887
65	83334.31	73811.31	92857.32	4753.802

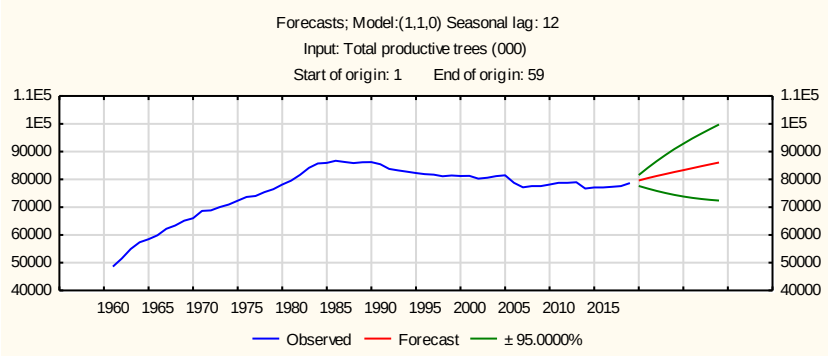


Figure 1. The forecast the total productive trees (000)

3. FRUIT PRODUCTION IN SERBIA

Fruits are considered ripe, fleshy and juicy seed-bearing structures of different perennial plants. They provide a dietary source of essential vitamins (A, B and C vitamins in particular) and nutrients, which human nutrition is often deficient in, necessary for proper body function. The nutritional value of fruits is not high (with the exception of some fruit crops such as walnuts, almonds and hazelnuts), but it still exceeds that of vegetables.

Vlahović (2003) argues that fruits can be divided into two groups according to their nutritional value:

- Fruits rich in water (namely oranges, lemons, grapes, raspberries, strawberries, blackberries, sour cherries, sweet cherries, apricots, peaches, apples, pears, plums, etc.), with a water content up to 95%, have a low energy value and low fat and protein contents.
- Fruits rich in fats (namely walnuts, almonds, hazelnuts, etc.) have a high energy value and a high fat content, whereas their water content is minute.

According to their sugar content, fruits can be divided into a number of groups:

- up to 5% (almonds),
- from 5% to 10% (lemons, blueberries, strawberries, watermelons and quinces),
- from 10% to 15% (apples, pears, apricots, peaches, raspberries and blackberries),
- from 15% to 20% (plums, grapes and figs),
- more than 20% (dates and bananas).

Continental fruit species are usually classified into four types:

- *Pome fruits* - apples, pears, quinces, sorb-apples and medlars
- *Stone fruits* - sweet cherries, sour cherries, apricots, peaches and plums
- *Berry fruits* - strawberries, blackberries, raspberries and currants
- *Shell fruits* - walnuts, hazelnuts, almonds and sweet chestnuts

The global production volume of fruits approximates to 588 million tonnes annually, of which bananas claim the largest share of approximately 17.5% (followed by apples and oranges with a joint share of around 12%). China is the leading world producer of fruits (with an

approximate volume of 115 million tonnes), followed by India (about 68 million tonnes) and Brazil (about 38 million tonnes) *(Vračar, 2012)*. The volumes of fruits produced globally can only meet one-third of the current demand worldwide.

Under contemporary conditions of fruit production, the overall production volume is not as important as the production of marketable fruits and fruit products. Fruit production can be very cost-effective provided fruit growing technologies are responsive to market demands *(Lukač Bulatović, 2014).* Therefore, a successful fruit production should be based on high-quality and high-yielding fruit cultivars, used for achieving the optimal production and economic gains under specific agroecological conditions of a plantation site. Moreover, certain less-produced fruit crops (namely apricots, peaches, sour cherries, pears, shell fruits and berry fruits) should claim a larger share in the Serbian fruit production structure on account of their great foreign marketability.

The fruit production in Serbia has been characterised by obsolete cultivar assortments, semi-intensive and extensive plantations with inadequate planting materials, low levels of cultural and pomological practices, inferior and non-uniform quality of fruits, and the lack of proper storage capacities. Over the past years, intensive fruit plantations have been established, featuring contemporary cultivar assortments and high-performance production technology. Furthermore, quality planting materials have been produced in domestic nurseries *(Nikolić et al., 2012),* and the number of modern cold storages and new processing facilities is constantly increasing *(Keserović, Magazin, 2014).*

The most significant improvements have been recorded in the application of apple-growing technologies. Contemporary standards in apple production require more intensive plantations with dense plant populations, irrigation systems and hail netting, accompanied by the introduction of quality assurance *(Keserović et al., 2007)*. Such plantations ought to incorporate fruit cultivar assortments based on market demands (e.g. 'Golden Delicious', 'Red Delicious' and 'Granny Smith' cultivars). Consequently, the yield per hectare would range from 50 to 70 tonnes on average with high investments per unit area *(Milić et al., 2005).*

The growing medium is a key limiting factor in intensifying the production of some pome fruit species in Serbia such as pears and quinces. Pear seedlings should grow into vigorous trees provided they are planted without irrigation and in a soil with a high content of calcium carbonate *(Nikolić et al., 2014).* New pear and quince plantations are being established by means of stem cuttings without hail netting, whereas

irrigation systems are increasingly scarce. The lack of more substantial investments in intensive pear and quince plantations is probably due to a threat of fire blight and pear psylla infestation *(Mišić, 2002).* The most prevalent pear cultivar in Serbian plantations is 'William's Bon Chrétien Bartlett', followed by 'Santa Maria', 'Abbate Fetel' and 'Coscia' *(Šoškić, 2008).* The assortment of quince cultivars in the world is rather regional in character. The 'Leskovačka' and 'Vranjska' cultivars predominate in the Serbian assortment of quince cultivars.

According to the total number of trees and annual fruit production, plums have been the most important fruit species in Serbia for a number of years. There was a slight decrease in the total number of trees during the last decade, whereas the total annual production increased. Therefore, it can be argued that semi-intensive and intensive means of growing are increasingly supplanting the extensive production *(Keserović et al., 2010; Lukač Bulatović et al., 2013; Lukač Bulatović, 2014).* The indigenous cultivars used for brewing account for a smaller share of the total plum production every year, whereas some other cultivars are gaining prominence such as 'Čačanska lepotica', 'Stanley' and 'Čačanska rodna'. 'Čačanska rana' and 'Čačanska najbolja' are present to a lesser extent *(Nikolić et al., 2012).*

The following factors exert most limiting effects on the cherry and sour cherry production in Serbia: inadequate cultivar assortments, lush trees and wide tree spacings, which hinder harvest and both cultural and pomological practices *(Milatović et al., 2011).* In order to increase the Serbian cherry production, more recent cultivars ought to be introduced, featuring superior productivity, better fruit appearance (i.e. larger size), harder mesocarp and higher quality in comparison with the existing cultivar assortment *(Milatović, Đurović, 2010).* The clones of 'Oblačinska višnja' and 'Cigančica' account for nearly 85% of the total sour cherry production in Serbia, whereas the remainder encompasses certain large-fruited cultivars such as 'Rexelle', 'Heimanns Konservenweichsel', 'Kelleriis 14' and 'Šumadinka' *(Cerović, Radičević, 2008).* 'Érdi Bötermö', 'Lara' and 'Újfehértói Fürtös' are the cultivars which are widely recommended for commercial growing in Serbia.

To achieve good results in peach and apricot production, growing areas ought to be restricted to favourable sites. Peach cultivars with favourable biological properties, in combination with more intensive growing technology, ought to be selected for enhancing the total peach production and fruit quality *(Ognjanov, 2003).* Nowadays, the following peach cultivars are most commonly grown in Serbia: 'Redhaven', 'Glohaven', 'Suncrest', 'Cresthaven' and 'Fayette' *(Nikolić et al., 2012).*

Apricot production could be improved by favourable agroecological conditions, virus-free planting materials, cultivar diversity in plantations and more intensive growing technology (with requisite irrigation, green pruning and frost protection).

The nut production in Serbia, notably the walnut and hazelnut production, has been ultimately extensive for a number of years, lacking proper care. The walnut production is based primarily on seedlings which are either propagated spontaneously by means of asexual reproduction or are, on a smaller scale, planted purposefully. Hazelnuts are grown in domestic gardens and production deficits are partly compensated for by common and Turkish hazelnuts, which arise spontaneously *(Nikolić at al., 2012).* Moreover, the investment period in walnut and hazelnut production (i.e. plantation establishment and care) is longer, whereas the full productivity of these plants is reached in 5 to 10 years, which is an additional hindrance compared to other continental fruit species *(Korać et al., 1996).* In Serbia, there are no statistical data on the number of productive trees, distribution of production areas, yield and total production volume of hazelnuts. The estimated areas devoted to hazelnuts approximate to 2,000 ha, and the annual hazelnut production approximates to 1,500 tonnes *(Šoškić, 2005).* The following hazelnut cultivars are the most prevalent in newly-established plantations in Serbia: 'Ennis', 'Tonda Gentile delle Langhe', 'Tonda Gentile Romana', 'Tonda di Gifoni' and 'Istarski Dugi' *(Mitrović et al., 2012).*

According to *Nikolić et al. (2012),* the prospects of soft fruit production in Serbia are promising provided numerous general and specific requirements are met. The following general requirements are the most pressing: the lack of sound strategy (both medium- and long-term), the establishment of plantations on unfavourable sites, insufficient plantation incentives, the lack of production subsidies (which deteriorates Serbia's competitiveness), ill-organised nursery production (which necessitates the extensive use of plant materials from productive plantations with subsequent detrimental effects on fruit growing), poorly organised extension services, an insufficient number of processing capacities (i.e. the advanced processing for export), small farms, the lack of labour force (especially for harvest), etc. These issues have been present for a number of decades and no significant improvements are pending *(Cerović et al., 2005*). The specific requirements in the Serbian soft fruit production address the issues of assortment, production technology application and harvest quality *(Nikolić, 2012).*

As fruits of many fruit varieties and cultivars are not suitable raw materials for high-quality products, the production of industrial fruits for

specific processing procedures (such as industrial peaches and apples) should be increased.

3.1. State and forecast of the total production of major fruit crops in Serbia

In the period 1960-2018, the actual fruit production in Serbia[2] averaged 992,638 t, varying annually from 290,130 t in 1960 to 1.61 million tonnes in 2013. The great annual variability in the Serbian fruit production volume is further confirmed by an absolute variation difference of 1.32 million tonnes recorded in the period under consideration (Table 8). With an average fruit production volume of 178,437 t, Vojvodina accounts for 17.79% of the total fruit production in Serbia.

Table 8. Trends in the Serbian fruit production in the period 1960-2018

Indicators	**Production (t)**			**Share of Vojvodina in the total Serbian fruit production (%)**
	Serbia	**Central Serbia**	**Vojvodina**	
1	2	3	4	5
Average 1980-2017	992,638	814,201	178,437	17.79
Min.	290,130	223,440	62,730	8.50
Max.	1,613,652	1,309,831	303,821	25.54
Annual Rate of Change (%)	0.96	0.79	1.89	0.92
Coefficient of Variation (%)	25.24	24.69	36.63	23.52
Average 1980-2017	826,742	711,184	115,558	14.40
Min.	290,130	223,440	62,730	8.50
Max.	1,310,600	1,165,510	179,766	23.88
Annual Rate of Change (%)	2.59	2.23	4.83	2.18
Coefficient of Variation (%)	27.43	28.96	31.67	28.83

[2] Apples, pears, quinces, plums, cherries, sour cherries, peaches, apricots, walnuts, strawberries and raspberries

1	2	3	4	5
Average 1980-2017	999,586	808,502	191,084	19.27
Min.	663,078	802,602	144,711	15.28
Max.	1,282,159	763,168	251,265	25.54
Annual Rate of Change (%)	-0.71	-0.68	-0.78	-0.07
Coefficient of Variation (%)	15.51	16.85	16.16	13.66
Average 1980-2017	1,159,953	928,639	231,314	19.79
Min.	592,966	688,344	66,707	11.25
Max.	1,613,652	1,065,397	303,821	25.06
Annual Rate of Change (%)	2.49	2.06	4.47	1.94
Coefficient of Variation (%)	21.54	21.59	26.74	17.13

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Growing trends in the total Serbian fruit production are associated with the increased fruit production in both Central Serbia (at an average annual rate of change of 0.79%) and Vojvodina (at an average annual rate of change of 1.89%). The share of Vojvodina in the total Serbian fruit production increased at an average annual rate of change of 0.92%.

Observed over shorter periods of time, the total fruit production in Serbia increased from 826,742 t (in the period 1980-2008) to 999,586 t (in the period 1991-2000), or to 1.16 million t in the final subperiod under consideration. The largest increase in the Serbian fruit production volume was recorded in the period 2000-2018 (at an average annual rate of change of 2.49%).

In the period under consideration (1960-2018), plum production claimed the largest average share in the Serbian fruit production structure (Table 9), accounting for 46.82% of the total fruit production in Serbia. Apples, sour cherries and pears accounted for 20.97%, 6.68% and 6.21% of the total fruit production in Serbia, respectively. The remaining fruit crops considered (namely peaches, raspberries, strawberries, sour cherries, apricots, walnuts and quinces) claimed a share of less than 4.66% in the Serbian fruit production structure.

In the period under consideration, plums and apples jointly claimed the largest share in the fruit production structure in Central Serbia, accounting for 68.20%. Sour cherries, pears and raspberries accounted for 6.41%, 5.69% and 5.46% of the total fruit production in Central Serbia, respectively. The remaining fruit crops considered claimed shares ranging

from 0.99% (quinces) to 4.14% (peaches) of the total fruit production in Central Serbia.

Apples claimed the largest share in the fruit production structure in Vojvodina, accounting for 43.39% of the total Vojvodinian fruit production in the period under consideration. Plums, pears and sour cherries accounted for 20.13%, 8.78% and 8.65% of the total fruit production in Vojvodina, respectively. The remaining fruit crops considered claimed shares ranging from 0.45% (raspberries) to 7.37% (peaches) of the total Vojvodinian fruit production.

On balance, plums, apples and sour cherries were the most prevalent fruit crops in Serbia in the period under consideration relative to both the number of their productive trees and the volume of their actual production.

Tabela 9. Average actual production of fruit species in Serbia in the period 1960-2018

Fruits species	**Serbia**	**Central Serbia**	**Vojvodina**
Apples	20.97	15.87	43.39
Pears	6.21	5.69	8.78
Quinces	1.04	0.99	1.33
Plums	46.82	52.33	20.13
Sweet Cherries	2.52	2.55	2.53
Sour cherries	6.68	6.41	8.65
Peaches	4.66	4.14	7.37
Apricots	2.14	1.74	4.42
Walnuts	1.72	1.66	2.08
Strawberries	2.73	3.16	0.87
Raspberries	4.51	5.46	0.45
Total production	100.00	100.00	100.00

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Forecast of fruit production in Serbia - the ARIMA(2,1,0) model was selected for forecasting the fruit production volume in Serbia using the Statistica 13.3 program.

The model assessed (Table 10) indicates that the prior year value greatly affects the current year value.

The forecast values of the volume of fruit production (Table 11, Fig. 2) show a constant annual increase, and, at the end of the forecast period, the production volume will approximate to 1.4 million tonnes.

Table 10. Parameters of the ARIMA model employed for forecasting the fruit production volume in Serbia

Paramet.	Input: Total volume of fruit production (Spreadsheet1 in Workbook1) Transformations: D(1) Model:(2,1,0) MS Residual= 5478E7					
	Param.	Asympt. Std.Err.	Asympt. t(55)	p	Lower 95% Conf	Upper 95% Conf
p(1)	-0.57827	0.13193	-4.38317	0.000053	-0.84266	-0.31388
p(2)	-0.25376	0.13239	-1.91678	0.060467	-0.51908	0.01155

Total volume of fruit production - Residuals:

ACF **PACF**

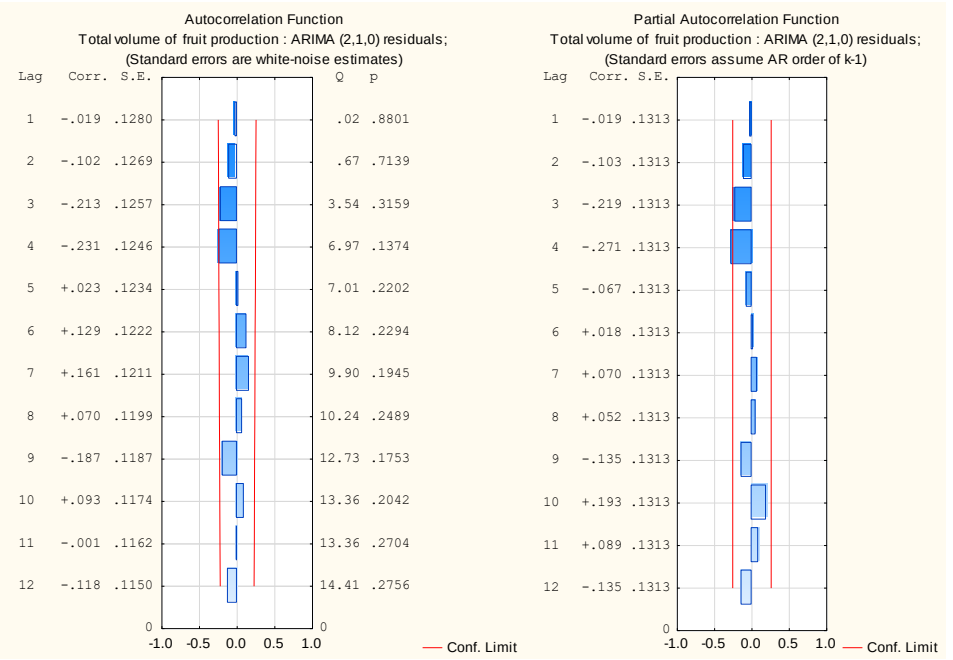


Table 11**.** The forecast of the total fruit production in Serbia (2019-2023)

CaseNo.	Forecasts; Model:(2,1,0) Seasonal lag: 12 (Spreadsheet1 in Workbook1) Input: Total volume of fruit production Start of origin: 1 End of origin: 59			
	Forecast	Lower 95.0000%	Upper 95.0000%	Std.Err.
61	1292198.85	783164.92	1801232.78	254003.27
62	1328281.91	767359.75	1889204.08	279895.02
63	1332248.78	704167.91	1960329.65	313406.60
64	1346676.62	672200.76	2021152.49	336557.28
65	1363205.14	642076.11	2084334.16	359836.78

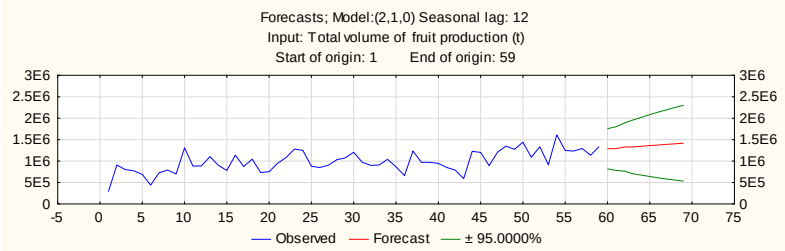


Figure 2. The forecast the total fruit production (000)

3.1.1. Analysis and forecast of apple production

In the period 1960-2018, the total number of productive apple trees in Serbia averaged 13.21 million, indicating a growing trend (Table 12). The number of productive apple trees in Central Serbia and Vojvodina increased at average annual rates of change of 2.55% and 3.97%, respectively. A more rapid increase in the number of productive apple trees in Vojvodina than that recorded in Central Serbia led to an increase in the Vojvodinian share in the total number of productive apple trees in Serbia from 17.23% in 1960 to 28.61% in the final year of the period under consideration.

Similar trends were also observed over shorter periods of time, and the largest increase in the number of productive apple trees in Vojvodina was recorded in the period 1960-1979 (at an average annual rate of change of 5.00%).

Table 12. Trends in the number of productive apple trees in Serbia in the period 1960-2018

Indicators	**Number of productive trees (000)**			**Share of Vojvodina in the number of productive apple trees in Serbia (%)**
	Serbia	**Central Serbia**	**Vojvodina**	
1	2	3	4	5
Average 1960-2018	13,212	9,304	3,908	27.78
Min.	3,866	3,200	648	14.88
Max.	25,202	17,991	8,664	37.54
Annual Rate of Change (%)	2.91	2.55	3.97	1.03
Coefficient of Variation (%)	46.23	43.13	55.40	19.78

1	2	3	4	5
Average 1960-1979	6,789	5,287	1,502	21.32
Min.	3,866	3,200	648	14.88
Max.	10,194	7,730	2,464	24.78
Annual Rate of Change (%)	5.00	4.31	7.76	2.63
Coefficient of Variation (%)	27.92	24.65	39.94	16.10
Average 1980-1999	12,826	8,868	3,958	30.71
Min.	10,705	8,110	2,595	24.24
Max.	14,393	9,708	4,634	32.89
Annual Rate of Change (%)	1.06	0.62	2.12	1.05
Coefficient of Variation (%)	6.99	4.23	14.07	8.22
Average 2000-2018	20,380	13,992	6,388	31.49
Min.	14,176	9,638	4,538	27.65
Max.	25,202	17,991	8,664	37.54
Annual Rate of Change (%)	3.50	3.81	2.76	-0.72
Coefficient of Variation (%)	19.20	20.96	18.95	8.76

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

The average share of Vojvodina in the total number of productive apple trees in Serbia increased from 21.32% (in the period 1960-1979) to 31.49% (in the period 2000-2018).

In the period 1960-2018, the total apple production in Serbia averaged 217,431 t, increasing at an average annual rate of change of 2.66% (Table 13). This increase was brought about by the increased apple production in both Central Serbia (at an average annual rate of change of 2.33%) and Vojvodina (at an average annual rate of change of 3.41%). The share of Vojvodina in the total apple production in Serbia averaged 36.99% in the period under consideration. A coefficient of variation of 57.23% indicates considerable variability in the apple production in Vojvodina.

Observed over shorter periods of time, the actual apple production in Vojvodina increased from 127,434 t (in the period 1960-1979) to 212,447 t (in the period 1980-1999), or to 317,410 t in the period 2000-2018. The share of Vojvodina in the total apple production in Serbia increased from 32.23% (in the period 1960-1979) to 39.40% (in the period 2000-2018).

The coefficients computed indicate variability in the volume of the Serbian apple production, which is especially pronounced in the period 1960-1979 (CV = 46.66%).

Table 13. Trends in the apple production in Serbia in the period 1960-2018

Indicators	Production (t)			Share of Vojvodina in the total apple production in Serbia (%)
	Serbia	Central Serbia	Vojvodina	
Average 1960-2018	217,431	133,306	84,125	36.99
Min.	34,480	20,310	12,460	14.63
Max.	516,411	321,193	198,876	47.34
Annual Rate of Change (%)	2.66	2.33	3.41	0.73
Coefficient of Variation (%)	49.73	46.82	57.23	20.47
Average 1960-1979	127,434	84,074	43,360	32.23
Min.	34,480	20,310	12,460	14.63
Max.	213,820	154,210	94,420	47.34
Annual Rate of Change (%)	8.16	6.30	12.21	3.74
Coefficient of Variation (%)	46.66	43.75	64.86	30.88
Average 1980-1999	212,447	128,560	83,887	39.47
Min.	133,822	73,757	58,289	33.61
Max.	306,950	182,670	124,280	45.69
Annual Rate of Change (%)	-1.40	-1.33	-1.48	-0.09
Coefficient of Variation (%)	19.18	19.26	22.12	9.02
Average 2000-2018	317,410	190,124	127,286	39.40
Min.	95,584	72,747	22,837	23.89
Max.	516,411	321,193	198,876	46.44
Annual Rate of Change (%)	6.36	5.60	7.71	1.27
Coefficient of Variation (%)	35.39	34.70	38.95	13.56

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

With 25.2 million productive trees, apples claimed a share of approximately 32% in the total number of productive fruit trees in Serbia

in 2018 (Table 14). Compared to the base year of 1960, the total number of productive apple trees in Serbia increased by 21.34 million (or 652 index points) in the final year of the period under consideration. In 2018, the share of apples in the Serbian fruit plantation structure increased by 403 index points compared to the base year of 1960.

Table 14. Number of productive apple trees and the volume of apple production in Serbia in the years considered

Year	**Serbia**		
	Apples	**Other fruit species**	**Total**
1960			
Number of productive trees (000)	3,866	44,765	48,631
- Share (%)	7.95	92.05	100.00
Production (t)	34,480	255,650	290,130
- Share (%)	11.88	88.12	100.00
2018			
Number of productive trees (000)	25,202	53,467	78,669
Index 1980=100	*651.89*	*119.44*	*161.77*
- Share (%)	32.04	67.96	100.00
Index 1980=100	*403.02*	*73.83*	*/*
Production (t)	460,404	877,278	1,337,682
Index 1980=100	*1,335.28*	*343.16*	*461.06*
- Share (%)	34.42	65.58	100.00
Index 1980=100	*289.73*	*74.42*	*/*

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Apples claimed a 60.8% share in the total number of productive fruit trees in Vojvodina (Table 15). Compared to the base year of 1960, the total number of productive apple trees in Vojvodina increased by 6.55 million, or approximately tenfold (an index of 1,083), in the final year of the period under consideration. In 2018, the share of apples in the Vojvodinian fruit plantation structure increased by 416 index points compared to the base year of 1960.

With an actual production of 460,404 t in 2018, apples claimed the largest share (or 34.42%) in the total fruit production structure in Serbia. In the final year of the period under consideration, the total apple production in Serbia increased by 1,300 index points compared to the base year of 1960. The share of apples in the Serbian fruit production structure increased from 11.88% in 1960 to 34.42% in 2018, representing 290 index points.

Table 15. Number of productive apple trees and the volume of apple production in Vojvodina in the years considered

Year	Vojvodina		
	Apples	**Other fruit species**	**Total**
1960			
Number of productive trees (000)	666	3,889	4,555
- Share (%)	14.62	85.38	100.00
Production (t)	14,170	52,520	66,690
- Share (%)	21.25	78.75	100.00
2018			
Number of productive trees (000)	7,211	4,650	11,861
Index 1980=100	*1,082.73*	*119.57*	*260.40*
- Share (%)	60.80	39.20	100.00
Index 1980=100	*415.87*	*45.91*	/
Production (t)	178,266	94,019	272,285
Index 1980=100	*1,258.05*	*179.02*	*408.28*
- Share (%)	65.47	34.53	100.00
Index 1980=100	*308.09*	*43.85*	/

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Apples accounted for 65.47% of the total fruit production in Vojvodina in 2018. The apple production in Vojvodina increased by 164,096 t in 2018 (or by 1,258 index points) compared to the base year of 1960. In 2018, the share of apples in the Vojvodinian fruit production structure increased by 308 index points over that recorded in the initial year of the period under consideration.

Forecast of apple production in Serbia - the ARIMA(2,1,0) and ARIMA(0,1,1) models were selected for forecasting the number of productive apple trees and the volume of apple production in Serbia respectively.

Table 16 shows the parameters of the ARIMA models employed.

The forecast values obtained indicate that the increase in the number of productive apple trees in Serbia in the period under consideration will continue throughout the entire forecast period (Table 17 and Figure 3). At the end of the forecast period, the expected number of productive apple trees in Serbia will approximate to 27 million, representing an increase of about 23 million over the number of productive apple trees in Serbia in 1960 and an increase of approximately 14 million over the average number of productive apple trees in the period 1960-2018.

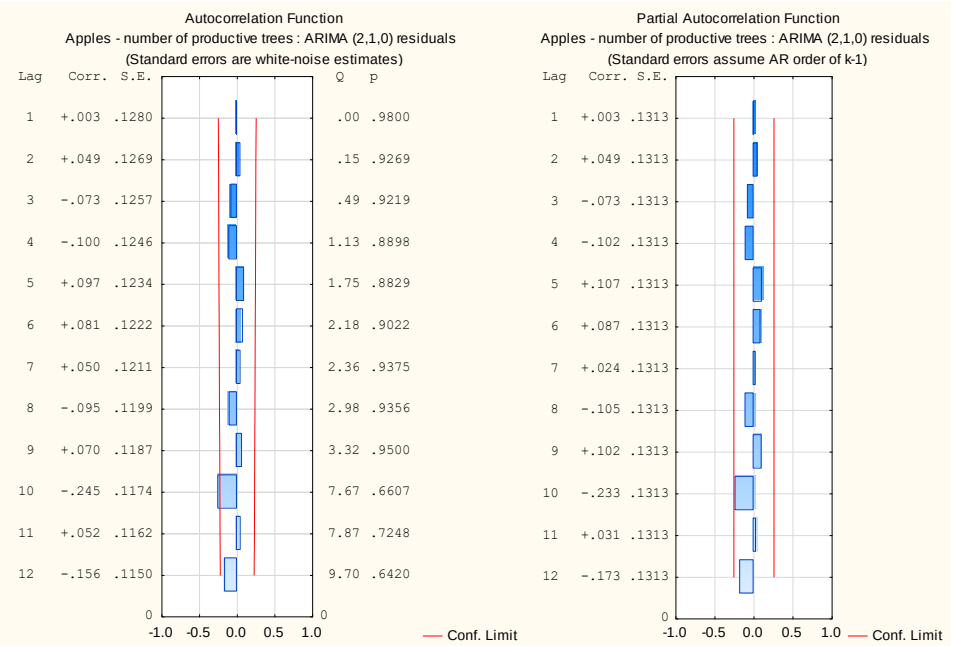
The forecast trend values of apple production in Serbia indicate a slight increase throughout the entire forecast period (Table 17 and Figure 4). The expected apple production in Serbia will approximate to 460,000 t by the end of 2023, representing an increase of about 430,000 t over the actual apple production in Serbia in the initial year of the period under consideration (1960) and an increase of approximately 240,000 t over the average apple production in Serbia in the period under consideration (1960-2018).

Table 16. Parameters of the models for forecasting the number of productive apple trees and the volume of apple production in Serbia

ARIMA Model Parameters		**Apples**			
		Number of productive trees			**Production**
Model		(2,1,0)			(0,1,1)
MS Residual		64538			3069E6
Parameters		Constant	p(1)	p(2)	q(1)
Param.		293.71834	-0.00819	0.44439	0.63257
SE		57.91144	0.12806	0.12853	0.09371
t		5.07185	-0.06398	3.45733	6.75029
p		0.00001	0.93922	0.00107	0.00001
Confidence interval (95%)	Lower	177.61289	-0.26494	0.18669	0.44485
	Upper	409.82378	0.24855	0.70209	0.82030

Number of productive apple trees – Residuals:

ACF PACF



Total volume of apple production - Residuals:

ACF PACF

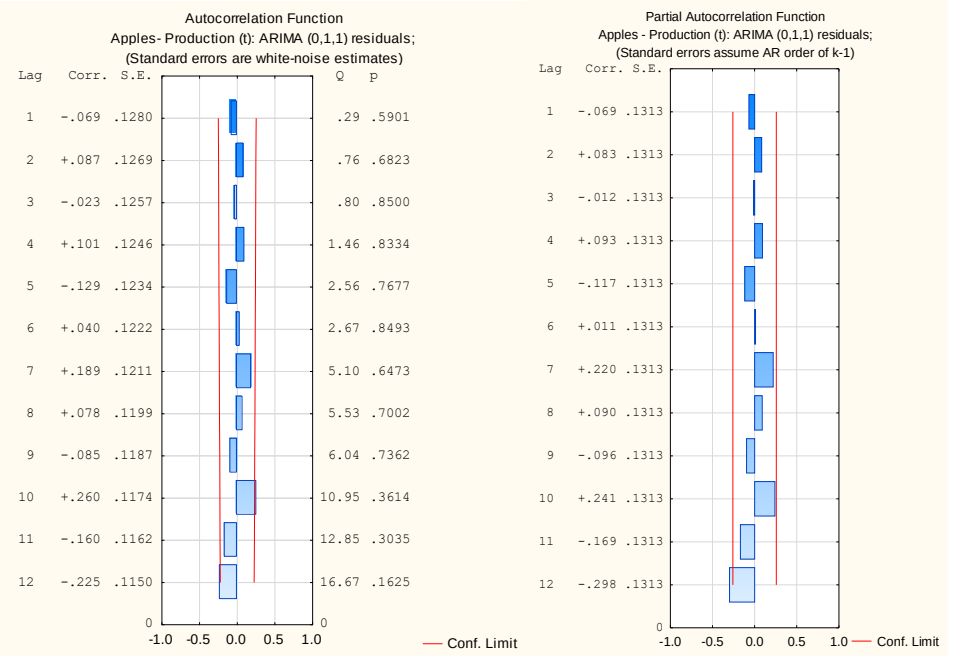


Table 17. The forecast of the number of productive apple trees and the total volume of apple production in Serbia (2019-2023)

Apples	**Forecast**				
	2019	2020	2021	2022	2023
Number of productive trees (000)	25999.59	26292.72	26678.72	26971.42	27306.15
LCL	25282.24	25268.17	25421.96	25466.18	25589.19
UCL	26716.94	27317.28	27935.47	28476.66	29023.12
SE	357.802	511.032	626.848	750.789	856.394
Production (t)	437042.70	443704.90	450367.20	457029.40	463691.70
LCL	326072.30	325481.0	325309.70	325492.90	325980.70
UCL	548013.10	561928.90	575424.70	588565.90	601402.70
SE	55395.46	59016.36	62427.59	65661.85	68744.11

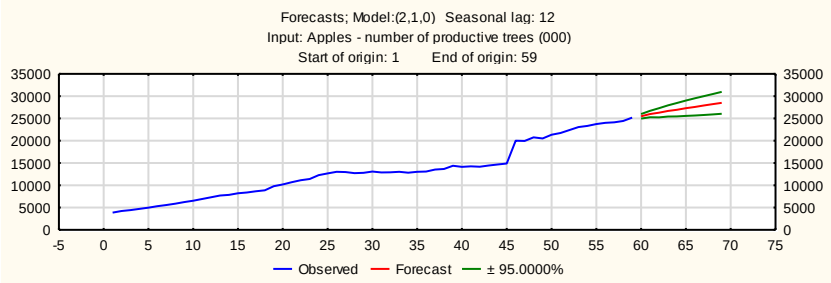


Figure 3. The forecast the number of productive apple trees (000)

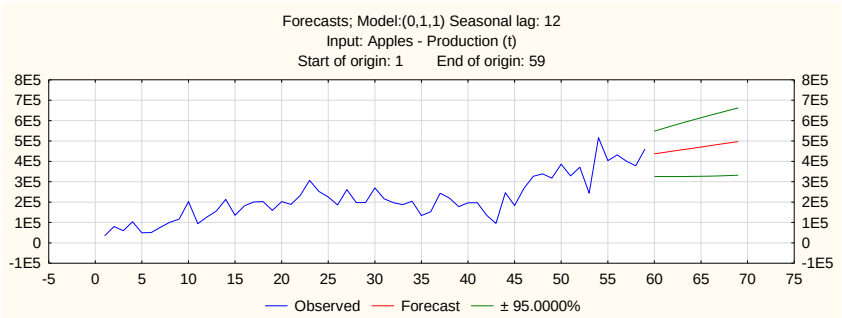


Figure 4. The forecast the total volume of apple production (tonnes)

Utility value of apples - apples are considered exquisite and durable fresh fruits, which can be preserved and used throughout the entire year. Owing to their chemical composition and organoleptic properties, apples are held in high regard as delicious, healthy and sanitary food, exerting a number of powerful nutritional and therapeutic effects. As these beneficial properties are not lost in processing, apples are used as a good raw material in different industries (namely the juice, marmalade, pectin and other industries). Ripe apple fruits have a water content of 85% and a sugar content of 14%, whereas proteins and fats account for only 0.4% *(Milić, Radojević, 2003)*. A relatively low energy value of apples is favourable to human health: a total of 100 g of apples contain 240 kJ (which is approximately four times lower than in 100 g of bread).

Apples provide a dietary source of essential minerals such as calcium, phosphorus and iron. A total of 100 g of apples contain about 4 mg of calcium and about 0.3 mg of iron. In addition to sugars, they also have a number of fruit acids such as apple, lemon and other fruit acids. Vitamins B_1 and B_2 are the most prevalent in the apple fruit (approximating to 80 International Units (IU)), followed by vitamin C (with a content of approximately 15 mg) and substantial amounts of beta-carotene, which is transformed into active vitamin A in the body. The

vitamin C content of apples ranges from 7 mg to 60 mg per 100 g of apples depending on their cultivar and the length and conditions of storage *(Ljubisavljević, 1990).*

In addition to fresh consumption and processing for domestic purposes, apples are a very desirable industrial raw material in Serbia, especially the indigenous apple cultivars. The following industrially processed and semi-processed apple products are deemed most important: concentrates, purees (frozen and/or sterilised), pulps, marmalades, jams, *pekmez* preserves, apple purees, candied fruits, brandies, etc. *(Lukač Bulatović, 2010).*

Rott (1994) also adds the following apple products to the list stated above:

1. *Fresh (natural) apple cider* is produced by pressing fresh apple fruits without the use of preservatives. This highly perishable apple drink is usually available at farm stands and healthy food markets (very well known as sweet (apple) cider in the USA).
2. *Dried apples* are produced by drying apple fruits in a dryer, i.e. under microclimatic conditions. The process of apple drying involves the following procedures: washing, inspection, classification, cutting (into rings or pieces) and drying. The 'Golden Delicious' and 'Red Delicious' apple cultivars are very suitable for drying.
3. *Glazed apples* are made by immersing previously candied apple fruits into glazing syrup, thus coating them with a thin, transparent, glazy layer of sugar when dried. The most common glazing syrup is made by cooking down sucrose, glucose syrup and water at a temperature of 113-114 ^{0}C. Candied fruits are immersed into the syrup and subsequently dried at a temperature of 49^0 C. The syrup fruit content is approximately 63%.
4. *Apple butter* is made by cooking down apples (whole and/or pieces) with sugar, acid and water. Various spices (namely cinnamon, nuts, etc.) can also be added at the end of the cooking-down process.
5. *Apple sauce or dip* is made by cooking down apple pulp with sugar syrup. Apple fruits should be previously peeled, cored and cut.
6. *Apple jelly* is made by cooking down clear and/or cloudy apple juice with sugar and acids in order to obtain a product of

consistent and desirable colour, aroma, firmness, texture and clarity.

Jovanović et al. (1994) underlined the poor quality of apples used for industrial processing in Serbia. Such apples are mostly fruits originally intended for fresh consumption, but showing mechanical damage, moulds or even rot. Only in recent years have the first steps been taken towards producing (i.e. breeding) apple cultivars for specific industrial processing procedures, using special plant breeding techniques. Apple cultivars suitable for processing are characterized by high contents of and a harmonious relationship between sugars, organic acids, tannins, aromatic compounds, vitamins, enzymes and mineral substances *(Mišić, 2003).*

Contemporary apple cultivars should produce fruits of exceptional quality, featuring high and regular yields. Apples with a harmonious relationship between sugars, acids and aromatic compounds are particularly desirable. The shape of the apple fruit should facilitate mechanical sorting (*Nikolić, Fotirić, 2009*). Apples for processing should be firm, showing great flesh consistency when cut.

The following acidic apple cultivars are mostly used for industrial processing: 'Bobovec', 'Boskovka', 'Kolačarka' and 'Šampanjka'. However, even some less acidic well-established apple cultivars are often processed such as 'Jonathan', 'Golden Delicious', 'Kanadska remeta', 'Šumatovka' and 'Bela ruzmarinka'. Apples are usually processed into juices, concentrates, purees and marmalades, whereas a smaller share of apples produced are hot processed (such as pasteurised pulps) or dried *(Niketić-Aleksić, 1988).*

Most apple cultivars can be used for producing apple purees, but only a few are considered ideal for this purpose due to their rich aroma and high sugar and acid contents *(Downing, 1989).* 'Golden Delicious', 'York' and 'Rome' are typically used for puree production.

The 'Prima' and 'Florina' apple cultivars are especially suitable for juice production *(Gvozdenović, 2003)*. 'Prima' is favoured in healthy juice and baby food production because practically no insecticides are applied for pest control in the growing process (as these apples are not produced for fresh consumption). 'Florina' apples can be used for both fresh consumption and concentrated juice production.

3.1.2. Analysis and forecast of pear production

The total number of productive pear trees in Serbia averaged 4.99 million in the period 1960-2018, with annual variations ranging from 1.90

million in 1960 to 7.20 million in 1992 (an absolute variation difference of 5.30 million (Table 18)).

Table 18. Trends in the number of productive pear trees in Serbia in the period 1960-2018

Indicators	Number of productive trees (000)			Share of Vojvodina in the number of productive pear trees in Serbia (%)
	Serbia	Central Serbia	Vojvodina	
Average 1960-2018	4,986	3,681	1,305	24.87
Min.	1,904	1,624	280	13.82
Max.	7,198	5,028	2,414	34.50
Annual Rate of Change (%)	1.04	0.99	1.24	0.19
Coefficient of Variation (%)	28.45	23.49	45.58	21.72
Average 1960-1979	3,479	2,714	765	21.26
Min.	1,904	1,624	280	13.82
Max.	4,796	3,621	1,175	25.04
Annual Rate of Change (%)	4.64	4.08	7.14	2.39
Coefficient of Variation (%)	25.30	22.71	35.99	18.10
Average 1980-1999	6,445	4,447	1,998	30.86
Min.	5,024	3,795	1,229	24.46
Max.	7,198	5,028	2,414	34.50
Annual Rate of Change (%)	0.27	-0.01	0.93	0.67
Coefficient of Variation (%)	9.15	7.54	14.54	7.62
Average 2000-2018	5,035	3,893	1,142	22.36
Min.	3,532	2,956	576	16.31
Max.	5,872	4,406	1,800	30.65
Annual Rate of Change (%)	-1.98	-1.34	-4.19	-2.25
Coefficient of Variation (%)	12.67	9.99	25.51	15.22

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

This number increased throughout the entire period under consideration at an average annual rate of change of 1.04% due to the increasing numbers of pear trees in both Central Serbia and Vojvodina (at average annual rates of change of 0.99% and 1.24% respectively). The share of Vojvodina in the total number of productive pear trees in Serbia averaged 24.87%.

Observed over shorter periods of time, the number of productive pear trees in Serbia increased from 3.48 million (in the period 1960-1979) to 6.45 million (in the period 1980-1999), followed by a decrease to 5.04 million in the final subperiod under consideration. The share of Vojvodina in the total number of productive pear trees in Serbia increased from 21.26% (in the period 1981-1990) to 22.36% (in the period 2000-2018).

The total pear production in Serbia averaged 60,975 t in the period 1960-2018, with annual variations ranging from 16,130 t in 1965 to 96,400 t in 1989 (an absolute variation difference of 80,270 t (Tabela 19)). The actual pear production in Central Serbia and Vojvodina increased at average annual rates of change of 1.04% and 1.14%, respectively. Vojvodina accounted for 24.43% of the total Serbian pear production in the period under consideration.

Observed over shorter periods of time, the total pear production in Serbia increased from 45,006 t (in the period 1960-1979) to 75,127 t (in the period 1980-1999), followed by a decrease to 62,887 t in the period 2000-2018. The share of Vojvodina in the total pear production in Serbia decreased from 22.80% (in the period 1960-1979) to 21.77% (in the period 2000-2018).

Table 19. Trends in the Serbian pear production in the period 1960-2018

Indicators	**Production (t)**			**Share of Vojvodina in the total pear production in Serbia (%)**
	Serbia	**Central Serbia**	**Vojvodina**	
1	2	3	4	5
Average 1960-2018	60,975	45,714	15,261	24.43
Min.	16,130	11,500	3,610	12.42
Max.	96,400	67,780	28,620	35.17
Annual Rate of Change (%)	1.05	1.04	1.15	0.09
Coefficient of Variation (%)	29.73	28.24	41.05	21.94

1	2	3	4	5
Average 1960-1979	45,006	34,546	10,460	22.80
Min.	16,130	11,500	3,610	12.42
Max.	72,420	56,500	19,360	35.17
Annual Rate of Change (%)	4.51	3.59	7.87	3.22
Coefficient of Variation (%)	33.84	32.61	45.28	25.36
Average 1980-1999	75,127	53,664	21,463	28.58
Min.	58,690	40,558	14,210	23.05
Max.	96,400	67,780	28,620	33.10
Annual Rate of Change (%)	-0.48	-0.40	-0.66	-0.18
Coefficient of Variation (%)	13.81	14.44	16.98	10.17
Average 2000-2018	62,887	49,102	13,785	21.77
Min.	33,645	29,122	4,523	13.44
Max.	88,224	67,573	24,556	30.02
Annual Rate of Change (%)	1.13	0.85	2.18	1.05
Coefficient of Variation (%)	21.95	22.18	30.88	19.91

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

With 3.53 million productive trees, pears claimed a share of 3.92% in the total number of productive fruit trees in Serbia in 2018 (Table 20). Compared to the base year of 1960, the total number of productive pear trees in Serbia increased by 1.63 million, or by 85.50%. In 2018, the share of pears in the Serbian fruit plantation structure increased by 14.67% compared to the initial year of the period under consideration.

With 576,000 productive trees, pears claimed a 4.86% share in the total number of productive fruit trees in Vojvodina in 2018 (Table 21). Compared to the base year of 1960, the total number of productive pear trees in Vojvodina increased by 208 index points in 2018. However, the share of pears in the Vojvodinian fruit plantation structure decreased by approximately 30% in 2018 compared to the base year.

With an actual production of 53,905 t in 2018, pears claimed a 4.03% in the fruit production structure in Serbia. Compared to the base year of 1960, the total Serbian pear production increased by 27,895 t, or approximately 207 index points, However, the share of pears in the

Serbian fruit production structure decreased by about 55% in the final year of the period under consideration.

Table 20. Number of productive pear trees and the volume of pear production in Serbia in the years considered

Year	**Serbia**		
	Pears	**Other fruit species**	**Total**
1960			
Number of productive trees (000)	1,904	46,727	48,631
- Share (%)	3.92	96.08	100.00
Production (t)	26,010	264,120	290,130
- Share (%)	8.96	91.04	100.00
2018			
Number of productive trees (000)	3,532	75,137	78,669
Index 1980=100	*185.50*	*160.80*	*161.77*
- Share (%)	4.49	95.51	100.00
Index 1980=100	*114.54*	*99.41*	/
Production (t)	53,905	1,283,777	1,337,682
Index 1980=100	207.25	486.06	461.06
- Share (%)	4.03	95.97	100.00
Index 1980=100	*44.98*	*105.42*	/

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Table 21. Number of productive pear trees and the volume of pear production in Vojvodina in the years considere

Year	**Vojvodina**		
	Pears	**Other fruit species**	**Total**
1960			
Number of productive trees (000)	280	4,275	4,555
- Share (%)	6.15	93.85	100.00
Production (t)	5,840	60,850	66,690
- Share (%)	8.76	91.24	100.00
2018			
Number of productive trees (000)	576	11,285	11,861
Index 1980=100	*205.71*	*263.98*	*260.40*
- Share (%)	4.86	95.14	100.00
Index 1980=100	*79.02*	*101.37*	/
Production (t)	9,535	262,750	272,285
Index 1980=100	*163.27*	*431.80*	*408.28*
- Share (%)	3.50	96.50	100.00
Index 1980=100	*39.95*	*105.77*	/

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Pears accounted for 3.50% of the total fruit production in Vojvodina in 2018. Therefore, the Vojvodinian pear production increased by 3,695 t, or by 63.27%, compared to the base year of 1960. The share of pears in the Vojvodinian fruit production structure in 2018 decreased by approximately 60% compared to the base year of 1960.

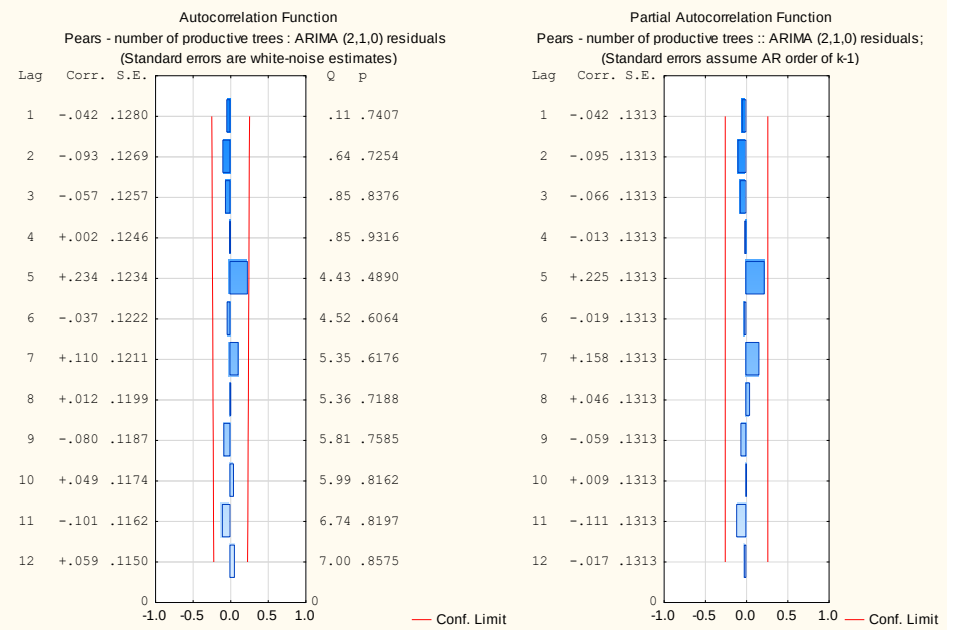
Forecast of pear production in Serbia - the forecast model employed (Table 22) indicates that the current year's value is greatly affected by the previous year's value.

Table 22. Models for forecasting the number of productive pear trees and the total volume of pear production in Serbia

ARIMA Model Parameters		**Pears**				
		Number of productive trees			**Production**	
Model		(2,1,0)			(1,1,0)	
MS Residual		30260			1717E5	
Parameters		Constant	p(1)	p(2)	Constant	p(1)
Param.		19.7336	0.39782	0.38400	478.3856	-0.58271
SE		89.7245	0.13472	0.13619	1102.734	0.10959
t		0.219935	2.95304	2.81967	0.43382	-5.31723
p		0.826751	0.00465	0.00671	0.666088	0.000002
Confidence interval (95%)	Lower	-160.1532	0.12773	0.11096	-1730.66	-0.80224
	Upper	199.6204	0.66791	0.65704	2687.428	-0.36318

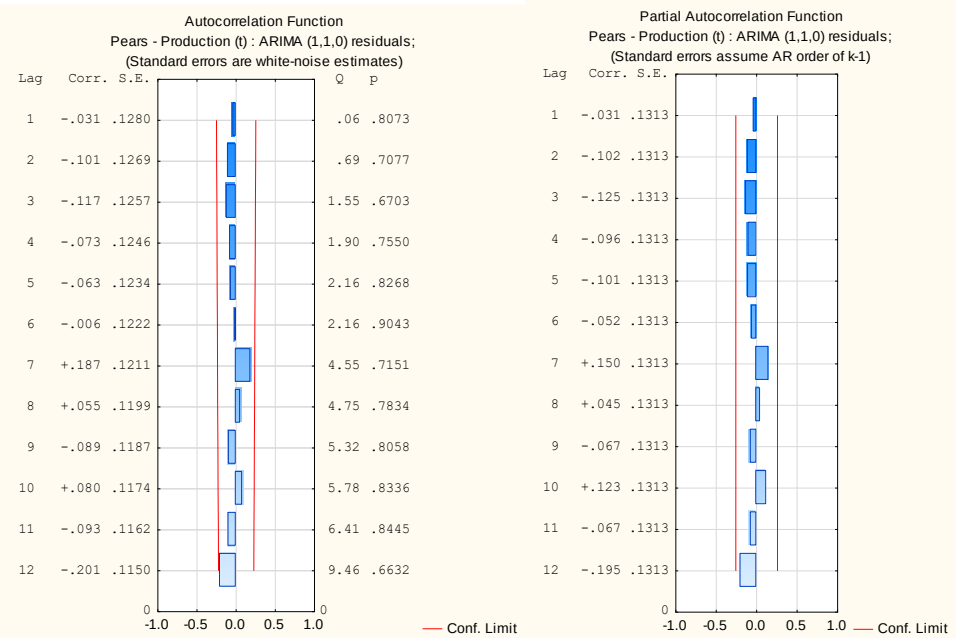
Number of productive pear trees – Residuals:

ACF PACF



Total volume of pear production - Residuals:

ACF PACF



The forecast values obtained (Table 23 and Figure 5) indicate that the number of productive pear trees in Serbia will continue to decrease annually in the forecast period. In the period 2019-2023, the total number of productive pear trees in Serbia will decrease to 23 million, a decrease of approximately 2 million productive pear trees from the average number of productive pear trees in Serbia in the period 1960-2018.

Table 23. The forecast of the number of productive pear trees and the total volume of pear production in Serbia (2019-2023)

Pears	**Forecast**				
	2019	2020	2021	2022	2023
Number of productive trees (000)	2968.00	2751.62	2555.47	2398.66	2265.26
LCL	2368.59	1847.67	1344.95	872.81	425.72
UCL	3567.41	3655.56	3766.00	3924.50	4104.79
SE	298.976	450.872	603.788	761.065	917.530
Production (t)	54585.64	54839.33	55448.65	55850.74	56373.58
LCL	26141.03	20143.24	17777.23	14228.22	11804.42
UCL	83030.24	89535.42	93120.06	97473.26	100942.74
SE	14199.29	17319.98	18805.24	20777.59	22248.53

The forecast values obtained suggest that the increase in the total pear production in Serbia in the period under consideration will continue throughout the entire forecast period (Table 23 and Figure 6). At the end of the forecast period, the expected pear production in Serbia will approximate to 56,000 t, representing an increase of about 5,000 t (8%) over the average pear production volume in Serbia in the period 1960-2018.

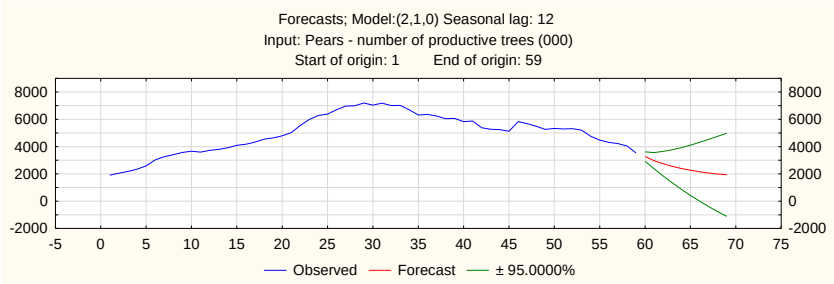


Figure 5. The forecast the number of productive pear trees (000)

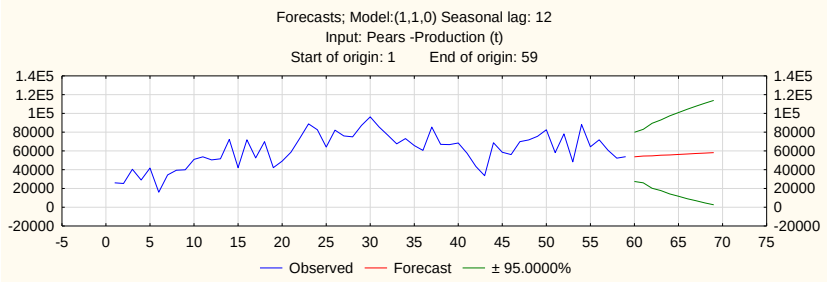


Figure 6. The forecast the total volume of pear production (tonnes)

Utility value of pears - pears are considered very valuable for their nutritional, prophylactic and therapeutic benefits. Compared to apples, the energy value of pears is somewhat higher due to higher contents of sugars and essential minerals (namely iron, calcium, phosphorus, etc.). The sugar content of pears ranges from 7% to 13.5%, whereas proteins and fats account for merely 0.4%.

Vitamin C is the most prevalent vitamin in the pear fruit, with a content 2-3 times as high as that of apples. The vitamin C content of pears ranges from 2.31 mg to 12.5 mg/100 g. Pears also contain fruit acids such as apple and lemon acids, which jointly account for 0.32% of the pear fruit *(Ljubisavljević, 1990).*

In addition to fresh consumption and processing for domestic purposes, pears are regarded as a very desirable industrial raw material in Serbia, especially the autumn and winter pear cultivars *(Lukač Bulatović,*

2010, 2014). The following industrially processed and semi-processed pear products are considered most important: purees, frozen halves, compotes, marmalades, *pekmez* preserves, jellies, creams, salads, juices, concentrates, candied pears, dried pears, brandies, etc.

Niketić-Aleksić Gordana (1988) recommend the following pear cultivars for industrial processing: 'Williams Christ Birne Bartlett', 'Max Red Bartlett', 'Beurre Hardy', 'Conference', 'Beurre Claigeay', 'Doyenne du Comise', 'Šampionka' and 'Curé'. According to specific processing procedures, pear cultivars can be grouped into those suitable for compote production (namely 'Williams Christ Birne Bartlett', 'Trevlek', 'Starking Delicious', 'Santa Maria', 'Precoce de Trevoux' and 'Beurre Hardy') and those suitable for jam, marmalade and brandy production ('Williams Christ Birne Bartlett', 'Trevlek', 'Beurre Hardy', 'Beurre Clairgeau' and 'Šampionka').

3.1.3. Analysis and forecast of quince production

The total number of productive quince trees in Serbia averaged 786,000 in the period 1960-2018, with annual variations ranging from 431,000 in 1960 to 990,000 in 2017 (Table 24). The rates of change computed indicate a growing trend in the number of productive quince trees in Serbia in the period under consideration. The number of productive quince trees in Central Serbia increased at an average annual rate of change of 1.30%, whereas the number of productive quince trees in Vojvodina increased at an average annual rate of change of 0.17%.

Table 24. Trends in the number of productive quince trees in Serbia in the period 1960-2018

Indicators	**Number of productive trees (000)**			**Share of Vojvodina in the number of productive quince trees in Serbia (%)**
	Serbia	**Central Serbia**	**Vojvodina**	
1	2	3	4	5
Average 1960-2018	786	635	151	19.72
Min.	431	330	101	13.31
Max.	990	834	186	25.50
Annual Rate of Change (%)	1.08	1.30	0.17	-0.91
Coefficient of Variation (%)	19.08	22.45	14.3	18.01

1	2	3	4	5
Average 1960-1979	613	473	140	22.69
Min.	431	330	101	21.03
Max.	714	548	180	25.50
Annual Rate of Change (%)	2.35	2.14	3.07	0.71
Coefficient of Variation (%)	13.66	12.63	17.91	5.51
Average 1980-1999	844	674	170	20.49
Min.	701	523	153	16.79
Max.	974	808	186	25.39
Annual Rate of Change (%)	1.82	2.48	-0.68	-2.46
Coefficient of Variation (%)	11.25	14.98	5.38	15.50
Average 2000-2018	909	766	143	15.79
Min.	824	686	119	13.31
Max.	990	834	157	17.01
Annual Rate of Change (%)	0.11	0.26	-0.71	-0.82
Coefficient of Variation (%)	5.40	5.94	8.31	7.84

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

The share of Vojvodina in the total number of productive quince trees in Serbia averaged 19.72%.

Growing trends in the number of productive quince trees in Serbia were also observed in the specific subperiods under consideration, with the largest increase recorded in the period 1960-1979 (at an average annual rate of change of 2.35%). The Vojvodinian share in the total number of productive quince trees in Serbia decreased from 22.69% (in the period 1960-1979) to 15.79% (in the period 2000-2018).

The actual quince production in Serbia averaged 10,173 t in the period 1960-2018, with annual variations ranging from 4,570 t in 1960 to 15,754 t in 2013 (an absolute variation difference of 11,184 t (Table 25)). The total Serbian quince production in the period under consideration indicates a growing trend (at an average annual rate of change of 1.17%). The quince production in Central Serbia increased at an average annual rate of change of 1.13%, whereas the quince production in Vojvodina increased at an average annual rate of change of 1.25%. The share of

Vojvodina in the total quince production in Serbia averaged 22.06% in the period under consideration.

Table 25. Trends in the quince production in Serbia in the period 1960-2018

Indicators	Production (t)			Share of Vojvodina in the total quince production in Serbia (%)
	Serbia	Central Serbia	Vojvodina	
Average 1960-2018	10,173	7,944	2,229	22.06
Min.	4,570	3,260	1,120	16.90
Max.	15,754	13,004	3,919	35.22
Annual Rate of Change (%)	1.17	1.13	1.25	0.08
Coefficient of Variation (%)	27.11	28.23	30.95	18.14
Average 1960-1979	7,883	6,197	1,686	21.71
Min.	4,570	3,260	1,120	17.15
Max.	10,540	8,590	2,390	30.93
Annual Rate of Change (%)	-0.04	-0.10	0.09	0.13
Coefficient of Variation (%)	24.67	26.04	23.80	15.51
Average 1980-1999	10,452	8,186	2,266	21.98
Min.	6,410	5,070	1,340	18.18
Max.	14,771	12,025	2,910	29.07
Annual Rate of Change (%)	2.11	2.52	0.68	-1.40
Coefficient of Variation (%)	20.34	22.58	18.03	14.95
Average 2000-2018	12,288	9,527	2,761	22.52
Min.	7,100	5,900	1,200	16.90
Max.	15,754	13,004	3,919	35.22
Annual Rate of Change (%)	1.44	0.62	3.82	2.35
Coefficient of Variation (%)	18.37	20.31	27.07	23.43

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Observed over shorter periods of time, the total quince production in Serbia increased from 7,883 t (in the period 1960-1979) to 10,452 t (in the period 1980-1999), or to 12,288 t in the period 2000-2018. The share of Vojvodina in the total quince production in Serbia increased at an average annual rate of change of 2.35% in the subperiod 2000-2018.

With 986,000 productive trees, quinces claimed a share of 1.25% in the total number of productive fruit trees in Serbia in 2018 (Table 26). Compared to the base year of 1960, the total number of productive quince trees in Serbia increased by 555,000 (an index of 229). The share of quinces in the Serbian fruit plantation structure increased by 40% in 2018 compared to the initial year of the period under consideration.

Table 26. Number of productive quince trees and the volume of quince production in Serbia in the years considered

Year	**Serbia**		
	Quinces	**Other fruit species**	**Total**
1960			
Number of productive trees (000)	431	48,200	48,631
- Share (%)	0.89	99.11	100.00
Production (t)	4,570	285,560	290,130
- Share (%)	1.58	98.42	100.00
2018			
Number of productive trees (000)	986	77,683	78,669
Index 1980=100	*228.77*	*161.17*	*161.77*
- Share (%)	1.25	98.75	100.00
Index 1980=100	*140.45*	*99.64*	/
Production (t)	12,318	1,325,364	1,337,682
Index 1980=100	*269.54*	*464.13*	*461.06*
- Share (%)	0.92	99.08	100.00
Index 1980=100	*58.23*	*100.67*	/

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Quinces claimed a share of 1.30% in the total Vojvodinian fruit plantation structure in 2018. Relative to the base year of 1960, the total number of productive quince trees in Vojvodina increased by 53%. (Table 27). However, the share of quinces in the Vojvodinian fruit plantation structure decreased by 41% in 2018 compared to the base year of 1960.

With an actual production of 12,318 t, quinces accounted for merely 0.92% of the Serbian fruit production in 2018. Relative to the base year of 1960, the total quince production in Serbia increased approximately 300 index points. However, the share of quinces in the Serbian fruit

production structure decreased by 42% in 2018 compared to the base year of 1960.

Table 27. Number of productive quince trees and the volume of quince production in Vojvodina in the years considered

Year	**Vojvodina**		
	Quinces	**Other fruit species**	**Total**
1960			
Number of productive trees (000)	101	4,454	4,555
- Share (%)	2.22	97.78	100.00
Production (t)	1,160	65,530	66,690
- Share (%)	1.74	98.26	100.00
2018			
Number of productive trees (000)	154	11,707	11,861
Index 1980=100	*152.48*	*262.84*	*260.40*
- Share (%)	1.30	98.70	100.00
Index 1980=100	*58.56*	*100.94*	/
Production (t)	3,919	268,366	272,285
Index 1980=100	*337.84*	*409.53*	*408.28*
- Share (%)	1.44	98.56	100.00
Index 1980=100	*82.76*	*100.31*	/

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Quinces claimed a share of 1.44% in the Vojvodinian fruit production structure in 2018. The actual quince production in Vojvodina in 2018 increased by 338 index points over that recorded in the base year of 1960. However, the share of quinces in the Vojvodinian fruit production structure decreased by 17% in the final year of the period under consideration compared to the base year of 1960.

Forecast of quince production in Serbia - the ARIMA(0,1,1) and ARIMA(1,1,1) models were selected for forecasting the number of productive quince trees and the volume of quince production in Serbia respectively, using the Statistica 13.3 program. Table 28 shows the parameters of the ARIMA models employed.

The forecast values obtained indicate that the increase in the number of productive quince trees in Serbia in the period under consideration will continue throughout the entire forecast period (Table 29 and Figure 7). By the end of 2023, the expected number of productive quince trees in Serbia will approximate to 1 million, representing an increase of about 60% over the actual number of quince trees in Serbia in the base year of 1960.

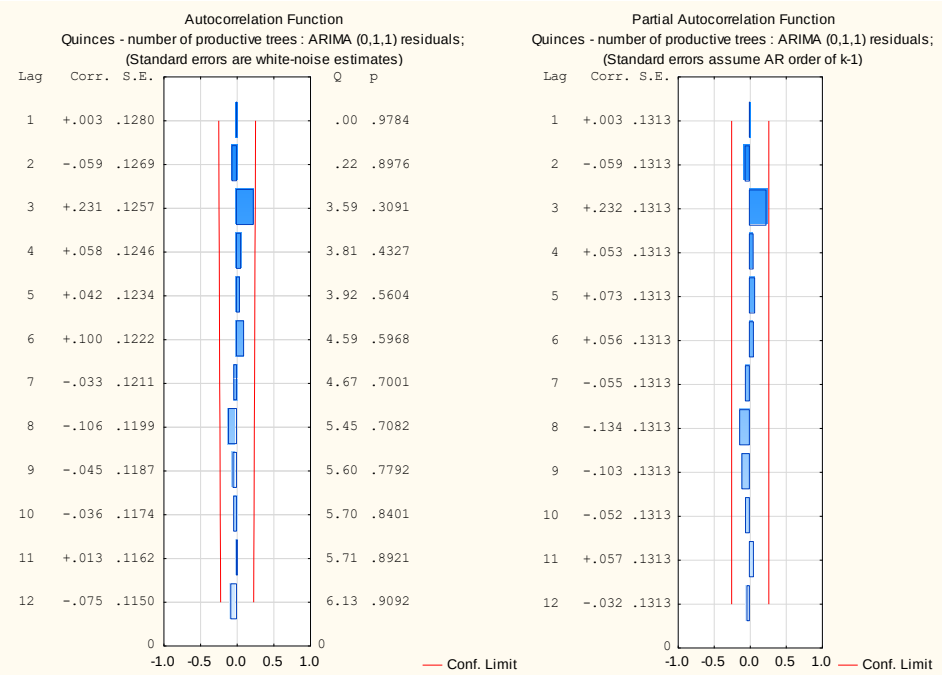
The forecast trend values of quince production in Serbia indicate an annual increase in the total Serbian quince production throughout the entire forecast period (Table 29 and Figure 8).

Table 28. Models for forecasting the number of productive quince trees and the total volume of quince production in Serbia

ARIMA Model Parameters		**Quinces**			
		Number of productive trees		**Production**	
Model		(0,1,1)		(1,1,1)	
MS Residual		908.06		4576E3	
Parameters		Constant	p(1)	Constant	p(1)
Param.		19.7336	0.39782	140.8146	0.2843
SE		89.7245	0.13472	34.96772	0.15395
t		0.219935	2.95304	4.02699	1.84671
p		0.826751	0.00465	0.000175	0.070172
Confidence interval (95%)	Lower	-160.1532	0.12773	70.73774	-0.02422
	Upper	199.6204	0.66791	210.8915	0.59282

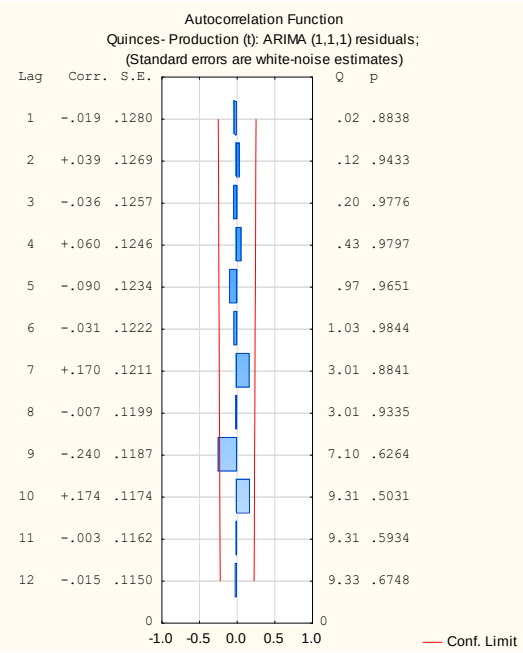
Number of productive quince trees – Residuals:

ACF PACF

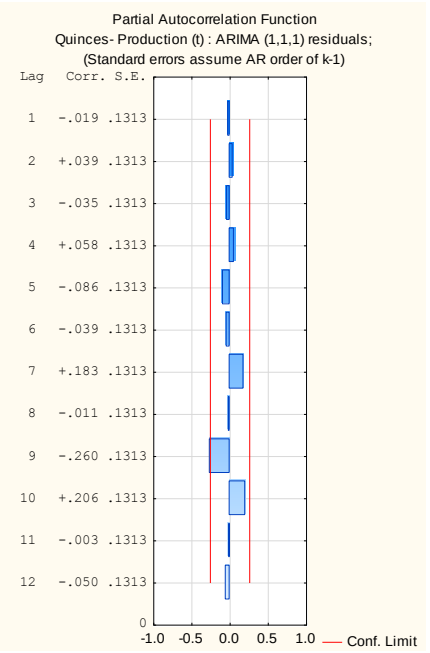


Total volume of quince production - Residuals:

ACF



PACF



At the end of the forecast period, the expected quince production in Serbia will approximate to 14,000 t, representing an increase of about 9,000 t compared to the base year of 1960 and an increase of about 4,000 t over the average quince production in Serbia in the period under consideration (1960-2018).

Table 29. The forecast of the number of productive quince trees and the total volume of quince production in Serbia (2019-2023)

Quinces	**Forecast**				
	2019	2020	2021	2022	2023
Number of productive trees (000)	1006.43	1015.88	1025.33	1034.78	1044.23
LCL	927.50	922.00	918.56	916.53	915.51
UCL	1085.36	1109.77	1132.10	1153.04	1172.96
SE	39.39895	46.86673	53.29824	59.03317	64.25829
Production (t)	13917.37	14141.12	14305.51	14453.03	14595.75
LCL	9379.38	9550.64	9691.44	9821.52	9948.40
UCL	18455.36	18731.59	18919.57	19084.54	19243.09
SE	2264.415	2290.606	2302.376	2311.081	2318.984

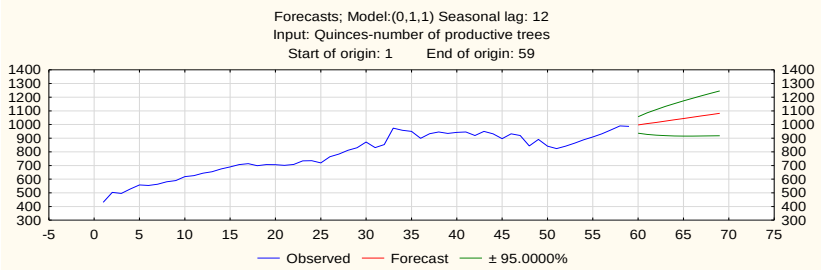


Figure 7. The forecast the number of productive quince trees (000)

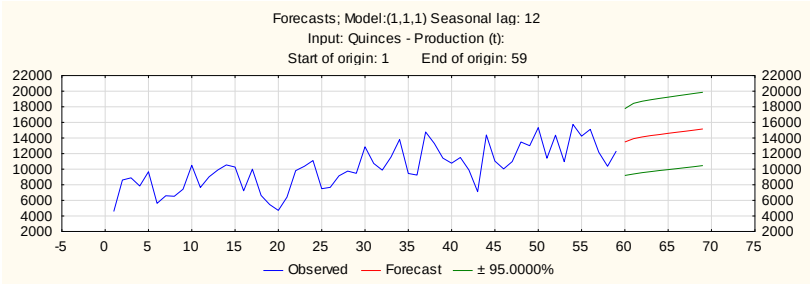


Figure 8. The forecast the total volume of quince production (tonnes)

Utility value of quinces - quinces have a sugar content of approximately 10%, followed by acids (1%), pectins (0.5%) and essential minerals (0.8%). A total of 100 g of quinces provide about 33 calories. They contain considerable amounts of vitamin C (5-20 mg per 100 g), vitamin PP (about 20 mg per 100 g) and vitamin B (especially vitamins B1 and B2 approximating to 0.02 mg per 100 g). In addition to relatively high contents of sugars and acids, quinces are fairly rich in aromatic compounds and essential minerals such as iron and potassium.

The quince is an enduring fruit crop with trees which can live for periods in excess of 70 years. It bears first fruits in the second season of growth, whereas the full fruiting potential of the quince tree is reached after 5-6 years. However, the quince cultivar assortment in the world is considered rather poor *(Nikolić, 2009)*, embracing not more than 500 cultivars produced by various breeding programmes (only 30 of which are well-established and produced worldwide). The following quince cultivars are the most prevalent in the Serbian quince production: 'Leskovačka', 'Vranjska', 'Šampion', 'Asenica', 'Hemus' and 'Trijumf'.

Since antiquity, quinces have been regarded as a suitable raw material for processing into a number of products. The high technological value of quinces stems from their rich chemical composition *(Gvozdenović et al., 1985)*. Quinces are processed into different products

such as marmalades, jams, *pekmez* preserves, compotes, clear juices, liqueurs, wine-poached quinces, rum-poached quinces, brandies, etc.

Quince fruits are presently considered an extremely valuable and even precious industrial raw material which can be processed into the following products: concentrates, frozen purees and halves, clear juices, purees, compotes, marmalades, jams, *pekmez* preserves, creams, salads, pectins, jellies, candied quinces and dried quinces *(Milić, Radojević, 2003)*. Most of these products are highly marketable and well-priced in international markets, which should encourage their production.

The quinces used for domestic purposes in Serbia are mostly processed into compotes and preserves (in combination with apples and pears), or used, to a lesser extent, in the *Quittenkäse* and cake production. Quince seeds also have numerous pharmacological and cosmetic applications.

3.1.4. Analysis and forecast of plum production

The total number of productive plum trees in Serbia averaged 41.59 million in the period 1960-2018, with annual variations ranging from 25.50 million in 2017 to 50.44 million in 1982 ((an absolute variation difference of 24.94 million (Table 30)). The rates of change computed indicate a downward trend in the number of productive plum trees in both Central Serbia (at an average annual rate of change of -0.98%) and Vojvodina (at an average annual rate of change of -0.76%).

Table 30. Trends in the number of productive plum trees in Serbia in the period 1960-2018

Indicators	**Number of productive trees (000)**			**Share of Vojvodina in the number of productive plum trees in Serbia (%)**
	Serbia	**Central Serbia**	**Vojvodina**	
1	2	3	4	5
Average 1960-2018	41,589	39,463	2,126	5.10
Min.	25,504	24,732	772	3.01
Max.	50,438	47,716	2,845	6.59
Annual Rate of Change (%)	-0.96	-0.98	-0.76	0.21
Coefficient of Variation (%)	20.17	20.16	26.51	19.62

1	2	3	4	5
Average 1960-1979	46,180	44,133	2,047	4.42
Min.	36,605	34,961	1,644	4.11
Max.	49,810	47,716	2,654	5.34
Annual Rate of Change (%)	1.36	1.32	2.15	0.78
Coefficient of Variation (%)	8.42	8.32	13.83	8.49
Average 1980-1999	46,545	43,934	2,610	5.62
Min.	43,137	40,616	2,405	4.84
Max.	50,438	47,593	2,845	5.89
Annual Rate of Change (%)	-0.84	-0.88	-0.27	0.57
Coefficient of Variation (%)	5.08	5.27	4.31	4.67
Average 2000-2018	31,541	29,840	1,701	5.25
Min.	25,504	24,732	772	3.01
Max.	43,104	40,515	2,609	6.59
Annual Rate of Change (%)	-3.11	-2.91	-7.34	-4.36
Coefficient of Variation (%)	21.88	21.18	40.20	28.04

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

The share of Vojvodina in the total number of productive plum trees in Serbia averaged 5.10% in the period under consideration.

Observed over shorter periods of time, the total number of productive plum trees in Serbia decreased from 46.18 million (in the period 1960-1979) to 31.54 million (in the period 2000-2018). The annual rates of change computed suggest a decrease in the total number of productive plum trees in Serbia throughout the entire period under consideration, especially in the period 2000-2018 (at an average annual rate of change of -3.11%). In the final subperiod under consideration, the share of Vojvodina in the total number of productive plum trees in Serbia decreased at an average annual rate of change of -4.36%.

The actual plum production in Serbia averaged 454,964 t in the period 1960-2018, with annual variations ranging from 141,020 t in 1960 to 886,540 t in 1969 (an absolute variation difference of 745,520 t (Table 31)). The total Serbian plum production indicates a downward trend in the period under consideration (at an average annual rate of change of -0.37%) primarily due to the falling plum production in Central Serbia (at

an average annual rate of change of -0.43%). The share of Vojvodina in the total Serbian plum production in the period under consideration averaged 7.67%.

Table 31. Trends in the plum production in Serbia in the period 1960-2018

Indicators	Production (t)			Share of Vojvodina in the total plum production in Serbia (%)
	Serbia	Central Serbia	Vojvodina	
Average 1960-2018	454,964	422,277	32,687	7.67
Min.	141,020	122,650	16,760	3.45
Max.	886,540	842,230	50,620	13.50
Annual Rate of Change (%)	-0.37	-0.43	0.59	0.96
Coefficient of Variation (%)	30.13	31.79	25.77	31.24
Average 1960-1979	503,532	476,601	26,931	5.89
Min.	141,020	122,650	18,370	3.45
Max.	886,540	842,230	44,310	13.03
Annual Rate of Change (%)	1.00	1.05	0.55	-0.44
Coefficient of Variation (%)	33.54	34.66	25.49	39.07
Average 1980-1999	445,688	409,203	36,485	8.47
Min.	216,250	187,893	24,280	5.57
Max.	638,980	598,190	50,620	13.11
Annual Rate of Change (%)	-1.38	-1.49	-0.05	1.35
Coefficient of Variation (%)	24.98	26.09	21.80	23.33
Average 2000-2018	413,606	378,857	34,749	8.70
Min.	197,486	180,726	16,760	5.32
Max.	606,599	574,344	46,068	13.50
Annual Rate of Change (%)	0.98	1.13	-0.53	-1.49
Coefficient of Variation (%)	27.42	28.65	21.30	21.28

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Observed over shorter periods of time, the actual plum production in Serbia decreased from 503,532 t (in the period 1960-1979) to 445,688 t (in the period 1980-1999), or to 413,606 t in the last subperiod under consideration. The share of Vojvodina in the total Serbian plum production increased from 5.89% (in the period 1960-1979) to 8.70% (in the period 2000-2018).

The decrease in the number of productive plum trees in Serbia in the period under consideration, accompanied by a simultaneous increase in the volume of plum production, suggests that the Serbian plum production has been intensifying, which is most evident in the final subperiod under consideration (following the year 2000).

With 25.58 million productive trees, plums claimed a 32.51% share in the total number of productive fruit trees in Serbia in 2018 (Table 32). Compared to the base year of 1960, the total number of productive plum trees in Serbia increased by 11 million in 2018 (or by approximately 30%). However, the share of plums in the Serbian fruit plantation structure decreased by 57% compared to the initial year of the period under consideration.

Table 32. Number of productive plum trees and the volume of plum production in Serbia in the years considered

Year	**Serbia**		
	Plums	**Other fruit species**	**Total**
1960			
Number of productive trees (000)	36,605	12,026	48,631
- Share (%)	75.27	24.73	100.00
Production (t)	141,020	149,110	290,130
- Share (%)	48.61	51.39	100.00
2018			
Number of productive trees (000)	25,575	53,094	78,669
Index 1980=100	*69.87*	*441.49*	*161.77*
- Share (%)	32.51	67.49	100.00
Index 1980=100	*43.19*	*272.91*	*/*
Production (t)	430,199	907,483	1,337,682
Index 1980=100	*305.06*	*608.60*	*461.06*
- Share (%)	32.16	67.84	100.00
Index 1980=100	*66.16*	*132.01*	*/*

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Plums claimed a 6.54% share in the Vojvodinian fruit plantation structure in 2018 (Table 33). Relative to the base year of 1960, the

number of productive plum trees in Vojvodina decreased by 53% in 2018. Moreover, the share of plums in the Vojvodinian fruit production structure decreased by 82% in 2018 compared to the base year of 1960.

Table 33. Number of productive plum trees and the volume of plum production in Vojvodina in the years considered

Year	**Vojvodina**		
	Plums	**Other fruit species**	**Total**
1960			
Number of productive trees (000)	1,644	2,911	4,555
- Share (%)	36.09	63.91	100.00
Production (t)	18,370	48,320	66,690
- Share (%)	27.55	72.45	100.00
2018			
Number of productive trees (000)	776	11,085	11,861
Index 1980=100	*47.20*	*380.80*	*260.40*
- Share (%)	6.54	93.46	100.00
Index 1980=100	*18.12*	*146.24*	*/*
Production (t)	32,816	239,469	272,285
Index 1980=100	*178.64*	*495.59*	*408.28*
- Share (%)	12.05	87.95	100.00
Index 1980=100	*43.74*	*121.39*	*/*

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

With an actual production of 430,199 t, plums accounted for 32.16% of the total fruit production in Serbia in 2018 (following only apples which ranked first with an actual production of 460,404 t in 2018). The total plum production in Serbia increased by 289,179 t in 2018 over that recorded in 1960, or approximately twofold (an index of 305). The share of plums in the Serbian fruit plantation structure decreased by 34% in 2018 compared to the base year of 1960.

Plums accounted for 12.05% of the total Vojvodinian fruit production in 2018. The plum production in Vojvodina increased by 79% in 2018 compared to the base year of 1960. However, the share of plums in the Vojvodinian fruit production structure decreased by 56% in 2018 compared to the base year of 1960.

Forecast of plum production in Serbia - the forecast values obtained (using the ARIMA model shown in Table 34) indicate that the decrease in the number of productive plum trees in Serbia in the period under consideration will continue throughout the entire forecast period, i.e. up to 2023 (Table 34 and Figure 9). At the end of the forecast period, the

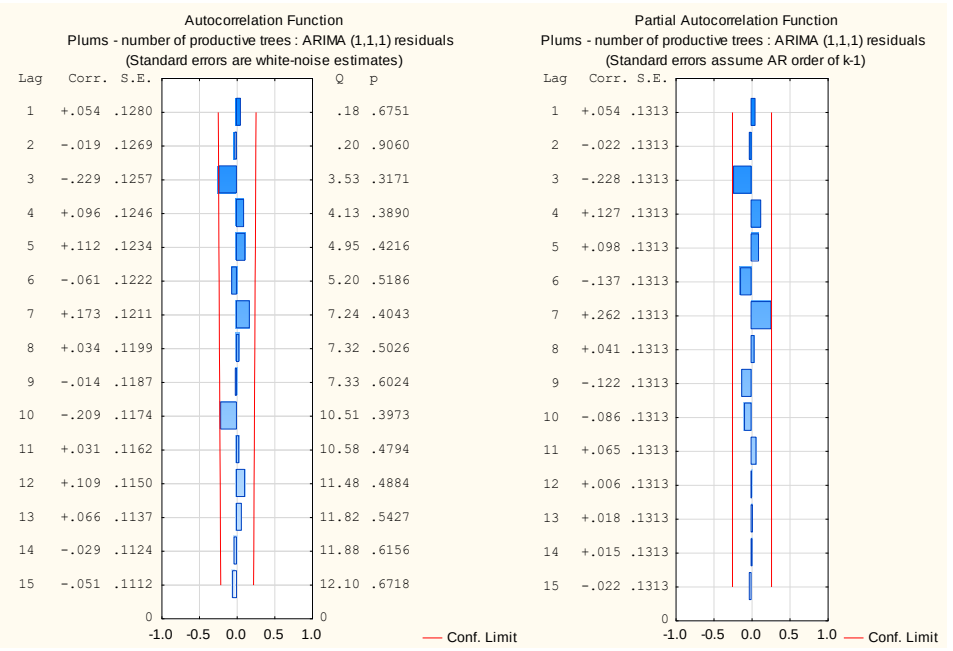
expected number of productive plum trees in Serbia will approximate to 25 million, representing a decrease of about 1.2 million (or 30%) from the number of productive plum trees in Serbia in 1960 and a decrease of about 40% from the average number of productive plum trees in Serbia in the period under consideration.

Table 34. Models for forecasting the number of productive plum trees and the total volume of plum production in Serbia

ARIMA Model Parameters		**Plums**			
		Number of productive trees		**Production**	
Model		(1,1,1)		(1,0,1)	
MS Residual		4036E2		1910E7	
Parameters		Constant	q(1)	p(1)	q(1)
Param.		36367.7015	-0.10987	-0.65747	-0.76302
SE		1880.7825	0.12708	0.26180	0.21148
t		19.33647	-0.86453	-2.51132	-3.60805
p		0.0000005	0.390982	0.014940	0.000659
Confidence interval (95%)	Lower	32600.04	-0.36445	-1.18192	-1.18666
	Upper	40135.36	0.14471	-0.13302	-0.33938

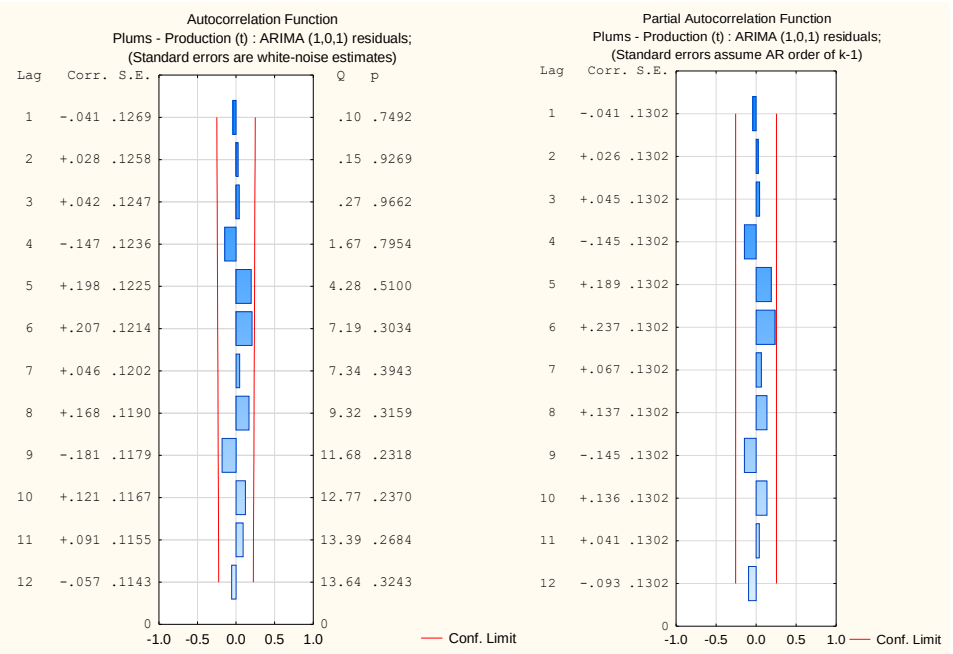
Number of productive plum trees – Residuals:

ACF PACF



Total volume of plum production - Residuals:

ACF PACF



The forecast trend values of plum production in Serbia indicate annual variations throughout the entire forecast period (Table 35 and Figure 10). By the end of 2023, the volume of plum production in Serbia will approximate to 450,000 t, representing a decrease of about 5,000 t from the average Serbian plum production in the period under consideration (1960-2018).

Table 35. The forecast of the number of productive plum trees and the total volume of plum production in Serbia (2019-2023)

Plums	**Forecast**				
	2019	2020	2021	2022	2023
Number of productive trees (000)	25304.9	25194.4	25097.7	25012.90	24938.64
LCL	23199.7	22269.9	21352.6	20447.74	19557.91
UCL	27410.15	28118.9	28842.7	29578.05	30319.36
SE	1050.492	1459.29	1868.756	2277.970	2684.931
Production (t)	452492.0	455680.5	453584.2	454962.4	454056.3
LCL	174140.7	176667.0	174285.0	175539.8	174580.3
UCL	730843.4	734693.9	732883.3	734385.0	733532.2
SE	138950.5	139281.0	139423.7	139485.3	139511.9

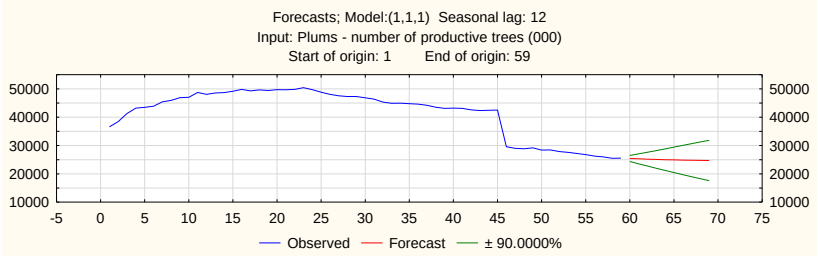


Figure 9. The forecast the number of productive plum trees (000)

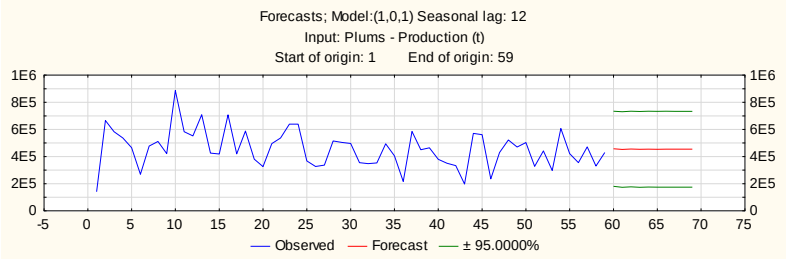


Figure 10. The forecast the total volume of plum production (tonnes)

Utility value of plums - the plum is considered an important fruit crop from both nutritional and industrial perspectives. It provides multiple benefits (namely energetic (2200-4560 kJ/kg), protective, dietary and therapeutic benefits), containing all the compounds essential to human functioning. Plum fruits are rich in sugars such as glucose, fructose and sucrose (about 0.80%), proteins (about 0.80%) and fats (about 0.10%). They contain vitamin C (2-19 mg), vitamin PP (0.3 mg per 100g) and vitamins B_1 and B_2 (about 0.1mg). Plums are also a source of essential minerals such as potassium, calcium, phosphorus, iron, etc. *(Ljubisavljević, 1990)*.

The industrial significance of plums is determined by their utility value, prevalence in the total fruit and agricultural production, share in international trade, production workforce requirements, processing and marketing, and their contribution to sustainable agriculture and environmental protection *(Milić, Radojević, 2003)*.

Plums are consumed fresh or used for domestic and/or industrial processing. They can be processed into well over 50 products, approximately 30 of which are produced in Serbia *(Ševarlić, 2000)*. *Jokić et al. (1999)* report the amounts of fresh plums required for one kilogram of different plum products: 1 kg of plum jam/ marmalade requires 3 kg of fresh plums, 1 kg of plum compote requires 0.73 kg of fresh plums, 1 kg of plum juice requires 1.6 kg of fresh plums, 1 kg of plum brandy requires

6.6 kg of fresh plums, 1 kg of dried plums requires 3.5 kg of fresh plums, and 1 kg of plum pulp requires 1.09 kg of fresh plums.

From a technological perspective, plums are not ideally suitable for processing. However, the plum production and processing in Serbia can be significantly improved provided the primary production and the industrial processing of plums are more closely integrated (especially by stimulating plum production in the private sector) and marketing associations adopt a clear standard of quality for plums produced for international markets *(Zlatković, 2000)*.

Plums can be processed (into various products such as jams, marmalades, compotes, thin preserves, etc.), dried and used for brewing (namely the production of the famous Serbian slivovitz). The Serbian slivovitz is a strong high-quality alcoholic drink (in the category of spirits such as cognac). The main disadvantage of the slivovitz production in Serbia is the inconsistent and non-standardised quality of the slivovitz produced due to a large number of producers using different production technologies. Accordingly, all the elements of this production should be unified for obtaining a product of high and consistent quality with greater foreign marketability. However, little effort has been expanded to protect the Serbian slivovitz brand both locally and globally.

Owing to favourable ecological conditions for growing plums in Serbia and, to some extent, the Serbian plum cultivar assortment and processing industry, the Serbian slivovitz is characterized by a distinctive aroma and an authentic flavour, which are highly appreciated by both domestic and foreign consumers. The Serbian slivovitz of the highest quality is produced from the following plum cultivars: 'Požegača', 'Crvena ranka', 'Valjevka' and 'Čačanska rodna' *(Obradović, 2001)*. Moreover, the following plum cultivars are particularly suitable for drying: 'Požegača', 'Čačanska rodna', 'Agen 707' and 'Stanley'.

According to the food classification system argued by *Jokić et al. (1999)*, plums belong to the category of fruits and processed fruit products, i.e. all four of the pertinent subcategories: fresh fruits (namely fresh plums), dried fruits (namely dried plums), frozen fruits (namely frozen plums) and processed fruit products (namely compotes, thin preserves, marmalades, jams, *pekmez* preserves, juices, brandies, etc.). *Vlahović (2003)* reports that plums are mostly used in Serbia for plum brandy production (about 65%), fresh consumption (about 8%), dried plum production (about 4%) and *pekmez* preserve production (about 2%), whereas the remaining 21% of plum fruits are processed into other products.

Dried plums are the most valuable product from both nutritional and economic perspectives, especially from the foreign currency income perspective *(Mitrović, 2012*). The global consumption of dried plums approximates to 260,000 t annually. Serbia used to export 26,000 t of dried plums at the end of the nineteenth century, whereas the current export volume is merely 4,000 t annually. Russia is the largest importer of dried plums in the world, but Serbia only claims a 1% share of the vast Russian market.

3.1.5. Analysis and forecast of sweet and sour cherry production

In the period 1960-2018, the total number of productive sweet cherry trees in Serbia averaged 1.68 million, indicating a slightly growing trend (Table 36). The increase in the total number of productive sweet cherry trees in Serbia in the period under consideration (at an average annual rate of change of 0.12%) is primarily attributed to the increase in the number of productive sweet cherry trees in Central Serbia in the same period (at an average annual rate of change of 0.28%). However, a simultaneous decrease in the number of productive sweet cherry trees in Vojvodina (at an average annual rate of change of -0.95%) reduced the Vojvodinian share in the total number of productive sweet cherry trees in Serbia. The share of Vojvodina in the total number of productive sweet cherry trees in Serbia decreased from 20.25% in the initial year of the period under consideration to 7.27% in 2018.

Table 36. Trends in the number of productive sweet cherry trees in Serbia in the period 1960-2018

Indicators	**Number of productive trees (000)**			**Share of Vojvodina in the number of productive sweet cherry trees in Serbia (%)**
	Serbia	**Central Serbia**	**Vojvodina**	
1	2	3	4	5
Average 1960-2018	1,684	1,418	266	15.84
Min.	1,259	1,004	114	7.27
Max.	1,933	1,662	342	20.25
Annual Rate of Change (%)	0.12	0.28	-0.95	-1.07
Coefficient of Variation (%)	12.46	13.11	21.83	19.32

1	2	3	4	5
Average 1960-1979	1,567	1,285	282	18.10
Min.	1,259	1,004	255	16.78
Max.	1,857	1,521	336	20.25
Annual Rate of Change (%)	2.00	2.18	1.24	-0.75
Coefficient of Variation (%)	11.79	12.72	8.34	5.64
Average 1980-1999	1,880	1,572	308	16.38
Min.	1,841	1,533	290	15.54
Max.	1,933	1,607	342	17.69
Annual Rate of Change (%)	-0.07	0.03	-0.61	-0.54
Coefficient of Variation (%)	1.28	1.22	4.37	3.72
Average 2000-2018	1,601	1,396	205	12.90
Min.	1,342	1,136	114	7.27
Max.	1,900	1,662	289	15.57
Annual Rate of Change (%)	-0.46	0.14	-5.13	-4.70
Coefficient of Variation (%)	12.54	13.63	30.76	28.53

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Observed over shorter periods of time, the number of productive sweet cherry trees in Serbia increased from 1.57 million (in the period 1960-1979) to 1.88 million (in the period 1980-1999), followed by a decrease to 1.60 million in the final subperiod under consideration. The share of Vojvodina in the total number of productive sweet cherry trees in Serbia decreased from 18.10% (in the period 1960-1999) to 16.38% (in the period 1980-1999), or to 12.90% in the period 2000-2018.

The total sweet cherry production in Serbia averaged 23,451 t in the period 1960-2018, with annual variations ranging from 15,334 t in 2005 to 30,823 t in 2004 (an absolute variation difference of 15,489 t (Table 37)). The total sweet cherry production in Central Serbia and Vojvodina decreased at average annual rates of change of -0.05% and -0.73%, respectively. Vojvodina accounted for 16.31% of the total Serbian sweet cherry production in the period under consideration. The total sweet cherry production in Serbia in the subperiods under consideration increased from 23,231 t (in the period 1960-1979) to 25,382 t (in the period 1980-1999), followed by a decrease to 21,649 t in the final

subperiod under consideration. The share of Vojvodina in the total Serbian sweet cherry production decreased from 16.22% (in the period 1960-1979) to 14.28% (in the period 2000-2018).

Table 37. Trends in the sweet cherry production in Serbia in the period 1960-2018

Indicators	Production (t)			Share of Vojvodina in the total sweet cherry production in Serbia (%)
	Serbia	Central Serbia	Vojvodina	
Average 1960-2018	23,451	19,613	3,838	16.31
Min.	15,334	11,887	1,417	7.40
Max.	30,823	25,870	6,300	24.33
Annual Rate of Change (%)	-0.14	-0.05	-0.73	-0.59
Coefficient of Variation (%)	15.92	16.06	29.5	23.87
Average 1960-1979	23,231	19,475	3,756	16.22
Min.	17,310	14,330	2,650	12.96
Max.	26,640	22,690	5,640	24.33
Annual Rate of Change (%)	0.31	0.63	-1.19	-1.50
Coefficient of Variation (%)	11.58	12.70	22.05	20.97
Average 1980-1999	25,382	20,735	4,647	18.34
Min.	17,950	14,334	2,700	14.44
Max.	30,760	25,870	6,300	22.70
Annual Rate of Change (%)	0.18	0.20	0.06	-0.11
Coefficient of Variation (%)	14.65	15.26	19.08	13.79
Average 2000-2018	21,649	18,576	3,073	14.28
Min.	15,334	11,887	1,417	7.40
Max.	30,823	25,602	5,221	22.48
Annual Rate of Change (%)	0.49	1.21	-4.47	-4.94
Coefficient of Variation (%)	17.92	18.95	36.03	32.08

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

With 1.65 million productive trees, sweet cherries claimed a 2.10% share in the total number of productive fruit trees in Serbia in 2018 (Table 38). Compared to the base year of 1960, the total number of sweet cherry trees in Serbia increased by 392,000 (or by approximately 31%). However, the share of sweet cherries in the Serbian fruit plantation structure decreased by 19% in 2018 compared to the base year of 1960.

Sweet cherries claimed a share of about 1% in the Vojvodinian fruit plantation structure in 2018 (Table 39). The number of productive sweet cherry trees in Vojvodina decreased by 53% in 2018 compared to the base year of 1960. Moreover, the share of sweet cherries in the Vojvodinian fruit production structure decreased by 82% in 2018 compared to the base year of 1960.

Table 38. Number of productive sweet cherry trees and the volume of sweet cherry production in Serbia in the years considered

Year	**Serbia**		
	Sweet cherries	**Other fruit species**	**Total**
1960			
Number of productive trees (000)	1,259	47,372	48,631
- Share (%)	2.59	97.41	100.00
Production (t)	20,100	270,030	290,130
- Share (%)	6.93	93.07	100.00
2018			
Number of productive trees (000)	1,651	77,018	78,669
Index 1980=100	*131.14*	*162.58*	*161.77*
- Share (%)	2.10	97.90	100.00
Index 1980=100	*81.08*	*100.50*	/
Production (t)	19,153	1,318,529	1,337,682
Index 1980=100	*95.29*	*488.29*	*461.06*
- Share (%)	1.43	98.57	100.00
Index 1980=100	*20.63*	*105.91*	/

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

With an annual production volume of 19,153 t, sweet cherries claimed a 1.43% share in the Serbian fruit production structure in 2018. The total sweet cherry production in Serbia decreased by approximately 5% in 2018 compared to the base year of 1960. The share of sweet cherries in the Serbian fruit plantation structure decreased by 79% in 2018 from that recoded in 1960.

Table 39. Number of productive sweet cherry trees and the volume of sweet cherry production in Vojvodina in the years considered

Year	**Vojvodina**		
	Sweet cherries	**Other fruit species**	**Total**
1960			
Number of productive trees (000)	255	4,300	4,555
- Share (%)	5.60	94.40	100.00
Production (t)	4,890	61,800	66,690
- Share (%)	7.33	92.67	100.00
2018			
Number of productive trees (000)	120	11,741	11,861
Index 1980=100	*47.06*	*273.05*	*260.40*
- Share (%)	1.01	98.99	100.00
Index 1980=100	*18.04*	*104.86*	*/*
Production (t)	1,417	270,868	272,285
Index 1980=100	*28.98*	*438.30*	*408.28*
- Share (%)	0.52	99.48	100.00
Index 1980=100	*7.09*	*107.35*	/

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

With an actual production of 1,417 t, sweet cherries accounted for 0.52% of the total Vojvodinian fruit production in 2018, thus ranking last of all the fruit crops considered. The sweet cherry production in Vojvodina decreased by 71% in 2018 compared to the base year of 1960. Moreover, the share of sweet cherries in the Vojvodinian fruit production structure decreased by 93% in 2018 from that recorded in 1960.

Forecast of sweet cherry production in Serbia - the forecast model employed (Table 40) indicates that the number of productive sweet cherry trees in the current year is greatly affected by the stochastic process and the number of productive sweet cherry trees recorded in the previous year.

The forecast values obtained suggest a slight annual increase in the number of productive sweet cherry trees in Serbia throughout the entire forecast period. At the end of the forecast period, the number of productive sweet cherry trees in Serbia will approximate to 1.7 million, representing an increase of 16,000 sweet cherry trees (or 1%) over the average number of productive sweet cherry trees in Serbia in the period under consideration (Table 41 and Figure 12).

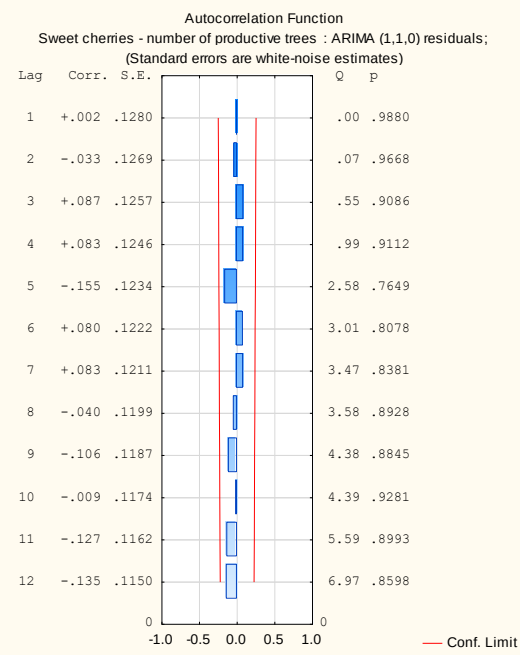
The forecast trend values of actual sweet cherry production in Serbia indicate annual variations throughout the entire forecast period (Table 41 and Figure 12). At the end of the forecast period, the expected sweet cherry production in Serbia will approximate to 23,000 t.

Table 40. Models for forecasting the number of productive sweet cherry trees and the total volume of sweet cherry production in Serbia

ARIMA Model Parameters		**Sweet cherries**			
		Number of productive trees		**Production**	
Model		(1,1,0)		(1,1,0)	
MS Residual		5804.9		1604E4	
Parameters		Constant	p(1)	Constant	p(1)
Param.		6.65356	0.07236	226.5922	-0.49647
SE		10.86889	0.14042	362.0205	0.12412
t		0.61217	0.51532	0.62591	-3.99983
p		0.54291	0.60836	0.53396	0.00019
Confidence interval (95%)	Lower	-15.11944	-0.20893	-498.9132	-0.74522
	Upper	28.42656	0.35365	952.0976	-0.24772

Number of productive sweet cherry trees – Residuals:

ACF



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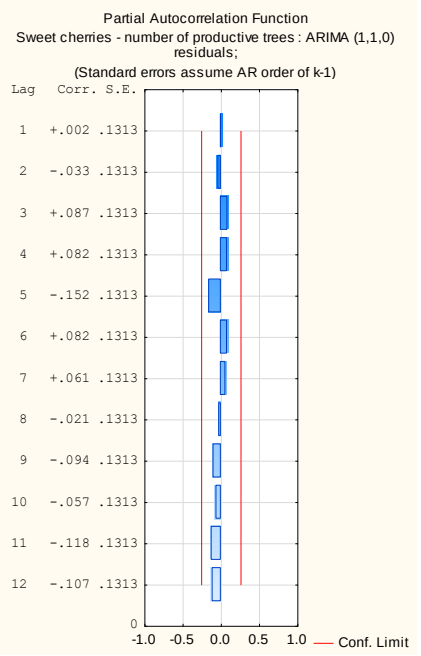

Total volume of sweet cherry production - Residuals:

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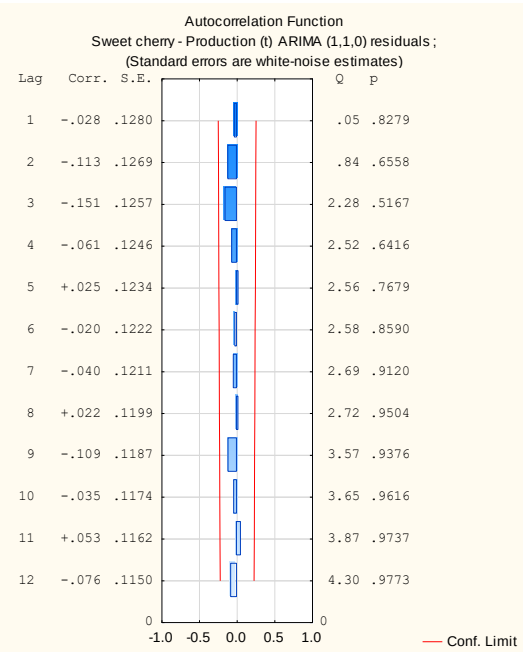

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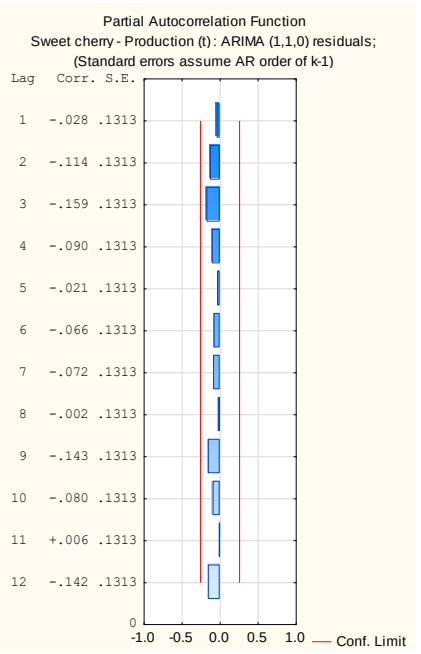


Table 41. The forecast of the number of productive sweet cherry trees and the total volume of sweet cherry production in Serbia (2019-2023)

Sweet cherries	**Forecast**				
	2019	2020	2021	2022	2023
Number of productive trees (000)	1651.61	1658.20	1664.85	1671.50	1678.16
LCL	1427.82	1380.47	1342.05	1309.19	1280.23
UCL	1875.40	1935.93	1987.65	2033.82	2076.08
SE	111.7149	138.6395	161.1407	180.8649	198.6402
Production (t)	21705.23	22959.34	22675.80	23155.66	23256.51
LCL	12720.17	12144.59	10745.62	10008.47	9087.81
UCL	30690.28	33774.10	34605.97	36302.85	37425.21
SE	4483.460	5396.463	5953.048	6560.327	7070.053

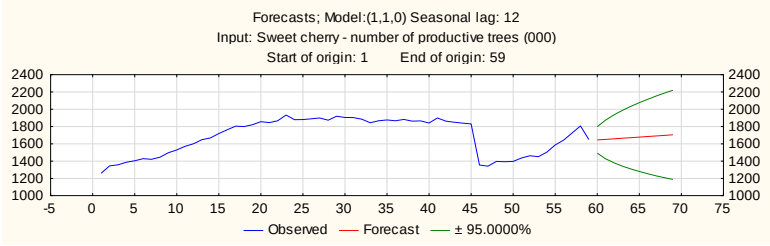


Figure 11. The forecast the number of productive sweet *cherry trees (000)*

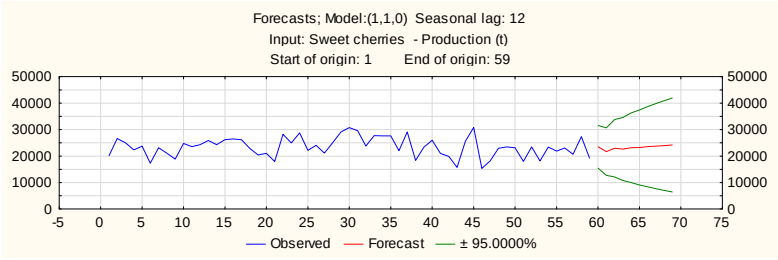


Figure 12. The forecast the total volume of sweet cherry production (tonnes)

In the period 1960-2018, the total number of productive sour cherry trees in Serbia averaged 7.20 million, indicating a growing trend (Table 42). The number of productive sour cherry trees in Central Serbia and Vojvodina increased at average annual rates of change of 5.12% and 1.49%, respectively.

Table 42. Trends in the number of sour cherry trees in Serbia in the period 1960-2018

Indicators	**Number of productive trees (000)**			**Share of Vojvodina in the number of productive sour cherry trees in Serbia (%)**
	Serbia	**Central Serbia**	**Vojvodina**	
1	2	3	4	5
Average 1960-2018	7,159	5,974	1,185	22.59
Min.	1,122	500	622	8.33
Max.	14,172	12,631	2,140	55.44
Annual Rate of Change (%)	4.15	5.12	1.49	-2.56
Coefficient of Variation (%)	53.78	59.25	34.84	58.5

1	2	3	4	5
Average 1960-1979	2,363	1,566	797	38.16
Min.	1,122	500	622	22.57
Max.	4,568	3,537	1,031	55.44
Annual Rate of Change (%)	7.64	11.11	2.30	-4.97
Coefficient of Variation (%)	43.48	58.68	13.77	29.69
Average 1980-1999	8,325	7,102	1,223	14.86
Min.	5,225	4,208	1,017	13.02
Max.	9,527	8,118	1,409	19.46
Annual Rate of Change (%)	0.96	1.26	-0.63	-1.58
Coefficient of Variation (%)	13.28	14.44	9.68	11.87
Average 2000-2018	10,981	9,426	1,555	14.34
Min.	8,337	7,184	907	8.33
Max.	14,172	12,631	2,140	20.34
Annual Rate of Change (%)	2.40	2.81	-0.67	-3.00
Coefficient of Variation (%)	15.46	17.71	29.34	28.28

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

The share of Vojvodina in the total number of productive sour cherry trees in Serbia decreased from 55.44% in 1960 to 10.87% in 2018 on account of a more rapid increase in the number of productive sour cherry trees in Central Serbia than in Vojvodina.

Observed over shorter periods of time, the total number of productive sour cherry trees in Serbia increased from 2.36 million (in the period 1960-1979) to 8.33 million (in the 1980-1999), or to 10.98 million in the final subperiod under consideration. The largest increase in the number of productive sour cherry trees in Serbia was recorded in the period 1960-1979 (at an average annual rate of change of 7.64%). The share of Vojvodina in the total number of productive sour cherry trees in Serbia decreased from 38.16% (in the period 1960-1979) to 14.34% (in the period 2000-2018).

The total sour cherry production in Serbia averaged 68,892 t in the period 1960-2018, with annual variations ranging from 14,350 t in 1965 to 145,805 t in 2009 (an absolute variation difference of 131,455 t (Table 43)). The total Serbian sour cherry production indicates a growing trend

in the period under consideration (at an average annual rate of change of 3.61%) primarily due to the increased sour cherry production in Central Serbia (at an average annual rate of change of 4.72%). The share of Vojvodina in the total sour cherry production in Serbia averaged 26.79% in the period under consideration, indicating a downward trend (at an average annual rate of change of -2.28%).

Table 43. Trends in the sour cherry production in Serbia in the period 1960-2018

Indicators	**Production (t)**			**Share of Vojvodina in the total sour cherry production in Serbia (%)**
	Serbia	**Central Serbia**	**Vojvodina**	
Average 1960-2018	68,892	54,177	14,715	26.79
Min.	14,350	4,970	5,570	8.04
Max.	145,805	133,896	36,054	70.19
Annual Rate of Change (%)	3.61	4.72	1.25	-2.28
Coefficient of Variation (%)	55.06	61.28	44.76	53.11
Average 1960-1979	25,412	15,759	9,653	41.86
Min.	14,350	4,970	5,570	17.77
Max.	47,670	33,430	14,240	70.19
Annual Rate of Change (%)	5.36	10.16	-0.63	-5.69
Coefficient of Variation (%)	36.34	55.72	21.33	35.02
Average 1980-1999	79,019	62,567	16,452	20.77
Min.	43,910	37,160	6,750	15.37
Max.	109,740	87,820	22,850	25.02
Annual Rate of Change (%)	0.19	0.18	0.25	0.06
Coefficient of Variation (%)	19.51	19.64	22.58	12.43
Average 2000-2018	103,998	85,785	18,213	17.28
Min.	48,919	41,995	6,924	8.04
Max.	145,805	133,896	36,054	27.14
Annual Rate of Change (%)	2.96	3.45	0.05	-2.82
Coefficient of Variation (%)	26.85	27.04	47.86	31.86

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Observed over shorter periods of time, the actual sour cherry production in Serbia increased from 25,412 t (in the period 1960-1979) to 79,019 t (in the period 1980-1999, or to 103,998 t in the period 2000-2018. The share of Vojvodina in the total sour cherry production in Serbia decreased at an average annual rate of change of -2.82% in the final subperiod under consideration.

Sour cherries claimed a share of approximately 18% in the total number of productive fruit trees in Serbia in 2018 (Table 44). The number of productive sour cherry trees in Serbia increased from 1.12 million in 1960 to 14.17 million in 2018 (an increase of 1,263 index points), representing the largest increase of all the fruit crops considered in the given period. The share of sour cherries in the Serbian fruit plantation structure increased by 780 index points in 2018 compared to the base year of 1960.

Table 44. Number of productive sour cherry trees and the volume of sour cherry production in Serbia in the years considered

Year	**Serbia**		
	Sour cherries	**Other fruit species**	**Total**
1960			
Number of productive trees (000)	1,122	47,509	48,631
- *Share (%)*	2.31	97.69	100.00
Production (t)	16,670	273,460	290,130
- *Share (%)*	5.75	94.25	100.00
2018			
Number of productive trees (000)	14,172	64,497	78,669
Index 1980=100	*1263.10*	*135.76*	*161.77*
- *Share (%)*	18.01	81.99	100.00
Index 1980=100	*779.65*	*83.93*	/
Production (t)	128,023	1,209,659	1,337,682
Index 1980=100	*767.98*	*442.35*	*461.06*
- *Share (%)*	9.57	90.43	100.00
Index 1980=100	*166.43*	*95.95*	/

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

With approximately 1.5 million productive trees, sour cherries claimed a share of about 13% in the Vojvodinian fruit plantation structure in 2018. The number of productive sour cherry trees in Vojvodina increased by 248 index points in 2018 compared to the base year of 1960 (Table 45). The share of sour cherries in the Vojvodinian fruit production structure decreased by about 5% in 2018 from that recorded in 1960.

Table 45. Number of productive sour cherry trees and the volume of sour cherry production in Vojvodina in the years considered

Year	**Vojvodina**		
	Sour cherries	**Other fruit species**	**Total**
1960			
Number of productive trees (000)	622	3,933	4,555
- *Share (%)*	13.66	86.34	100.00
Production (t)	11,700	54,990	66,690
- *Share (%)*	17.54	82.46	100.00
2018			
Number of productive trees (000)	1,541	10,320	11,861
Index 1980=100	*247.75*	*262.40*	*260.40*
- *Share (%)*	12.99	87.01	100.00
Index 1980=100	*95.10*	*100.78*	/
Production (t)	15,527	256,758	272,285
Index 1980=100	*132.71*	*466.92*	*408.28*
- *Share (%)*	5.70	94.30	100.00
Index 1980=100	*32.50*	*114.36*	/

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

With an annual production volume of 128,023 t, sour cherries claimed a 9.57% share in the Serbian fruit production structure in 2018. The total sour cherry production in Serbia increased by 111,353 t (or 768 index points) in 2018 compared to the base year of 1960. Moreover, the share of sour cherries in the Serbian fruit plantation structure increased by 66% in 2018 compared to the base year of 1960.

Sour cherries claimed a 5.70% share in the Vojvodinian fruit production structure in 2018. Relative to the base year of 1960, the sour cherry production in Vojvodina increased by 33% in 2018, whereas the share of sour cherries in the Vojvodinian fruit production structure decreased by 67% in the same year.

Forecast of sour cherry production in Serbia - the forecast model employed (Table 46) indicates that the current year's value is greatly affected by the previous year's value.

The forecast values obtained (using the ARIMA model shown in Table 46) indicate that the increase in the number of productive sour cherry trees recorded in the period 1960-2018 will continue throughout the entire forecast period (Table 47 and Figure 13). At the end of the forecast period, the expected number of productive sour cherry trees in Serbia will approximate to 17 million, representing an increase of about 1.5 million (or about 90%) compared to the initial year of the period under

consideration and an increase of approximately 9 million (or about 50%) over the average number of sour cherry trees in the period 1960-2018.

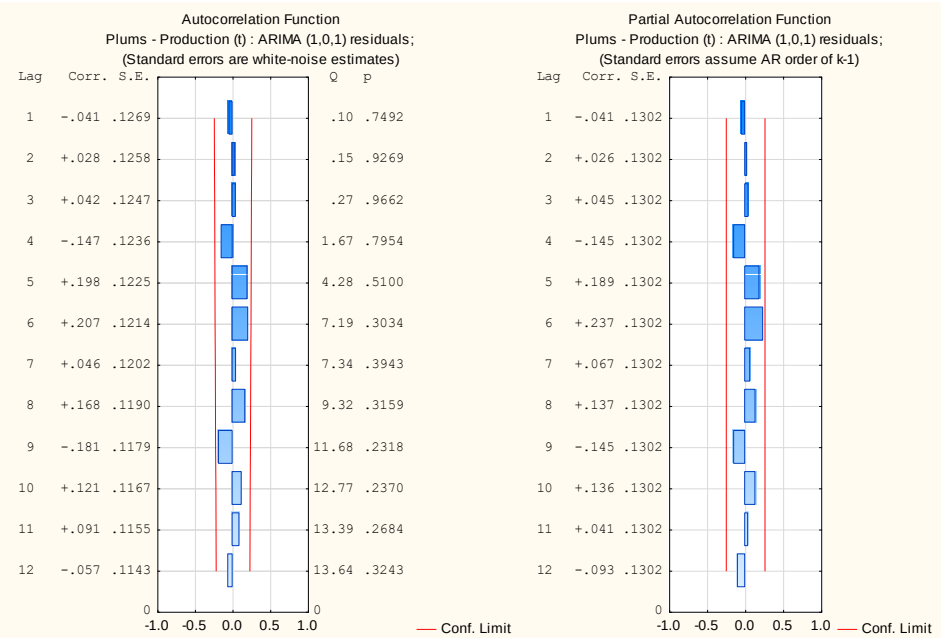
The forecast trend values of actual sour cherry production in Serbia indicate annual variations throughout the entire forecast period (Table 47 and Figure 14). At the end of the forecast period, the expected sour cherry production in Serbia will approximate to 120,000 t.

Table 46. Models for forecasting the number of productive sour cherry trees and the total volume of sour cherry production in Serbia

ARIMA Model Parameters		**Sour cherries**				
		Number of productive trees			**Production**	
Model		(2,1,1)			(1,1,0)	
MS Residual		58424.			1604E4	
Parameters		Constant	p(1)	p(2)	Constant	p(1)
Param.		189.648	-0.83754	-0.13369	1698.226	-0.55618
SE		136.56	0.12023	0.11652	1347.693	0.11728
t		1.38875	-6.96593	-1.14730	1.26010	-4.74243
p		0.17072	0.0000001	0.25641	0.212860	0.000015
Confidence interval (95%)	Lower	-84.256	-1.07869	-0.3674	-1001.52	-0.79112
	Upper	463.552	-0.59638	0.10003	4397.98	-0.32125

Total volume of plum production - Residuals:

ACF PACF



Total volume of plum production - Residuals:

ACF PACF

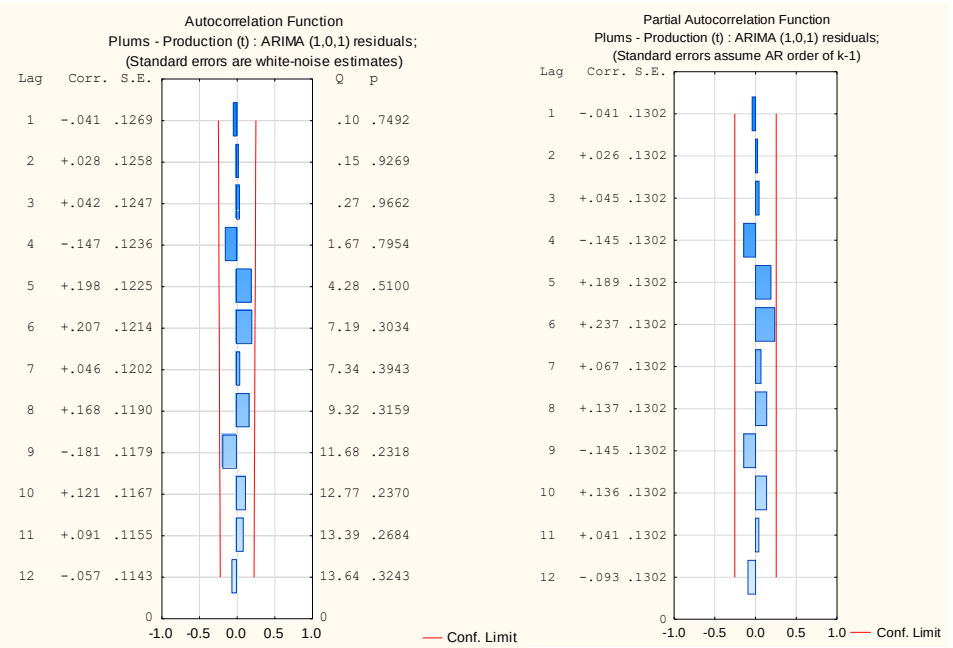


Table 47. The forecast of the number of productive sour cherry trees and the total volume of cherry production in Serbia (2020-2024)

Sour cherries	**Forecast**				
	2019	2020	2021	2022	2023
Number of productive trees (000)	15680.14	16276.99	16813.87	17273.78	17697.34
LCL	14722.33	14774.61	14774.86	14677.79	14567.60
UCL	16637.95	17779.37	18852.87	19869.78	20827.09
SE	477.532	749.037	1016.581	1294.277	1560.388
Production (t)	122862.68	118596.86	123612.18	123465.50	126189.8
LCL	88355.18	76703.29	77884.66	73000.79	72027.87
UCL	157370.18	160490.43	169339.71	173930.21	180351.8
SE	17225.84	20912.90	22826.77	25191.54	27037.17

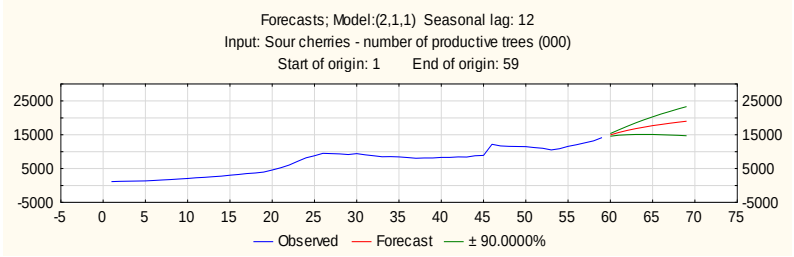


Figure 13. The forecast the number of productive sour cherry trees (000)

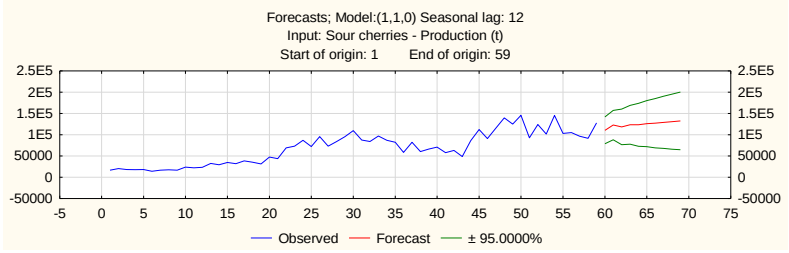


Figure 14. The forecast the total volume of sour cherry production (tonnes)

Utility value of sweet cherries - sweet cherries are rich in diverse nutrients such as sugars (namely glucose, fructose and some sucrose jointly accounting for about 12%), organic acids (up to 0.7%), cellulose (1%), pectins, tannins, anthocyanins, vitamins (namely vitamins A1, B1, B3, B5, B6 and C), essential minerals (namely S, P, Na, K, Ca, Fe, Zn, Cu, Mn, etc.), enzymes, aromatic compounds, etc.

Juicy, delicious and nutritious sweet cherries are not only used for fresh consumption but also for domestic and industrial processing (especially in compote and preserve production). Yellow sweet cherries such as 'Dragons Yellow' and 'Donessens Gelbe' are particularly suitable for processing into compotes and thin preserves due to their firm and juicy flesh, bitter-sweet flavour and pleasant aroma. Black sweet cherries of the 'Bojadiser' cultivar are used as a natural additive for colouring juices and other fruit products because of their neutral aroma. Therefore, sweet cherries are very desirable and highly regarded fruits, depending greatly upon the cultivar grown.

According to *Mišić et al. (2002)*, the following sweet cherry cultivars are considered most important in Serbia: 'Burlat', 'Van', 'Stella', 'Stark Hardy Giant' and 'Stella'. These cultivars are characterized by high yields, high quality and diverse utility value. However, a number of other newer sweet cherry cultivars, which are already well-established in the EU and worldwide, have recently been added to the Serbian sweet cherry

cultivar assortment. 'Early Lori', 'Crystalline', 'Summit', 'Kordia', 'Lapins' and 'Regina' are newer sweet cherry cultivars exceptionally suitable for commercial growing, which should receive increased attention due to their biological and production characteristics *(Milatović et al., 2011; Radičević et al., 2011)*. Such positive trends in expanding the sweet cherry cultivar assortment in Serbia should be accompanied by the introduction of modern high-performance technologies, the application of proper cultural and pomological practices, and improved growing systems *(Nikolić et al., 2012)*.

Utility value of sour cherries - although very perishable and sensitive to handling and transportation, sour cherries are regarded as a precious raw material of great and diverse technological value suitable for different preserving and processing procedures. The nutrient composition of sour cherries includes mostly carbohydrates (of which sugars predominate with about 17%), followed by proteins (about 2.1%), organic acids (about 2%) and fats (about 0.5%). A total of 100 g of sour cherries contain an energy value of 322 kJ. Sour cherries are rich in vitamin C (about 17 mg) and, in smaller amounts, carotene, vitamin B_1, vitamin B_2 and vitamin PP *(Ljubisavljević, 1990)*. They also provide a source of essential minerals such as potassium, calcium, phosphorus, iron, etc.

Sour cherries are usually used for industrial purposes, i.e. freezing and processing, whereas only a small portion of sour cherries produced are consumed fresh. They can be processed into numerous semi-processed and finished products such as pulps, compotes, sour cherry-flavoured dairy products (namely desserts, ice cream, yoghurt, kefir, whey, etc.), brandies, liqueurs, etc. The most renowned sour cherry products of the Serbian processing industry are sour cherry compotes, thin preserves, juices, syrups, jellies, *pekmez* preserves, marmalades, candied fruits, brandies, liqueurs and *ratafia* liqueurs.

In some EU countries such as Germany, Switzerland and France, sour cherries are increasingly used in the production of kirschwasser or kirsch, a b brandy distilled from the fermented juice of the black 'Morello' cherries. Kirsch ranks first of all the fruit brandies in the German market, with a price twice as high as that of whisky. It is used for direct consumption and as an ingredient in cocktails, cakes, frozen desserts and the confectionery industry.

According to *Stanković (1980)*, sour cherries can be preserved using the following procedures: pulping, freezing and hot processing. The pulping of sour cherries entails the treatment of ripe, firm and healthy sour cherries with chemical preservatives such as SO_2 solutions,

sulphurous acid or formic acid. The main disadvantage of this procedure is the possible and undesirable softening of fruits. Freezing is the best and the most expensive method of sour cherry preservation which keeps all the nutrients intact, including vitamin C. Sour cherries are frozen at a temperature of -35 ^{0}C and kept at a temperature of -18 ^{0}C, whereas fruit stems need not be removed. The hot processing of sour cherries (as in compote production) is often used despite its adverse effects on the utility value of finished products, which is particularly reflected in the oxidation of vitamin C found in sour cherries. Prior to hot processing, sour cherries are sterilized and placed in sugar syrup.

The following industrial sour cherry cultivars are suitable for processing: 'Heimanns Konservenweichel', 'Kelleris 14', 'Šumadinka', 'Oblačinska', 'North Star', 'Ujfehertoi Fürtos Meteor Korai' and 'Kelleris 16' *(Nikolić et al., 1993)*. The 'Oblačinska' cultivar predominates in the Serbian sour cherry production and processing industry *(Milatović, Nikolić, 2011)*.

Sour cherry stones contain bitter oil (approximately 30%) which can be refined and used in the pharmaceutical industry, or even as edible oil. Moreover, sour cherry stone cake, remaining after oil pressing, can also be used as animal feed *(Milić, Radojević, 2003)*. Upon dehydration, such cake contains proteins (about 31.0%), non-nitrogenous compounds (about 42.0%), crude fibres (9.8%), and extracts (13.1%).

Sour cherry trees are of great technological value (*Milić, Radojević, 2003*). A total of 1 ha of sour cherry plantation, at the end of its fruiting life, can yield approximately 100 m³ and 150 m³ of technological wood and firewood, respectively.

3.1.6. Analysis and forecast of peach production

In the period 1960-2018, the total number of productive peach trees in Serbia averaged 3.58 million, indicating a growing trend (Table 48). The number of productive peach trees in Central Serbia and Vojvodina increased at average annual rates of change of 1.69% and 1.71%, respectively. The share of Vojvodina in the total number of peach trees in Serbia averaged 24.78% in the period under consideration.

Observed over shorter periods of time, the total number of productive peach trees in Serbia increased from 2.46 million (in the period 1960-1979) to 3.69 million (in the period 1980-1999), or to 4.65 million in the final subperiod under consideration. In the period 2000-2018, the share of Vojvodina in the total number of peach trees in Serbia decreased at an average annual rate of change of -1.74%.

Table 48. Trends in the number of productive peach trees in Serbia in the period 1960-2018

Indicators	Number of productive trees (000)			Share of Vojvodina in the number of productive peach trees in Serbia (%)
	Serbia	Central Serbia	Vojvodina	
Average 1960-2018	3,580	2,690	890	24.78
Min.	1,450	1,164	286	19.00
Max.	6,338	5,075	1,392	29.80
Annual Rate of Change (%)	1.69	1.69	1.71	0.01
Coefficient of Variation (%)	30.83	31.87	31.03	12.09
Average 1960-1979	2,463	1,876	587	23.34
Min.	1,450	1,164	286	19.00
Max.	3,546	2,666	983	27.72
Annual Rate of Change (%)	4.85	4.39	6.39	1.47
Coefficient of Variation (%)	27.20	25.03	35.01	10.42
Average 1980-1999	3,687	2,669	1,018	27.64
Min.	3,566	2,504	944	24.84
Max.	3,941	2,962	1,073	29.80
Annual Rate of Change (%)	-0.03	-0.17	0.30	0.34
Coefficient of Variation (%)	2.85	4.77	3.69	5.57
Average 2000-2018	4,646	3,571	1,075	23.27
Min.	3,563	2,630	795	19.93
Max.	6,338	5,075	1,392	26.37
Annual Rate of Change (%)	0.55	1.08	-1.20	-1.74
Coefficient of Variation (%)	19.75	21.02	19.36	10.86

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

The total peach production in Serbia averaged 46,531 t in the period 1960-2018, with annual variations ranging from 13,840 t in 1960 to 91,366 t in 2011 (an absolute variation difference of 77,526 t (Table 49)). The increase in the total Serbian peach production in the period under

consideration (at an average annual rate of change of 1.97%) is directly attributed to the increased peach production in both Central Serbia and Vojvodina at average annual rates of change of 2.06% and 1.79%, respectively. Vojvodina accounted for 27.87% of the total Serbian peach production in the period under consideration.

Table 49. Trends in the peach production in Serbia in the period 1960-2018

Indicators	Production (t)			Share of Vojvodina in the total peach production in Serbia (%)
	Serbia	Central Serbia	Vojvodina	
Average 1960-2018	46,531	33,698	12,833	27.87
Min.	13,840	11,220	2,040	13.87
Max.	91,366	70,621	20,803	38.15
Annual Rate of Change (%)	1.97	2.06	1.79	-0.18
Coefficient of Variation (%)	37.41	40.53	34.44	18.28
Average 1960-1979	31,030	22,255	8,775	27.68
Min.	13,840	11,220	2,040	13.87
Max.	47,870	34,780	13,660	36.47
Annual Rate of Change (%)	5.78	5.30	7.45	1.59
Coefficient of Variation (%)	33.75	33.34	38.79	19.69
Average 1980-1999	45,555	31,470	14,085	30.89
Min.	36,873	25,124	8,290	21.08
Max.	54,370	38,651	18,420	38.15
Annual Rate of Change (%)	-0.50	-0.15	-1.20	-0.71
Coefficient of Variation (%)	11.69	12.93	18.15	13.97
Average 2000-2018	63,875	48,088	15,787	24.89
Min.	38,700	26,300	7,000	16.55
Max.	91,366	70,621	20,803	32.04
Annual Rate of Change (%)	1.47	1.65	1.13	-0.33
Coefficient of Variation (%)	24.51	25.95	24.17	14.53

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Observed over shorter periods of time, the total peach production in Serbia increased from 31,030 t (in the period 1960-1979) to 45,555 t (in the period 1980-1999), or to 63,875 t in the final subperiod under consideration. The share of Vojvodina in the total Serbian peach production structure decreased from 27.68% (in the period 1960-1979) to 24.89% (in the period 2000-2018).

Peaches claimed a 5.06% share in the total number of productive fruit trees in Serbia in 2018 (Table 50). The total number of productive peach trees in Serbia increased by 2.53 million in 2018 compared to the base year of 1960 (an index of 275). The share of peaches in the Serbian fruit plantation structure increased by about 70% in 2018 compared to the base year of 1960.

Table 50. Number of productive peach trees and the volume of peach production in Serbia in the years considered

Year	**Serbia**		
	Peaches	**Other fruit species**	**Total**
1960			
Number of productive trees (000)	1,450	47,181	48,631
- Share (%)	2.98	97.02	100.00
Production (t)	13,840	276,290	290,130
- Share (%)	4.77	95.23	100.00
2018			
Number of productive trees (000)	3,982	74,687	78,669
Index 1980=100	*274.62*	*158.30*	*161.77*
- Share (%)	5.06	94.94	100.00
Index 1980=100	*169.80*	*97.86*	/
Production (t)	50,249	1,287,433	1,337,682
Index 1980=100	*363.07*	*465.97*	*461.06*
- Share (%)	3.76	96.24	100.00
Index 1980=100	*78.83*	*101.06*	/

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

With approximately 795,000 productive trees, peaches claimed a 6.70% share in the Vojvodinian fruit plantation structure in 2018. The number of productive peach trees in Vojvodina increased by 278 index points in 2018 compared to the base year of 1960 (Table 51). The share of peaches in the Vojvodinian fruit production structure increased by approximately 7% in 2018 over that recorded in 1960.

With an actual production of 50,249 t, peaches claimed a 3.76% share in the Serbian fruit production structure in 2018. The total peach

production in Serbia increased by approximately 36,000 t (or 363 index points) in 2018 compared to the base year of 1960. The share of peaches in the Serbian fruit plantation structure decreased by 21% in 2018 from that recorded in 1960.

Table 51. Number of productive peach trees and the volume of peach production in Vojvodina in the years considered

Year	**Vojvodina**		
	Peaches	**Other fruit species**	**Total**
1960			
Number of productive trees (000)	286	4,269	4,555
- Share (%)	6.28	93.72	100.00
Production (t)	2,620	64,070	66,690
- Share (%)	3.93	96.07	100.00
2018			
Number of productive trees (000)	795	11,066	11,861
Index 1980=100	*277.97*	*259.22*	*260.40*
- Share (%)	6.70	93.30	100.00
Index 1980=100	*106.69*	*99.55*	/
Production (t)	11,800	260,485	272,285
Index 1980=100	*450.38*	*406.56*	*408.28*
- Share (%)	4.33	95.67	100.00
Index 1980=100	*110.18*	*99.58*	/

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

With an actual production of 11,800 t, peaches claimed a 4.33% share in the Vojvodinian fruit production structure in 2018. The peach production in Vojvodina increased by 450 index points in 2018 compared to the base year of 1960. The share of peaches in the Vojvodinian fruit production structure increased by 10% in 2018 over that recorded in 1960.

Forecast of peach production in Serbia - the model employed for forecasting the number of productive peach trees in Serbia (Table 52) indicates that the current year's value is greatly affected by the previous year's value.

The forecast values obtained suggest an annual increase in the total number of peach trees in Serbia throughout the entire forecast period. At the end of the forecast period, the total number of peach trees in Serbia will approximate to 4 million, representing an increase of about 2 million peach trees (or about 60%) compared to the base year of 1960 (Table 53 and Figure 15). The expected number of peach trees in Serbia at the end

of the forecast period will increase by 10% compared to the average number of peach trees in Serbia in the period 1960-2018.

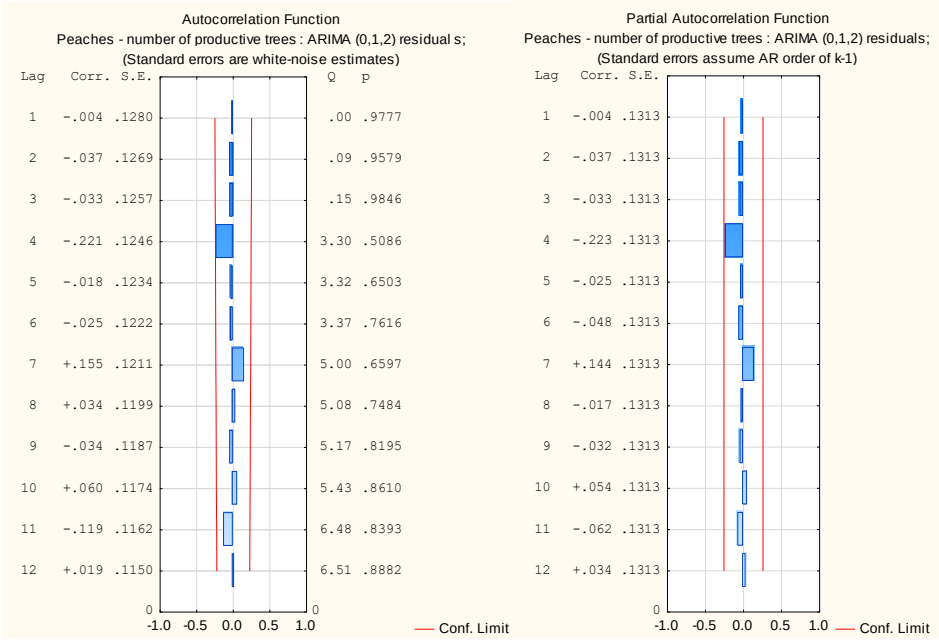
The forecast trend values of total peach production in Serbia indicate annual variations throughout the entire forecast period (Table 53 and Figure 16). At the end of the forecast period, the expected peach production in Serbia will approximate to 50,000 t, representing an increase of about 37,000 t over the actual Serbian peach production in 1960.

Table 52. Models for forecasting the number of productive peach trees and the total volume of peach production in Serbia

ARIMA Model Parameters		**Peaches**		
		Number of productive trees		**Production**
Model		(0,1,2)		(1,1,0)
MS Residual		99708.		5515E4
Parameters		q(1)	q(2)	p(1)
Param.		-0.02137	-0.17052	-0.208162
SE		0.13222	0.17756	0.132418
t		-0.16164	-0.96038	-1.5720
p		0.87219	0.34115	0.121581
Confidence interval (95%)	Lower	-0.28646	-0.52651	-0.47343
	Upper	0.24372	0.18546	0.05710

Number of productive peach trees – Residuals:

ACF PACF



Total volume of peach production - Residuals:

ACF PACF

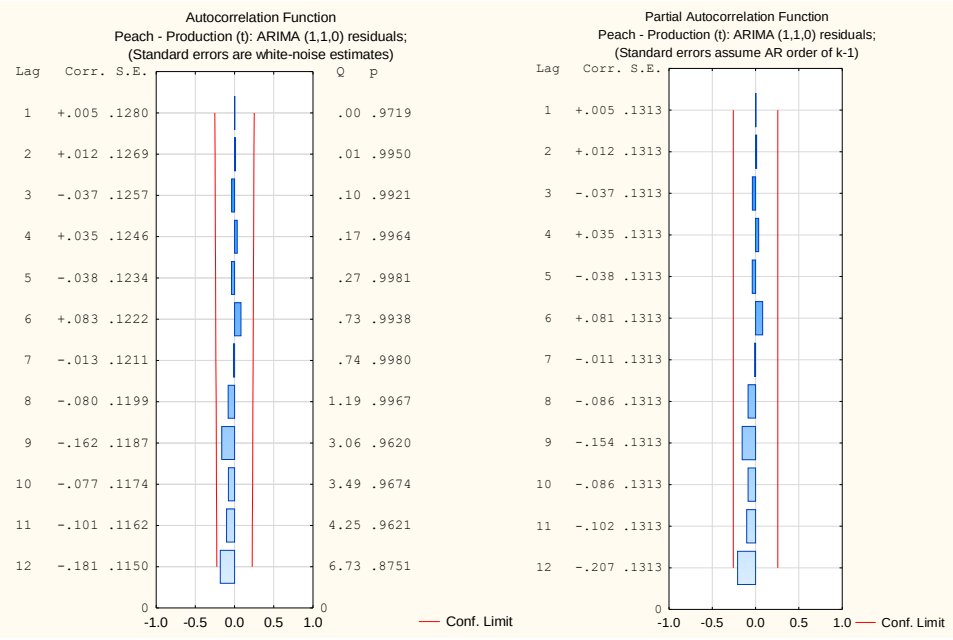


Table 53. The forecast of the number of productive peach trees and the total volume of peach production in Serbia (2019-2023)

Peaches	**Forecast**				
	2019	2020	2021	2022	2023
Number of productive trees (000)	4016.26	4037.19	4058.12	4079.06	4099.99
LCL	3111.34	2858.96	2658.99	2489.42	2340.36
UCL	4921.18	5215.42	5457.26	5668.69	5859.62
SE	451.357	587.682	697.866	792.884	877.674
Production (t)	52332.21	53009.18	53632.00	54266.10	54897.85
LCL	33356.62	30327.94	27834.96	25678.97	23772.02
UCL	71307.80	75690.42	79429.05	82853.23	86023.68
SE	9472.45	11322.27	12877.66	14270.44	15537.74

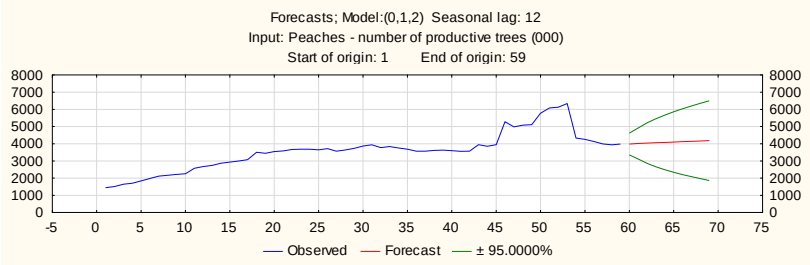


Figure 15. The forecast the number of productive peach trees (000)

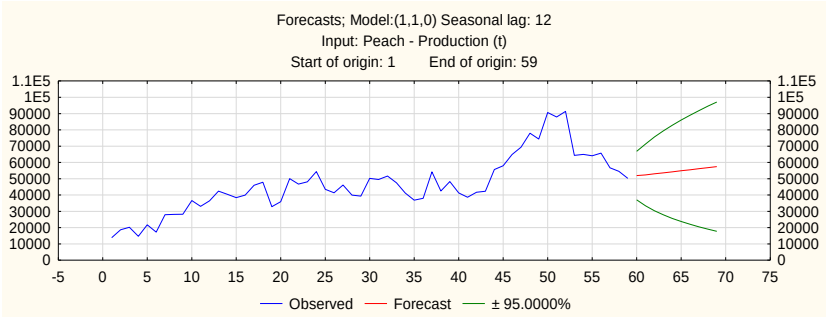


Figure 16. The forecast the total volume of peach production (tonnes)

Utility value of peaches - owing to their chemical composition, peaches are suitable for different uses such as fresh consumption, industrial processing, freezing and drying. They are usually consumed fresh (about 80%) or used as raw materials in the production of juices, compotes, baby food, marmalades, jams, etc. *(Bulatović, Mratinić, 1996)*.

Peaches mostly contain carbohydrates (of which sugars predominate accounting for 12%), proteins (about 0.1%) and fats (about 0.1%). They have a relatively low energy value of 217 kJ/100 g due to their high water content. Peach fruits also contain vitamin C (5-8 mg), provitamin A (about 0.30 mg), vitamin B_1 (0.03 mg), vitamin B_2 (0.05 mg) and vitamin PP (about 0.90 mg). They are a source of essential minerals such as potassium, calcium, phosphorus, iron, etc. *(Ljubosavljević, 1990)*.

Peach cultivars can be divided into three groups according to their uses: peach cultivars for fresh consumption, nectarine cultivars and industrial peach cultivars. The following industrial peach cultivars are considered most important: ‘Maria Sedena’, ‘Adriatica’, ‘Loadel’, ‘Villa Adriana’, ‘Villa Ada’, ‘Vivian’, ‘Babygold 6’, ‘Andros’, ‘Jungerman Babygold 8’ and ‘Babygold 9’ *(Ognjanov, 2003)*. Industrial peach cultivars have the following advantages over other peach cultivars:

– increased fruit firmness (which enables mechanical sorting and processing without fruit damage),

- higher juice contents (which is of paramount importance to the canning industry),
- a dry matter content higher by 5% than that of peaches for fresh consumption (which exerts a significant effects on the quality of final products, i.e. the higher the dry matter content is, the more valuable peach fruits will be),
- amounts of calcium 2-3 times as high as that of peaches for fresh consumption (which also greatly affects the quality of final products),
- clingstone pavia peaches are 2-3 times as firm as those for fresh consumption (despite containing less cellulose and pectins).

3.1.7. Analysis and forecast of apricot production

There is an enormous demand for apricots in both domestic and foreign markets. The actual apricot production in Serbia amounted to 13,633 t in 2006, whereas the number of productive apricot trees in the country approximated to 1.6 million *(Milić et al., 2009).* The key limiting factors in the mass production of apricots are irregular yields (due to winter and late spring frosts) and the premature withering of apricot trees (apoplexy).

In the period 1960-2018, the total number of productive apricot trees in Serbia averaged 1.62 million, indicating a growing trend (Table 54).

Table 54. Trends in the number of productive apricot trees in Serbia in the period 1960-2018

Indicators	**Number of productive trees (000)**			**Share of Vojvodina in the number of productive apricot trees in Serbia (%)**
	Serbia	**Central Serbia**	**Vojvodina**	
1	2	3	4	5
Average 1960-2018	1,615	1,140	475	31.36
Min.	1,033	483	385	21.12
Max.	2,762	2,171	652	53.24
Annual Rate of Change (%)	1.55	2.29	0.10	-1.43
Coefficient of Variation (%)	30.48	40.34	15.85	28.2

1	2	3	4	5
Average 1960-1979	1,177	684	493	42.13
Min.	1,033	483	422	34.79
Max.	1,348	874	624	53.24
Annual Rate of Change (%)	0.80	2.59	-1.50	-2.28
Coefficient of Variation (%)	6.58	15.39	11.50	14.29
Average 1980-1999	1,498	1,085	413	27.66
Min.	1,376	899	385	25.29
Max.	1,580	1,175	482	34.90
Annual Rate of Change (%)	0.62	1.15	-0.64	-1.26
Coefficient of Variation (%)	4.90	8.28	5.82	10.06
Average 2000-2018	2,199	1,677	522	23.92
Min.	1,545	1,154	389	21.12
Max.	2,762	2,171	652	26.14
Annual Rate of Change (%)	3.54	3.83	2.56	-0.95
Coefficient of Variation (%)	19.27	20.76	16.34	7.37

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

The number of productive apricot trees in Central Serbia and Vojvodina increased at average annual rates of change of 2.29% and 0.10%, respectively. The share of Vojvodina in the total number of productive apricot trees in Serbia averaged 31.36% in the period under consideration.

Growing trends in the number of productive apricot trees in Serbia were also observed across the subperiods under consideration, and the largest notable increase was recorded in the period 2000-2018 (at an average annual rate of change of 3.54%). In the subperiods under consideration, the share of Vojvodina in the total number of productive apricot trees in Serbia decreased at average annual rates of change ranging from -2.28% (in the period 1960-1979) to 0.95% (in the period 2000-2018).

The total apricot production in Serbia averaged 21,258 t in the period 1960-2018, with annual variations ranging from 5,592 t in 1998 to 44,077 t in 2011 (an absolute variation difference of 38,485 t (Table 55)).

Table 55. Trends in the apricot production in Serbia in the period 1960-2018

Indicators	Production (t)			Share of Vojvodina in the total apricot production in Serbia (%)
	Serbia	Central Serbia	Vojvodina	
Average 1960-2018	21,258	14,469	6,789	32.95
Min.	5,592	3,400	1,457	10.87
Max.	44,077	31,127	20,640	61.67
Annual Rate of Change (%)	1.25	2.02	-0.07	-1.31
Coefficient of Variation (%)	44.34	49.91	51.02	34.14
Average 1960-1979	16,752	9,375	7,377	42.97
Min.	8,850	3,400	1,750	19.77
Max.	36,240	15,810	20,640	61.67
Annual Rate of Change (%)	-1.38	1.28	-4.82	-3.48
Coefficient of Variation (%)	42.31	39.09	59.84	26.33
Average 1980-1999	18,927	13,223	5,704	30.34
Min.	5,592	3,894	1,510	12.86
Max.	31,220	23,320	9,742	43.07
Annual Rate of Change (%)	-0.99	-0.90	-1.05	-0.06
Coefficient of Variation (%)	40.61	42.07	44.39	24.49
Average 2000-2018	28,456	21,143	7,313	25.14
Min.	12,747	9,495	1,457	10.87
Max.	44,077	31,127	12,950	38.01
Annual Rate of Change (%)	3.38	3.36	3.92	0.52
Coefficient of Variation (%)	32.89	31.23	41.81	22.08

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

The increase in the total Serbian apricot production in the period under consideration (at an average annual rate of change of 1.25%) is attributed to the increased apricot production in Central Serbia (at an average annual rate of change of 2.02%) in the same period. However, a

simultaneous decrease in the Vojvodinian apricot production (at an average annual rate of change of -0.07%) reduced the share of Vojvodina in the total Serbian apricot production from 61.67% in 1960 to 24.09% in 2018.

The total apricot production in Serbia increased from 16,752 t (in the period 1960-1979) to 18,927 t (in the period 1980-1999), or to 28,456 t in the final subperiod under consideration. The share of Vojvodina in the total Serbian apricot production decreased from 42.97% in the initial subperiod under consideration to 25.14% in the period 2000-2018.

With 2.76 million productive trees, apricots claimed a 3.51% share in the total number of productive fruit trees in Serbia (Table 56). The total number of productive apricot trees in Serbia increased by 1.73 million, or approximately twofold (an index of 268), over that recorded in 1960. The share of apricots in the Serbian fruit plantation structure increased by 66% in 2018 compared to the base year of 1960.

Table 56. Number of productive apricot trees and the volume of apricot production in Serbia in the years considered

Year	**Serbia**		
	Apricots	**Other fruit species**	**Total**
1960			
Number of productive trees (000)	1,033	47,598	48,631
- *Share (%)*	2.12	97.88	100.00
Production (t)	8,870	281,260	290,130
- *Share (%)*	3.06	96.94	100.00
2018			
Number of productive trees (000)	2,762	75,907	78,669
Index 1980=100	*267.38*	*159.48*	*161.77*
- *Share (%)*	3.51	96.49	100.00
Index 1980=100	*165.57*	*98.58*	/
Production (t)	25,414	1,312,268	1,337,682
Index 1980=100	*286.52*	*466.57*	*461.06*
- *Share (%)*	1.90	98.10	100.00
Index 1980=100	*62.09*	*101.20*	/

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Apricots claimed a share of 4.98% in the Vojvodinian fruit plantation structure in 2018 (Table 57). The number of productive apricot trees in Vojvodina increased by approximately 8% in 2018 over that recorded in 1960. However, the share of apricots in the Vojvodinian fruit production structure decreased by 59% in 2018 compared to the base year of 1960.

Table 57. Number of productive apricot trees and the volume of apricot production in Vojvodina in the years considered

Year	**Vojvodina**		
	Apricots	**Other fruit species**	**Total**
1960			
Number of productive trees (000)	550	4,005	4,555
- *Share (%)*	12.07	87.93	100.00
Production (t)	5,470	61,220	66,690
- *Share (%)*	8.20	91.80	100.00
2018			
Number of productive trees (000)	591	11,270	11,861
Index 1980=100	*107.45*	*281.40*	*260.40*
- *Share (%)*	4.98	95.02	100.00
Index 1980=100	*41.26*	*108.06*	/
Production (t)	6,121	266,164	272,285
Index 1980=100	*111.90*	*434.77*	*408.28*
- *Share (%)*	2.25	97.75	100.00
Index 1980=100	*27.44*	*106.48*	/

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

With an actual production of 25,414 t, apricots accounted for 1.90% of the total Serbian fruit production in 2018. The total apricot production in Serbia increased by 287 index points compared to the base year of 1960. The share of apricots in the Serbian fruit plantation structure decreased by 38% in 2018 from that recorded in 1960.

Apricots claimed a 2.25% share in the Vojvodinian fruit production structure in 2018. The apricot production in Vojvodina increased by 12% in 2018 over that recorded in 1960. The share of apricots in the Vojvodinian fruit production structure decreased by 73% in 2018 compared to the base year of 1960.

Forecast of apricot production in Serbia - the forecast values obtained (using the ARIMA model shown in Table 58) indicate a growing trend in the number of productive apricot trees in Serbia throughout the entire forecast period (Table 59 and Figure 17). At the end of the forecast period, the expected number of productive apricot trees in Serbia will approximate to 3 million, representing an increase of about 2 million over the number of productive apricot trees in Serbia in 1960 and an increase of about 1.4 million over the average number of productive apricot trees in Serbia in the period 1960-2018.

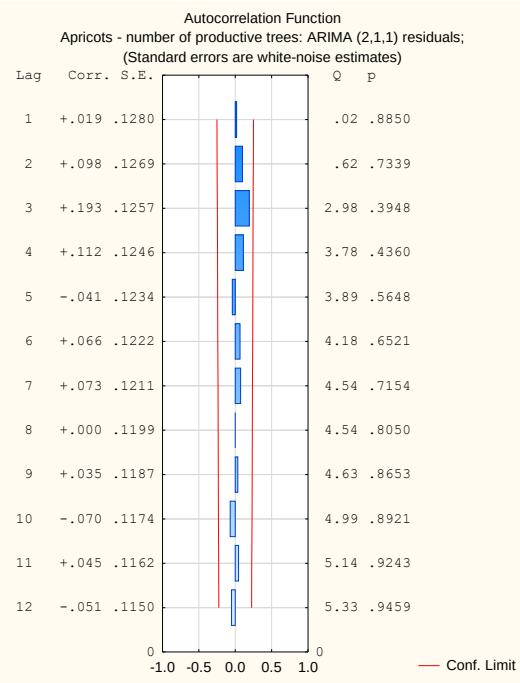
The forecast trend values of apricot production in Serbia indicate an annual increase in the total Serbian apricot production throughout the entire forecast period (Table 59 and Figure 18). At the end of the forecast period, the expected apricot production in Serbia will approximate to 33,000 t, representing an increase of about 24,000 t compared to the base year of 1960 and an increase of about 12,000 t over the average apricot production in Serbia in the period under consideration (1960-2018).

Table 58. Models for forecasting the number of productive apricot trees and the total volume of apricot production in Serbia

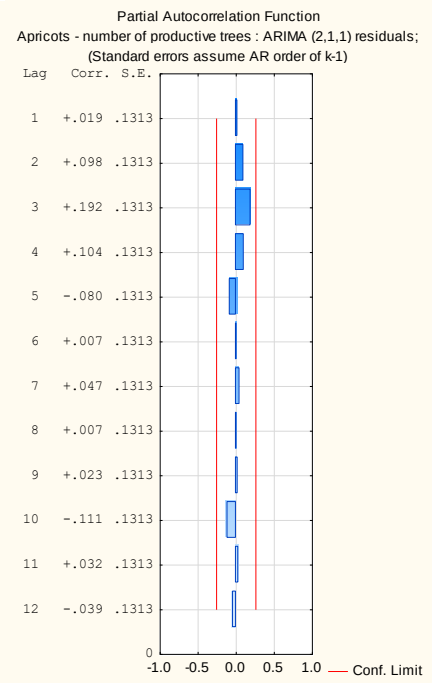
ARIMA Model Parameters	**Apricots**					
	Number of productive trees				**Production**	
Model	(2,1,1)				(0,1,1)	
MS Residual	6414.0				7459E4	
Parameters	Constant	p(1)	p(2)	q(1)	Constant	p(1)
Param.	29.4529	-0.71740	-0.1967	-0.61466	277.2308	-0.54863
SE	8.98474	0.55925	0.13595	0.56632	828.4120	0.11569
t	3.27810	-1.28278	-1.4473	-1.08535	0.33465	-4.74211
p	0.00183	0.20504	0.15358	0.28258	0.73914	0.000015
Lower	11.4395	-1.83864	-0.4693	-1.75007	-1382.278	-0.78038
Upper	47.4662	0.40384	0.07580	0.52075	1936.7394	-0.31687

Number of productive apricot trees – Residuals:

ACF



PACF



Total volume of apricot production - Residuals:

ACF PACF

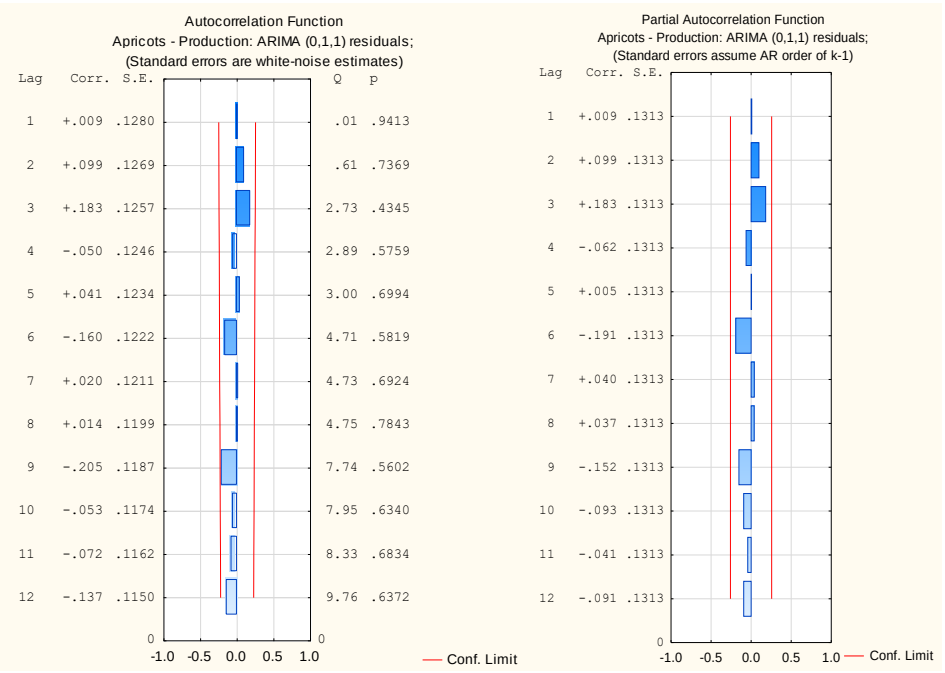


Table 59. The forecast of the number of productive apricot trees and the total volume of apricot production in Serbia (2019-2023)

Apricots	**Forecast**				
	2019	2020	2021	2022	2023
Number of productive trees (000)	2813.48	2850.00	2876.50	2906.68	2936.20
LCL	2597.76	2601.03	2590.01	2590.78	2592.31
UCL	3029.20	3098.98	3162.99	3222.59	3280.08
SE	107.5993	124.1852	142.8964	157.5692	171.5246
Production (t)	32210.23	32540.99	32871.74	33202.50	33533.25
LCL	14791.92	15006.68	15222.20	15438.46	15655.46
UCL	49628.55	50075.30	50521.29	50966.53	51411.04
SE	8695.067	8752.972	8810.497	8867.648	8924.433

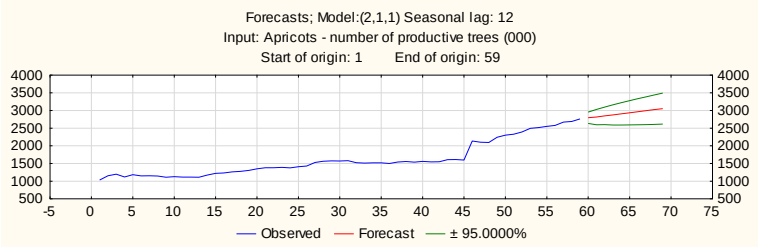


Figure 17. The forecast the number of productive apricot trees (000)

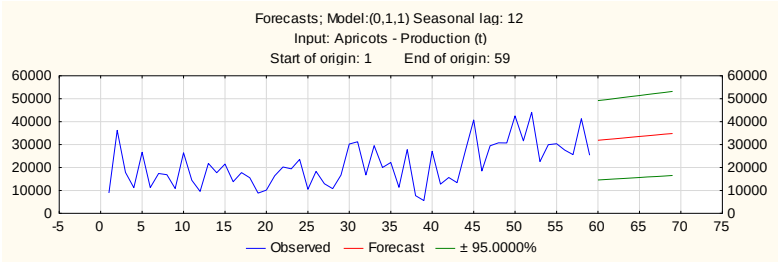


Figure 18. The forecast the total volume of apricot production (tonnes)

Utility value of apricots - the nutrient composition of apricots includes mostly carbohydrates (of which fructose, glucose and sucrose predominate with about 10%), proteins (about 0.8%) and fats (about 0.1%). A total of 100 g of apricots have an energy value of 184 kJ. They contain vitamin C (5-16 mg), provitamin A (1-7 mg), vitamin B_1 (0.06 mg), vitamin B_2 (0.12 mg) and vitamin PP (0.7 mg/100 g of edible fruit). Apricots also provide a source of essential minerals such as potassium, calcium, magnesium, phosphorus, iron, etc. *(Ljubisavljević, 1990)*.

Apricots are excellent for both fresh consumption and processing. Apricot cultivars for processing should yield medium- and even-sized fruits of regular shape with orange skin and flesh. The flesh of apricots should have a good texture which is not susceptible to pit burn, i.e. browning and softening of the flesh surrounding the apricot stone or pit. Moreover, the following properties of apricot fruits are also highly desirable: high contents of soluble dry matter, a good balance between sugars and acids, and rich aroma *(Milatović, 2013)*.

Fresh and/or frozen apricots can be further processed into a number of semi-processed and finished products: frozen purees, frozen halves, *pekmez* preserves, jams, marmalades, thin preserves, compotes, jellies, creams, salads, brandies, etc. Dried and candied apricots are considered especially valuable. Apricot fruits suitable for drying should be large, healthy and ripe with intense colour and pleasant flavour. The ‘Bleinheim (Royal)’, ‘Tilton’ and ‘Peterson’ apricot cultivars are exceptionally

suitable for drying due to their high sugar contents *(Szorza and Hui, 1994).*

Table 60. Apricot cultivar assortments of the most important apricot producers in the world

Spain	'Bulida', 'Canino', 'Moniqui', 'Velaquez Fino', 'Gitano', 'Mauricio', 'Valenciano', 'Currot', 'Palau', 'Ginesta', 'Tadeo', 'Pepito del Rubio'
France	'Bargeron', 'Orangé de Provance (Polonais)', 'Orange Red', 'Goldrich', 'Hargrand', 'Rouge de Roussillon' In the south: 'Bergarouge', 'Malice', 'Fantasme', 'Sortilege', 'Helena du Roussillon', 'Tardif de Tain'
Italy	'San Castrese', 'Monaco Bello', 'Portici', 'Palummella', 'Fracasso', 'Boccuccia', 'Pellecchiela' In the south: 'Ninfa', 'Aurora', 'Perla', 'Caldesi 2', 'Tardif de Tain'
Greece	'Bebecou', 'Tirynthos', 'Boccuccia', 'Baracca', 'Bergeron'
Turkey	'Hacihaliloglu', 'Turfanda', 'Coluglu', 'Mogoncok'
Romania	'Trainan', 'Neptun', 'Saturn', 'Venus', 'Mamaia', 'Callatis', 'Litoral', 'Sulmona', 'Comandor', 'Sirena', 'Olimp'
Ukraine	'Krasznoscsokij', 'Ananas', 'Krimszkij amur'
Armenia	'Salah (Jerevani)', 'Sateni', 'Nushi', 'Ordubadi', 'Anban', 'Magoncok'
Iran	'Shastomi', 'Malayer', 'Ghorban', 'Felfely'
China	'White Silver', 'Red Rainbow', 'Ji Pu', 'Ying Ji Sha', 'Li Guang', 'Hong Yu Li Ke'
California	'Bleinheim (Royal)', 'Tilton', 'Castelbrite', 'Modesto', 'Pattersen', 'Westley'
Canada	'Hargrand', 'Harogem', 'Harcot', 'Harglow', 'Harlayne', 'Veecot', 'Velvaglo', 'Viceroy', 'Vivagold', 'Tilton', 'Goldrich', 'Perfection'
Australia	'Moorpark', 'Trevatt', 'Story', 'Watkins', 'Pannach', 'Hunter'
New Zealand	'Moorpark', 'Sundrop', 'Clutha-sorozat', In the south: 'Gabriel', 'Dunstan', 'Benmore', 'Vulcan', 'Alex'
South African Republic	'Bulida', 'Royal (Bleinheim)', 'Peeka', 'Supergold', 'Palsteyn (Imperial)'

(Source: Szalay, 2003)

The following apricot cultivars are also very suitable for processing: 'Čačansko zlato' (for preserve and compote production), 'Čačanska

pljosnata' (for drying), 'Stark Early Orange' (for compote production), 'Kišinjevski ranij' (for preserve and compote production), 'Bergeron' (for compote production) and 'Maquar Legjobb' (for different uses). Pálinka (or *pálinkakészités* in Hungarian*)* is a traditional apricot brandy produced in Hungary, also known as *Hungarikum* in the EU *(Szalay, Penzes, 2003).*

3.1.8. Analysis and forecast of walnut production

In the period 1960-2018, the total number of productive walnut trees in Serbia averaged 1.38 million, indicating a slightly increasing trend (Table 61). The number of productive walnut trees in Central Serbia and Vojvodina increased at average annual rates of change of 0.26% and 0.82%, respectively. The share of Vojvodina in the total number of productive walnut trees in Serbia averaged 17.52% in the period under consideration.

Table 61. Trends in the number of productive walnut trees in Serbia in the period 1960-2018

Indicators	**Number of productive trees (000)**			**Share of Vojvodina in the number of productive walnut trees in Serbia (%)**
	Serbia	**Central Serbia**	**Vojvodina**	
1	2	3	4	5
Average 1960-2018	1,384	1,136	248	17.52
Min.	807	710	97	12.02
Max.	1,757	1,404	353	21.36
Annual Rate of Change (%)	0.36	0.26	0.82	0.46
Coefficient of Variation (%)	18.59	16.31	30.88	15.38
Average 1960-1979	1,172	999	173	14.73
Min.	961	810	142	13.83
Max.	1,388	1,183	216	16.76
Annual Rate of Change (%)	2.12	2.14	2.06	-0.07
Coefficient of Variation (%)	12.59	12.60	13.42	4.67

1	2	3	4	5
Average 1980-1999	1,597	1,289	308	19.24
Min.	1,392	1,166	226	16.24
Max.	1,742	1,400	343	20.48
Annual Rate of Change (%)	1.01	0.86	1.68	0.67
Coefficient of Variation (%)	6.09	5.16	10.88	6.07
Average 2000-2018	1,383	1,119	264	18.63
Min.	807	710	97	12.02
Max.	1,757	1,404	353	21.36
Annual Rate of Change (%)	-3.56	-3.11	-5.74	-2.26
Coefficient of Variation (%)	20.43	18.35	30.63	15.33

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Observed over shorter periods of time, the total number of productive walnut trees in Serbia increased from 1.17 million (in the period 1960-1979) to 1.60 million (in the period 1980-1999), followed by a decrease to 1.38 million in the final subperiod under consideration. The share of Vojvodina in the total number of productive walnut trees in Serbia increased from 14.73% (in the period1960-1979) to 18.63% (in the period 2000-2018).

In the period 1960-2018, the total walnut production in Serbia averaged 16,446 t, with annual variations ranging from 7,300 t in 1979 to 27,554 t in 2009 (an absolute variation difference of 20,254 t (Table 62)). The increase in the total Serbian walnut production in the period under consideration (at an average annual rate of change of 0.46%) is primarily due to the increased walnut production in both Central Serbia (at an average annual rate of change of 0.24%) and Vojvodina (at an average annual rate of change of 1.43%) in the same period. The share of Vojvodina in the total Serbian walnut production increased from 13.63% in 1960 to 21.43% in 2018.

Observed over shorter periods of time, the actual walnut production in Serbia increased from 14,350 t (in the period 1960-1979) to 17,180 t (in the period 1980-1999), or to 17,879 t in the period 2000-2018 (Table 63). The share of Vojvodina in the total Serbian walnut production

indicates a slightly increasing trend throughout the subperiod 2000-2018 (at an average annual rate of change of 0.41%).

Table 62. Trends in the walnut production in Serbia in the period 1960-2018

Indicators	Production (t)			Share of Vojvodina in the total walnut production in Serbia (%)
	Serbia	Central Serbia	Vojvodina	
Average 1960-2018	16,446	12,947	3,499	21.38
Min.	7,300	4,740	1,240	10.46
Max.	27,554	21,375	6,179	35.07
Annual Rate of Change (%)	0.46	0.24	1.43	0.97
Coefficient of Variation (%)	26.46	27.42	35.06	25.76
Average 1960-1979	14,350	12,048	2,302	16.96
Min.	7,300	4,740	1,240	10.46
Max.	21,040	18,390	4,180	35.07
Annual Rate of Change (%)	-1.14	-1.66	0.80	1.96
Coefficient of Variation (%)	27.51	30.63	26.21	33.74
Average 1980-1999	17,180	13,151	4,029	23.43
Min.	13,396	8,750	1,370	11.58
Max.	22,744	18,198	5,200	33.51
Annual Rate of Change (%)	1.84	1.80	2.12	0.28
Coefficient of Variation (%)	20.16	21.02	24.98	19.34
Average 2000-2018	17,879	13,679	4,200	23.87
Min.	9,272	7,285	1,987	17.82
Max.	27,554	21,375	6,179	30.66
Annual Rate of Change (%)	-2.28	-2.37	-1.87	0.41
Coefficient of Variation (%)	27.54	29.85	23.47	12.27

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

In 2018, walnuts claimed a 1.03% share in the Serbian fruit plantation structure. The total number of productive walnut trees in Serbia decreased by approximately 16% in 2018 compared to the base year of 1960 (Table 63). The share of walnuts in the Serbian fruit plantation structure decreased by about 48% from that recorded in 1960.

Table 63. Number of productive walnut trees and the volume of walnut production in Serbia in the years considered

Year	**Serbia**		
	Walnuts	**Other fruit species**	**Total**
1960			
Number of productive trees (000)	961	47,670	48,631
- Share (%)	1.98	98.02	100.00
Production (t)	9,100	281,030	290,130
- Share (%)	3.14	96.86	100.00
2018			
Number of productive trees (000)	807	77,862	78,669
Index 1980=100	*83.98*	*163.34*	*161.77*
- Share (%)	1.03	98.97	100.00
Index 1980=100	*52.02*	*100.97*	/
Production (t)	9,272	1,328,410	1,337,682
Index 1980=100	*101.89*	*472.69*	*461.06*
- Share (%)	0.69	99.31	100.00
Index 1980=100	*21.97*	*102.53*	/

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Walnuts claimed merely a 0.82% share in the Vojvodinian fruit plantation structure in 2018. The number of productive walnut trees in Vojvodina decreased by approximately 36% in 2018 compared to the base year of 1960 (Table 64). The share of walnuts in the Vojvodinian fruit plantation structure decreased by about 75% in 2018 from that recorded in 1960.

With an actual production of 9,272 t, walnuts accounted for 0.69% of the total Serbian fruit production in 2018, thus ranking last of all the fruit crops considered. The total walnut production in Serbia increased by approximately 2% compared to the base year of 1960. However, the share of walnuts in the Serbian fruit production structure decreased by about 78% in 2018 from that recorded in 1960.

With an actual production of merely 1,987 t, walnuts accounted for 0.73% of the total Vojvodinian fruit production in 2018. The actual walnut production in Vojvodina increased by approximately 60% in 2018

over that recorded in 1960. The share of walnuts in the Vojvodinian fruit production structure decreased by 61% in 2018 compared to the base year of 1960.

Table 64. Number of productive walnut trees and the volume of walnut production in Vojvodina in the years considered

Year	**Vojvodina**		
	Walnuts	**Other fruit species**	**Total**
1960			
Number of productive trees (000)	151	4,404	4,555
- Share (%)	3.32	96.68	100.00
Production (t)	1,240	65,450	66,690
- Share (%)	1.86	98.14	100.00
2018			
Number of productive trees (000)	97	11,764	11,861
Index 1980=100	*64.24*	*267.12*	*260.40*
- Share (%)	0.82	99.18	100.00
Index 1980=100	*24.70*	*102.59*	/
Production (t)	1,987	270,298	272,285
Index 1980=100	*160.24*	*412.98*	*408.28*
- Share (%)	0.73	99.27	100.00
Index 1980=100	*39.25*	*101.15*	/

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

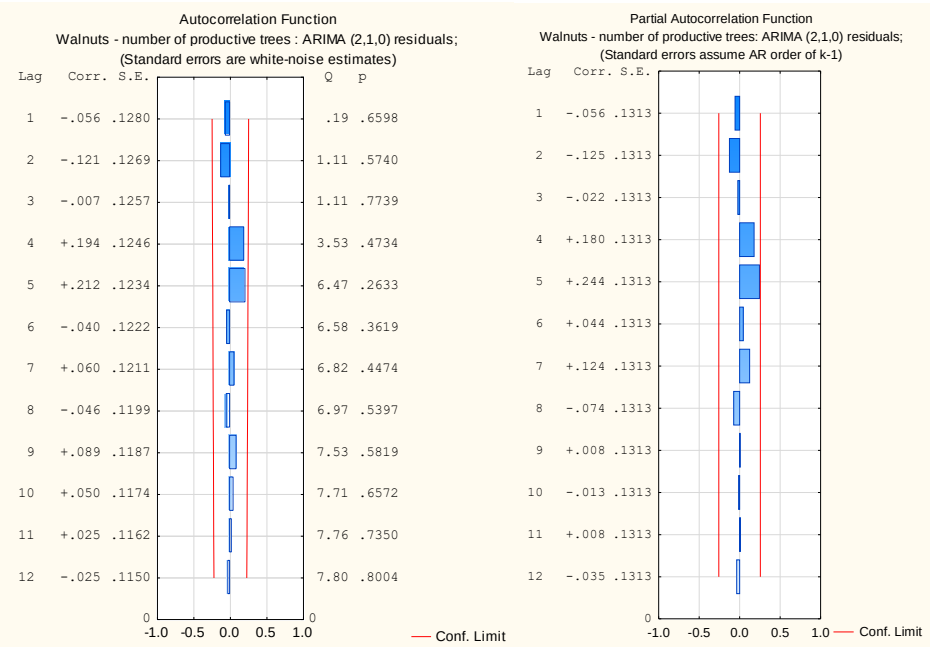
Forecast of walnut production in Serbia - the forecast values obtained (using the ARIMA model shown in Table 65) indicate an annual decrease in the number of productive walnut trees in Serbia throughout the entire forecast period.

Table 65. Models for forecasting the number of productive walnuts trees and the total volume of walnuts production in Serbia

ARIMA Model Parameters		**Walnuts**			
		Number of productive trees		**Production**	
Model		(2,1,0)		(2,1,0)	
MS Residual		2100.3		1928E4	
Parameters		p(1)	p(2)	p(1)	p(2)
Param.		0.19555	0.40501	-0.50515	-0.29842
SE		0.13701	0.14102	0.13066	0.13075
t		1.42722	2.87203	-3.86607	-2.28235
p		0.15927	0.00582	0.000295	0.026359
Confidence interval (95%)	Lower	-0.07915	0.12228	-0.7670	-0.5604
	Upper	0.47025	0.68774	-0.2433	-0.0364

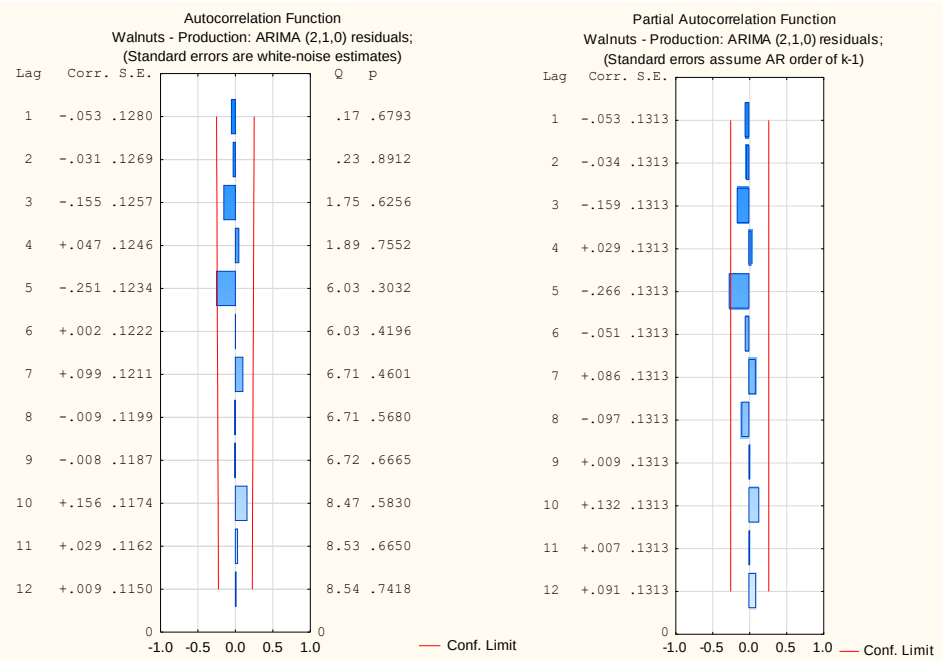
Number of productive walnut trees – Residuals:

ACF PACF



Total volume of walnut production - Residuals:

ACF PACF



At the end of the forecast period, the number of productive walnut trees in Serbia will approximate to 560,000, representing a decrease of 60% from the average number of productive walnut trees in Serbia in the period 1960-2018 (Table 66 and Figure 19).

The forecast trend values of walnut production in Serbia indicate a downward trend throughout the entire forecast period (Table 66 and Figure 20). By the end of 2024, the expected walnut production in Serbia will approximate to 14,000 t.

Table 66. The forecast of the number of productive walnut trees and the total volume of walnut production in Serbia (2019-2023)

Walnuts	**Forecast**				
	2020	2021	2022	2023	2024
Number of productive trees (000)	674.665	636.147	599.865	577.309	558.342
LCL	531.456	428.345	334.015	253.258	180.004
UCL	817.873	843.948	865.715	901.359	936.680
SE	71.4302	103.6480	132.6016	161.6311	188.7088
Production (t)	14047.21	14210.14	14272.90	14318.21	14360.49
LCL	4761.031	4567.717	4326.209	4082.703	3845.167
UCL	23333.39	23852.56	24219.59	24553.73	24875.81
SE	4633.719	4811.479	4963.308	5107.426	5247.048

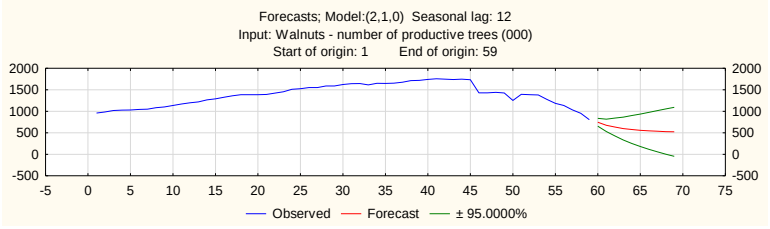


Figure 19. The forecast the number of productive walnut trees (000)

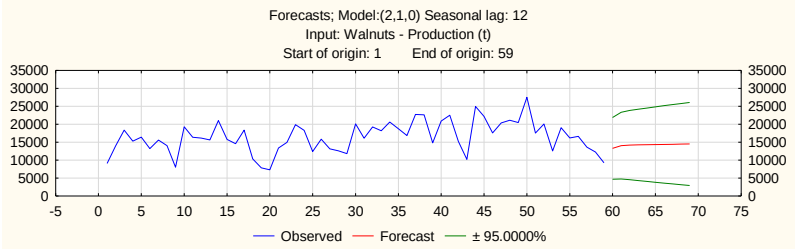


Figure 20. The forecast the total volume of walnut production (tonnes)

Utility value of walnuts - walnut meats contain oils (about 62%), proteins (about 16%), carbohydrates (about 12%), cellulose (about 2.5%) and essential minerals (about 1.5%). The energy value of walnut meats approximates to 2,947 kJ (of which proteins, oils and carbohydrates account for 272 kJ, 2.437 kJ and 238 kJ, respectively). With a yield of 5 t/ha and a kernel percentage of 50%, a total of 1.5 t/ha of walnut oil can be produced *(Milić, Radojević, 2003)*. Walnut oil is of higher quality than sunflower oil provided it is obtained by cold-pressing, a process which preserves all the vitamins found in walnut meats (especially considerable amounts of vitamin E). It is both edible and widely applicable in the pharmaceutical industry. Furthermore, walnut cake, remaining after oil pressing, is an excellent source of proteins.

Walnut meats are used for fresh consumption, drying and processing *(Milić, Radojević, 2003)*. In addition to meats (extensively used in the confectionery industry), other parts of the walnut tree such as green fruits, shell, bark and especially wood have a significant utility value. Walnut leaves and bark are used in the textile and beauty industries for their colouring properties. Tannins can be extracted from walnut bark, whereas young leaves are used for obtaining ascorbic acid and producing aromatic oils and medications. Walnut flowers and young fruits are used in the production of various medications, liqueurs and brandies. Walnut wood has long been one of the most valuable hardwoods particularly in the furniture and military industries. It is 2-3 times as expensive as mahogany wood. Walnut wood carvings are highly valued in art and furniture markets due to their appealing colour, firmness and longevity.

3.1.9. Analysis and forecast of strawberry production

In the period 1960-2018, the (productive) strawberry area in Serbia averaged 6,388 ha, indicating a slightly increasing trend (Table 67). The productive strawberry area in Central Serbia and Vojvodina increased at average annual rates of change of 0.71% and 0.68%, respectively. The share of Vojvodina in the total productive strawberry area in Serbia averaged 8.07% in the period under consideration.

Observed over shorter periods of time, the productive strawberry area in Serbia increased from 5,191 ha (in the period 1960-1979) to 7,555 ha (in the period 1980-1999), followed by a decrease to 6,421 ha in the period 2000-2018. The share of Vojvodina in the productive strawberry area in Serbia increased at an average annual rate of change of 3.91% in the final subperiod under consideration.

Table 67. Productive strawberry area in Serbia in the period 1960-2018

Indicators	Productive area (ha)			Share of Vojvodina in the productive strawberry area in Serbia (%)
	Serbia	Central Serbia	Vojvodina	
Average 1960-2018	6,388	5,885	503	8.07
Min.	2,929	2,657	247	5.42
Max.	9,116	8,565	894	12.67
Annual Rate of Change (%)	0.71	0.71	0.68	-0.03
Coefficient of Variation (%)	26.10	26.88	24.71	18.72
Average 1960-1979	5,191	4,777	414	8.22
Min.	2,929	2,657	247	6.83
Max.	8,261	7,690	571	10.89
Annual Rate of Change (%)	5.85	6.03	4.04	-1.71
Coefficient of Variation (%)	32.71	33.51	24.51	13.45
Average 1980-1999	7,555	6,974	581	7.75
Min.	6,311	5,725	464	6.29
Max.	8,743	8,115	665	9.50
Annual Rate of Change (%)	0.16	0.23	-0.72	-0.87
Coefficient of Variation (%)	9.26	10.00	7.92	12.23
Average 2000-2018	6,421	5,906	515	8.24
Min.	4,926	4,443	324	5.42
Max.	9,116	8,565	894	12.67
Annual Rate of Change (%)	-2.39	-2.74	1.42	3.91
Coefficient of Variation (%)	23.58	24.91	28.06	26.98

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

In the period 1981-2011, the actual strawberry production in Serbia averaged 26,195 t, with annual variations ranging from 9,730 t in 1960 to 39,707 t (an annual variation difference of 29,977 t (Table 68)). The rates of change computed indicate a growing trend in the total Serbian

strawberry production throughout the entire period under consideration. The actual strawberry production in Central Serbia and Vojvodina increased at average annual rates of change of 1.50% and 1.20%, respectively. The share of Vojvodina in the total strawberry production in Serbia averaged 5.99% in the period under consideration.

Table 68. Trends in the strawberry production in Serbia in the period 1960-2018

Indicators	Production (t)			Share of Vojvodina in the total strawberry production in Serbia (%)
	Serbia	Central Serbia	Vojvodina	
Average 1960-2018	26,195	24,744	1,451	5.99
Min.	9,730	5,580	646	2.16
Max.	39,707	38,149	3,424	12.02
Annual Rate of Change (%)	1.49	1.50	1.20	-0.29
Coefficient of Variation (%)	31.20	32.27	37.06	39.94
Average 1960-1979	19,387	18,246	1,141	6.74
Min.	6,330	5,580	670	3.64
Max.	33,400	32,184	1,710	12.02
Annual Rate of Change (%)	8.31	8.73	3.01	-4.90
Coefficient of Variation (%)	44.96	46.56	26.20	37.21
Average 1980-1999	28,830	27,384	1,446	5.11
Min.	20,004	18,653	1,132	3.92
Max.	39,707	38,149	1,964	6.94
Annual Rate of Change (%)	-0.83	-0.82	-1.03	-0.20
Coefficient of Variation (%)	18.50	19.06	13.17	15.48
Average 2000-2018	30,590	28,806	1,784	6.14
Min.	21,735	19,518	646	2.16
Max.	37,924	36,091	3,424	11.37
Annual Rate of Change (%)	-1.60	-2.15	7.81	9.57
Coefficient of Variation (%)	16.48	18.49	42.55	50.65

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Observed over shorter periods of time, the total strawberry production in Serbia increased from 19,387 t (in the period 1960-1979) to 28,830 t (in the period 1980-1999, or to 30,590 t in the final subperiod under consideration. In the period 2000-2018, the share of Vojvodina in the total Serbian strawberry production increased at an average annual rate of change of 9.57%.

The productive strawberry area in Serbia increased by 3,870 ha in 2018 (an index of 228), compared to the base year of 1960 (Table 69). However, the productive strawberry area in Vojvodina increased about threefold in 2018 over that recorded in 1960.

Table 69. Productive strawberry area in Serbia in the years considered

Year	**Productive area (ha)**	
	Serbia	**Vojvodina**
1960	3,022	329
2018	6,892	863
Index 1960=100	*228.06*	*262.31*

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

With an actual production of 21,735 t, strawberries accounted for 1.62% of the total fruit production in Serbia in 2018 (Table 70). The Serbian strawberry production increased by approximately 12,000 t in 2018, or by 223 index points, compared to the base year of 1960.

Table 70. Strawberry production in Serbia in the years considered (t)

Year	**Serbia**		
	Strawberries	**Other fruit species**	**Total**
1960			
Production (t)	9,730	280,400	290,130
- Share (%)	3.35	96.65	100.00
2018			
Production (t)	21,735	1,315,947	1,337,682
Index 1980=100	*223.38*	*469.31*	*461.06*
- Share (%)	1.62	98.38	100.00
Index 1980=100	*48.36*	*101.79*	/

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

The share of strawberries in the Serbian fruit production structure decreased by 52% in 2018 from that recorded in 1960.

Strawberries accounted for 0.81% of the total fruit production in Vojvodina in 2018 (Table 71). The strawberry production in Vojvodina increased by 70% in 2018 compared to the base year of 1960. The share of strawberries in the Vojvodinian fruit production structure decreased by 54% in 2018 from that recorded in 1960.

Table 71. Strawberry production in Vojvodina in the years considered (t)

Year	**Vojvodina**		
	Strawberries	**Other fruit species**	**Total**
1960			
Production (t)	1,170	65,520	66,690
- Share (%)	1.75	98.25	100.00
2018			
Production (t)	2,217	270,068	272,285
Index 1980=100	*189.49*	*412.19*	*408.28*
- Share (%)	0.81	99.19	100.00
Index 1980=100	*46.29*	*100.96*	/

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Forecast of strawberry production in Serbia - the forecast trend values of the distribution of productive strawberry area in Serbia (obtained using the ARIMA model shown in Table 72) indicate a slight annual increase throughout the entire forecast period. At the end of the forecast period, the productive strawberry area in Serbia will approximate to 7,000 ha (Table 73 and Figure 21).

Table 72. Models for forecasting the distribution of productive strawberry area and the volume of strawberry production in Serbia

ARIMA Model Parameters		**Strawberries**		
		Productive area		**Production**
Model		(1,1,0)		(1,1,0)
MS Residual		2799E2		1859E4
Parameters		Constant	p(1)	p(1)
Param.		66.72097	0.33314	-0.405425
SE		103.9955	0.12735	0.127944
t		0.641576	2.615911	-3.168776
p		0.523766	0.011417	0.002481
Confidence interval (95%)	Lower	-141.6070	0.07802	-0.661727
	Upper	275.0489	0.58825	-0.149123

Productive strawberry area in Serbia - Residuals

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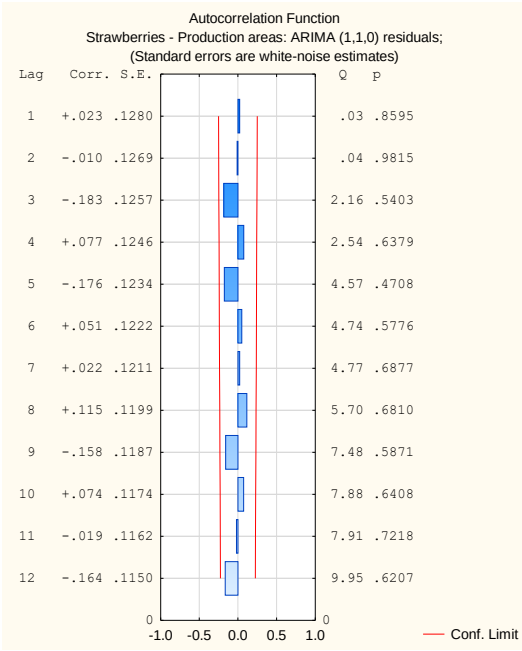

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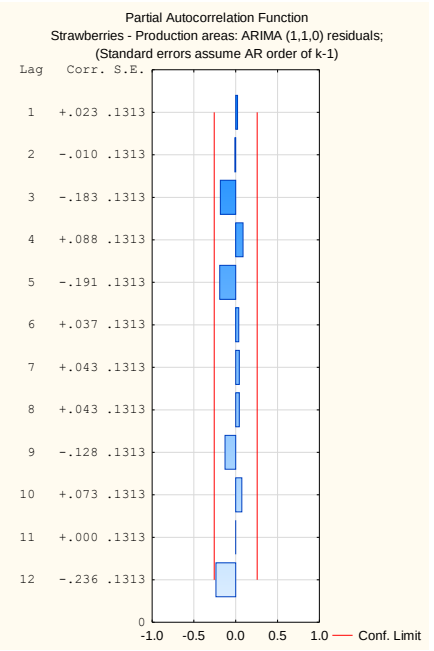
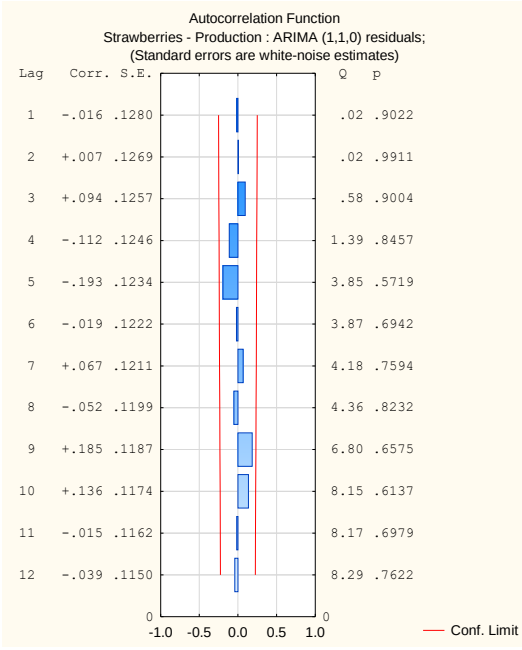


Total volume of strawberry production - Residuals:

ACF



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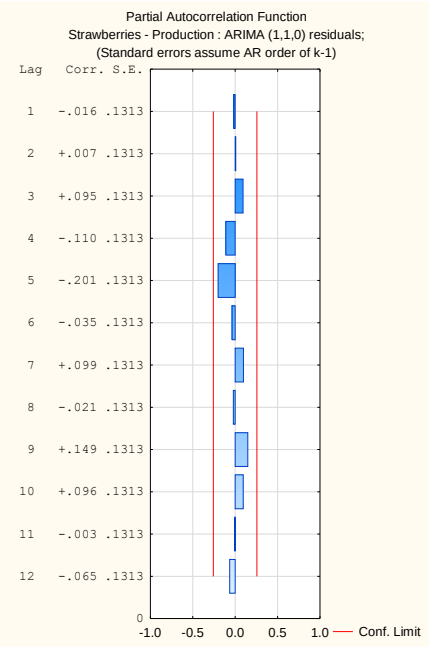


The forecast trend values of strawberry production in Serbia indicate an annual increase throughout the entire forecast period. At the end of the forecast period, the expected strawberry production in Serbia will approximate to 26,000 t (Table 73 and Figure 22).

Table 73. Forecast of trends in the total strawberry production and the distribution of productive strawberry area in Serbia (2019-2023)

Strawberries	**Forecast**				
	2019	2020	2021	2022	2023
Production areas (ha)	6923.86	6982.13	7046.03	7111.81	7178.22
LCL	5449.33	5030.99	4695.65	4415.46	4173.90
UCL	8398.40	8933.26	9396.41	9808.16	10182.54
SE	881.623	1166.582	1405.289	1612.146	1796.281
Production (t)	24309.46	25132.21	25147.70	25490.48	25700.56
LCL	15919.27	15114.61	13954.87	13153.93	12348.11
UCL	32699.66	35149.82	36340.54	37827.02	39053.00
SE	5016.49	5989.52	6692.19	7376.01	7983.42

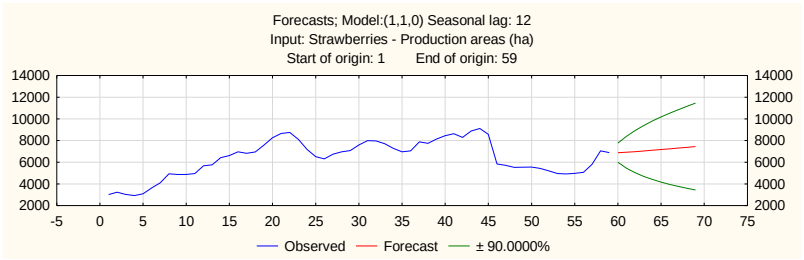


Figure 21. Forecast of the productive strawberry area in Serbia (ha)

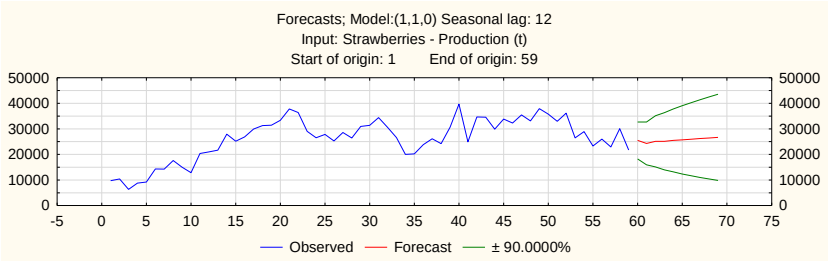


Figure 22. Forecast of the total strawberry production in Serbia (tonnes)

Utility value of strawberries - strawberries mostly contain carbohydrates (of which sugars predominate accounting for 7%), proteins (about 0.8%) and fats (about 0.6%). They have a relatively low energy

value of 170 kJ/100 g despite a high sugar content of the fruit's dry matter. In addition to vitamins (namely vitamin C (60 mg), vitamin B_1 (0.03 mg), vitamin B_2 (0.05 mg) and vitamin PP (about 0.4 mg/100g)), strawberries contain acids (1%), minerals (0.7%), pectins (6.5%) and tannins (about 0.3%). They are a source of essential minerals such as potassium, calcium, phosphorus, magnesium, iron, etc. *(Ljubosavljević, 1990)*.

In addition to fresh consumption, strawberries are used for both domestic and industrial processing. The following semi-processed and finished strawberry products are considered most important: pulps, purees, fresh (natural) juices, jellies, thin preserves, pulpy juices, syrups and compotes. Strawberries have numerous applications in the bakery industry (namely pie, cake and cream production), the dairy industry (namely yoghurt, ice cream and strawberry-flavoured drink production) and the confectionery industry.

Intensely-coloured and aromatic strawberries, with a balanced acid content and easily removable stems and leaves, are the most suitable for processing. Strawberries for compotes, thin preserves, freezing and drying should be red, firm, medium- and even-sized, fine-textured and fleshy. Strawberries for juices should be dark-coloured and fine-textured with pleasant aroma and high sugar contents. However, strawberries with white juicy flesh and low acid contents are not suitable for processing.

Strawberries for freezing should be firm enough to retain their quality after defreezing. Frozen strawberries for fresh consumption should be dark red, firm, fleshy, medium acid to acid, and aromatic. *Keserović et al. (2008)* recommend the following strawberry cultivars for different processing procedures (especially freezing): 'Senga Sengana', 'Polka', 'Pocahontas' and 'Belrubi'.

3.1.10. Analysis and forecast of raspberry production

In the period 1981-2011, the (productive) raspberry area in Serbia averaged 9.308 ha (Table 74). The productive raspberry area in Central Serbia and Vojvodina increased at average annual rates of change of 3.10% and 4.85%, respectively. The share of Vojvodina in the total productive raspberry area in Serbia increased at an average annual rate of change of 1.66% in the period under consideration.

Observed over shorter periods of time, the distribution of productive raspberry area in Serbia indicates a growing trend, with the largest increase recorded in the period 1980-1999 (at an average annual rate of

change of 5.43%). The share of Vojvodina in the total productive raspberry area in Serbia increased from 1.82% (in the period 1960-1979) to 3.24% (in the period 2000-2018).

Table 74. Productive raspberry area in Serbia in the period 1960-2018

Indicators	Productive area (ha)			Share of Vojvodina in the productive raspberry area in Serbia (%)
	Serbia	Central Serbia	Vojvodina	
Average 1960-2018	9,308	9,027	281	2.73
Min.	2,236	2,204	32	0.82
Max.	22,654	21,406	1,248	5.51
Annual Rate of Change (%)	3.14	3.10	4.85	1.66
Coefficient of Variation (%)	52.76	52.10	82.62	36.19
Average 1960-1979	4,545	4,463	82	1.82
Min.	2,236	2,204	32	0.82
Max.	5,980	5,931	156	3.52
Annual Rate of Change (%)	3.87	3.77	8.55	4.51
Coefficient of Variation (%)	28.38	28.48	47.50	38.40
Average 1980-1999	9,052	8,776	276	3.16
Min.	5,193	5,041	152	2.23
Max.	12,996	12,706	357	4.08
Annual Rate of Change (%)	5.43	5.49	3.36	-1.96
Coefficient of Variation (%)	30.69	31.08	21.77	16.37
Average 2000-2018	14,590	14,095	495	3.24
Min.	11,049	10,759	268	2.08
Max.	22,654	21,406	1,248	5.51
Annual Rate of Change (%)	1.77	1.61	6.79	4.93
Coefficient of Variation (%)	24.79	23.94	55.69	30.05

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

In the period 1960- 2018, the actual raspberry production in Serbia averaged 46,325 t, with annual variations ranging from 5,050 t in 1963 to 127,010 t in 2018 (a coefficient of variation of 72.26%). The total raspberry production in Serbia increased at an average annual rate of change of 5.10% due to the increased raspberry production in both Central Serbia (at an average annual rate of change of 5.05%) and Vojvodina (at an average annual rate of change of 7.22%). The share of Vojvodina in the total raspberry production in Serbia averaged 1.67% in the period under consideration.

Observed over shorter periods of time, the total raspberry production in Serbia increased from 12,729 t (in the period 1960-1979) to 40,980 t (in the period 1980-1999), or to 87,314 t in the period 2000-2018 (Table 75). The share of Vojvodina in the total Serbian raspberry production increased at an average annual rate of change of 15.87% in the final subperiod under consideration.

Table 75. Trends in the raspberry production in Serbia in the period 1960-2018

Indicators	**Production (t)**			**Share of Vojvodina in the total raspberry production in Serbia (%)**
	Serbia	**Central Serbia**	**Vojvodina**	
1	2	3	4	5
Average 1960-2018	46,325	45,313	1,012	1.67
Min.	5,050	5,000	40	0.36
Max.	127,010	118,330	8,680	6.83
Annual Rate of Change (%)	5.10	5.05	7.22	2.02
Coefficient of Variation (%)	72.26	71.30	165.68	81.58
Average 1960-1979	12,729	12,610	119	0.99
Min.	5,050	5,000	40	0.36
Max.	18,220	18,090	220	1.71
Annual Rate of Change (%)	4.76	4.73	8.19	3.28
Coefficient of Variation (%)	34.37	34.54	49.07	43.68

1	2	3	4	5
Average 1980-1999	40,980	40,359	621	1.61
Min.	17,432	17,047	265	0.94
Max.	64,680	63,963	988	2.23
Annual Rate of Change (%)	6.64	6.66	5.17	-1.38
Coefficient of Variation (%)	38.97	39.25	32.41	25.72
Average 2000-2018	87,314	84,952	2,362	2.45
Min.	55,999	55,530	310	0.39
Max.	127,010	118,330	8,680	6.83
Annual Rate of Change (%)	2.05	1.70	18.25	15.87
Coefficient of Variation (%)	18.54	16.83	103.90	86.05

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

In 2018, the productive raspberry area in Serbia and Vojvodina totalled 22,654 ha and 1,248 ha, respectively (Table 76). The productive raspberry area in Serbia increased by 20,418 ha in 2018, or by 1,013 index points, compared to the base year of 1960. The productive raspberry area in Vojvodina increased by 1,216 ha in 2018, or by 3,900 index points, over that recorded in 1960.

Table 76. Productive raspberry area in Serbia in the years considered (ha)

Year	**Productive area (ha)**	
	Serbia	**Vojvodina**
1960	2,236	32
2018	22,654	1,248
Index 1960=100	*1013.15*	*3900.00*

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

With an actual production of 127,010 t, raspberries accounted for 9.49% of the total Serbian fruit production in 2018 (Table 77). The raspberry production in Serbia increased by 121,270 t in 2018, or by 2,213 index points, compared to the base year of 1960. The share of raspberries in the Serbian fruit production structure increased by 479 index points in 2018 over that recorded in 1960.

Table 77. Raspberry production in Serbia in the years considered (t)

Year	Serbia		
	Raspberries	**Other fruit species**	**Total**
1960			
Production (t)	5,740	284,390	290,130
- Share (%)	1.98	98.02	100.00
2018			
Production (t)	127,010	1,210,672	1,337,682
Index 1980=100	*2,212.72*	*425.71*	*461.06*
- Share (%)	9.49	90.51	100.00
Index 1980=100	*479.29*	*92.34*	/

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

With an actual production of 8,680 t, raspberries claimed a 3.19% share in the Vojvodinian fruit production structure in 2018. The raspberry production in Vojvodina increased by 8,620 t in 2018, or by 14,466 index points, over that recorded in the base year of 1960. The share of raspberries in the Vojvodinian fruit production structure increased by 3,544 index points in 2018 compared to 1960, thus representing the largest increase of all the fruit corps considered.

Table 78. Raspberry production in Vojvodina in the years considered (t)

Year	Vojvodina		
	Raspberries	**Other fruit species**	**Total**
1960			
Production (t)	60	66,630	66,690
- Share (%)	0.09	99.91	100.00
2018			
Production (t)	8,680	263,605	272,285
Index 1980=100	*14,466.67*	*395.63*	*408.28*
- Share (%)	3.19	96.81	100.00
Index 1980=100	*3,544.44*	*96.90*	/

Source: Calculation based on the data obtained from the Statistical Office of the Republic of Serbia.

Forecast of raspberry production in Serbia - the forecast model employed (Table 79) indicates that the current year's value is greatly affected by the previous year's value. The forecast trend values of the

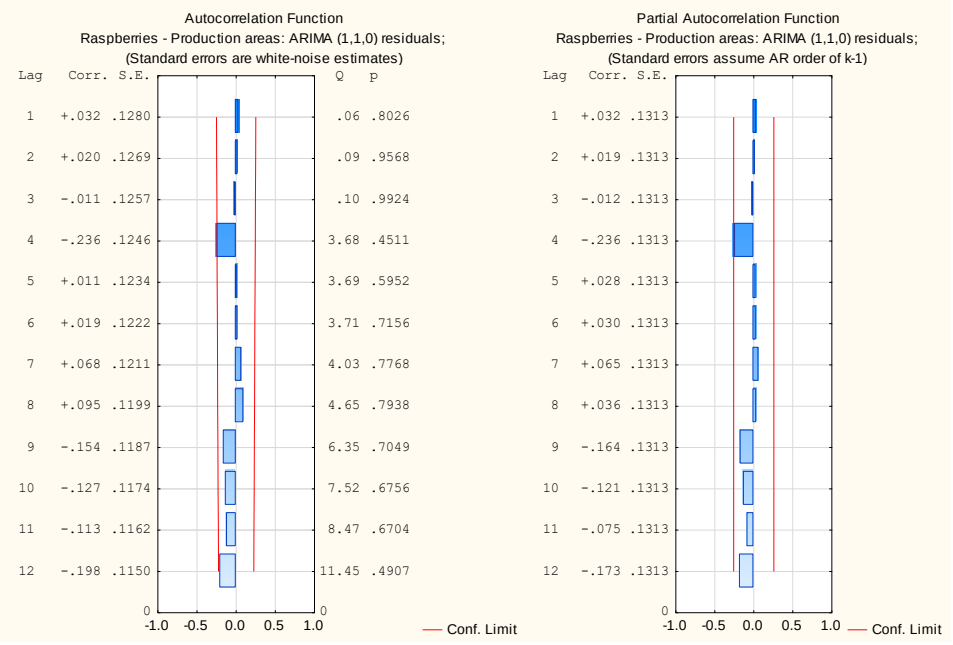
distribution of productive raspberry area in Serbia suggest an annual increase throughout the entire forecast period (Table 80 and Figure 23). At the end of the forecast period, the productive raspberry area in Serbia will approximate to 26,000 ha, representing an increase of about 24,000 ha (or about 90%) compared to 1960 and an increase of about 17,000 ha (or about 60%) over the average raspberry area in Serbia in the period 1960-2018.

Table 79. Models for forecasting the distribution of productive raspberry area and the volume of raspberry production in Serbia

ARIMA Model Parameters		**Raspberries**			
		Number of productive trees		**Production**	
Model		(1,1,0)		(1,1,0)	
MS Residual		4386E2		7149E4	
Parameters		Constant	p(1)	Constant	p(1)
Param.		409.7462	0.57132	2054.7487	-0.19074
SE		197.7105	0.11298	943.4633	0.13640
t		2.07246	5.05676	2.17788	-1.39831
p		0.042923	0.000005	0.03364	0.16753
Confidence interval (95%)	Lower	13.5254	0.34490	164.7647	-0.46399
	Upper	805.9669	0.79775	3944.7327	0.08251

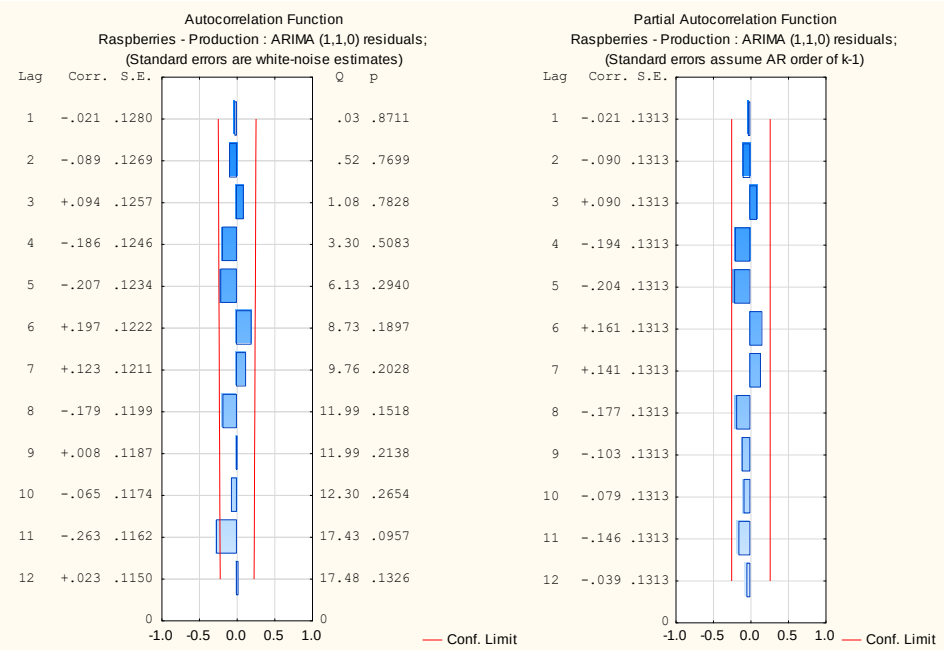
Productive raspberry area in Serbia - Residuals:

ACF PACF



Total raspberry production in Serbia - Residuals:

ACF PACF



The forecast trend values of the raspberry production in Serbia indicate an annual increase throughout the entire forecast period (2019-2023). By the end of 2013, the expected raspberry production in Serbia will approximate to 140,000 t (Table 80).

Table 80. Forecast of trends in the raspberry production and the distribution of productive raspberry area in Serbia in the period 2019-2023

Raspberries	**Forecast**				
	2019	2020	2021	2022	2023
Production areas (ha)	23817.55	24298.77	24749.35	25182.43	25605.50
LCL	21345.53	20769.62	20265.27	19838.13	19482.41
UCL	26289.57	27827.92	29233.43	30526.72	31728.59
SE	1233.516	1761.014	2237.517	2666.752	3055.366
Production (t)	128771.2	130720.4	132795.3	134846.2	136901.7
LCL	106982.5	104645.6	103102.0	101920.2	101034.8
UCL	150560.0	156795.3	162488.6	167772.2	172768.6
SE	10876.75	13016.32	14822.62	16436.38	17904.43

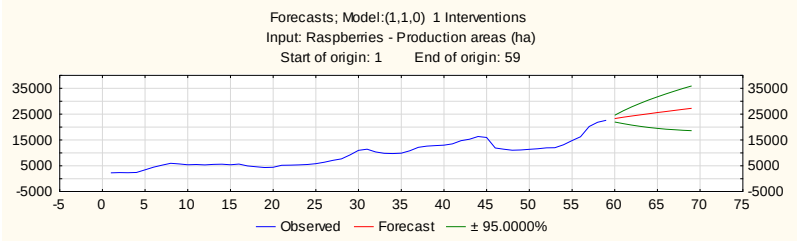


Figure 23. Forecast of trends in the distribution of raspberry area in Serbia (ha)

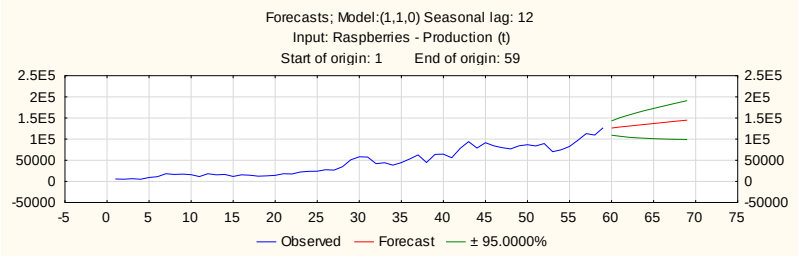


Figure 24. Forecast of the total raspberry production in Serbia (tonnes)

Utility value of raspberries - raspberries mostly contain carbohydrates (namely glucose, fructose (jointly accounting for about 2-7%) and sucrose (about 0.1-2%)), proteins (about 1%) and fats (about 0.6%). They have a relatively low energy value of 167 kJ/100 g. In addition to vitamins (mostly vitamin C (13-20 mg/100 g) and, in smaller amounts, vitamin B_1, vitamin B_2 and vitamin PP), raspberries also contain considerable amounts of aromatic compounds and essential minerals such as potassium, calcium, phosphorus and iron *(Ljubosavljević, 1990)*. They are usually frozen or semi-processed immediately after harvest (using special procedures), whereas only a small portion of raspberries produced are consumed fresh.

Raspberries have a great utility value due to their many uses such as fresh consumption ('Willamette', 'Miker', 'Gradina' and 'Malling Exploit'), freezing ('Willamette' and 'Miker') and processing ('Willamette', 'Malling Exploit', 'Miker' and 'Gradina').

Over the past decades, a share exceeding 90% of the total raspberry production in Serbia has been frozen (in cold storages) or semi-processed (namely rolend raspberries, raspberry groats and block raspberries). A 7-8% share of mostly second-class raspberries has been processed in hot processing facilities, whereas only 2-3% of raspberries produced have been used fresh or processed for both domestic and industrial purposes

(such as flavouring sweets and chocolates in the hospitality and confectionery industries, etc.) *(Petrović, Milošević, 2002)*.

Raspberries can be processed into a vast array of products such as concentrates, juices, syrups, compotes, jams, thin preserves, wines, liqueurs, brandies, powders, etc. All cultivated and edible wild varieties of raspberries can be used for hot and cold processing. However, there are significant varietal differences relative to their suitability for different uses and processing procedures.

Raspberry cultivars can be divided into three groups according to their suitability for different processing procedures:

- raspberry cultivars for deep-freezing (namely 'Norfolk Giant', 'Willamette', 'Scina', 'Lloyd George', 'Malling Exploit', 'Malling Jewel', 'Malling Promise' and 'Podgorina'),
- raspberry cultivars for juices, concentrates, syrups and jams (namely intensely-coloured and aromatic raspberry cultivars such as 'Norfolk Giant' and 'Lloyd George', as well as some raspberry cultivars indigenous to Serbia such as 'Jelička', 'Valjevka', 'Kopaoničanka', 'Zaječarka', etc.),
- raspberry cultivars for compotes and thin preserves (namely 'Norfolk Giant', 'Willamette', 'Scina', 'Lloyd George', 'Malling Exploit', 'Malling Jewel', 'Malling Promise' and 'Podgorina', which retain their distinctive colour and aroma after hot processing (e.g. blanching)).

Raspberries are usually frozen, concentrated or dried *(Zornić et al., 2003)*. The following industrially processed raspberry products are considered most important:

1. Frozen block red raspberries are block raspberries frozen in their own juice with or without added sugar. The original product contains no sugars or sweeteners, and is usually placed in plastic or metal packaging.
2. Individually frozen raspberries are frozen by flash-freezing at temperatures from - 20 ^{0}C to - 25 ^{0}C using tunnel freezers. Only whole raspberry fruits are suitable for this procedure, which ultimately preserves their original and individual shape. Individually frozen raspberries are usually placed in plastic bags or fibreboard boxes, and marketed as fresh frozen raspberries.
3. Raspberry concentrates are obtained by removing most of the water from fresh raspberry juice through filtration, extraction and evaporation processes. Owing to their different sugar and

dry matter contents, raspberry concentrates are mostly used for producing purees, puree concentrates, juices and concentrated juices.

4. Frozen raspberry puree is made by freezing pasteurized raspberries. Prior to pasteurization, raspberries are sorted and inspected for quality. Concentrated raspberry purees are also produced.
5. Raspberry puree ice cubes are made by a straightforward and speedy process in which raspberries are crushed, pressed into a thin layer and flash-frozen at temperatures from - 20 ^{0}C to - 23 ^{0}C. Flash-freezing procedures result in small (raspberry puree) ice cubes of even size.
6. Dried and semi-dried raspberries are produced either by air-drying or by freeze-drying (which is considered a novel drying technology). Fruits preserved by air- or freeze-drying are often referred to as concentrated frozen fruits because they are first dried, to reach the dry matter content 2 to 3 times as high as that of fresh fruits, and then frozen.

Raspberries have numerous applications in the bakery industry (namely whole wheat bread and dessert production), the dairy industry (namely yoghurt, ice cream and raspberry-flavoured drink production) and the confectionery industry (namely sweets and chocolate production). They are processed into jams, jellies, candied fruits, syrups, liqueurs, sauces, dessert dressings, fruit salads, etc.

Raspberries are also used for domestic purposes in Serbia, i.e. the production of homemade thin preserves, jams, purees, pastas, *pekmez* preserves, marmalades, jellies, juices, compotes, dried raspberries, non-alcoholic and alcoholic beverages, vinegars, etc.

4. FRUIT PROCESSING

As a source of many essential nutrients, fruits are best consumed fresh, i.e. used for table purposes. However, owing to their perishability (a direct consequence of their high water contents) and a fairly limited shelf life, fruits are usually preserved by processing.

In contrast to fruits for fresh consumption (which should be at optimum ripeness when consumed), fruits for processing can be of different sizes and shapes, and in various stages of ripeness.

According to the Rulebook on the Quality of Fruit, Vegetable and Mushroom Products and Pectin Preparations, fruits for processing should meet the following quality criteria:

- fruits should be fresh and healthy,
- fruits should be harvested at technological maturity,
- fruits should not have unusual flavours or aromas,
- fruits should not contain any impurities,
- fruits should not contain residues of plant protection agents exceeding the maximum levels permitted by law.

The minimum dry matter (DM) content has been established for specific fruit crops:

- strawberries 6%
- raspberries, blueberries and gooseberries 7%
- blackberries and lemons 8%
- quinces, peaches, mandarins, sweet cherries 9%
- apples, pears, apricots 10%

Fruits for processing are classified according to their suitability for different processing procedures (which essentially determines the quality of semi-processed and processed fruit products):

- Fruits for compotes include fruits of exceptional and/or first-class quality, at a maturity stage of 85-95%, without stems or surface damage. Such fruits are sorted by size and colour, allowing only minor deviations from the quality criteria stated above.
- Fruits for freezing comprise fruits of exceptional and/or first-class quality, at a maturity stage of 80-90%, without stems or surface damage. Only 3-4% of the fruits frozen can slightly deviate from the quality criteria stated above.

- Fruits for jams comprise fruits of first- and second-class quality with minor skin damage (such as cracks) except rot. These fruits can be of irregular size and in different stages of maturity.
- Fruits for *pekmez* preserves include fruits of first- and second-class quality with different sizes, colours, maturity stages and damage amounts. However, worm-infested fruits and fruits containing impurities of any sort cannot be used for this purpose.
- Fruits for purees comprise fruits of first- and second-class quality with different sizes, colours, maturity stages and damage amounts (permitting slight mechanical damage). These fruits can even show signs of physiological damage such as fruit spots, but cannot be decayed, virus-infected or ill-preserved, i.e. in the process of fermentation caused by unfavourable storage conditions.
- Fruits for juices, concentrates and marmalades include fruits of first- and second-class quality with different sizes, maturity stages and damage amounts. Fruit spots and some other imperfections are allowed provided the quality of final products remains unaffected. Moreover, fruits showing signs of decay, or poor storage and transportation, cannot be used for this purpose.

The selection of fruit cultivars is of paramount importance to fruit processing and the quality of final products. Fruit cultivars yielding intensely and even-coloured fruits of superior flavour and desirable size are considered most suitable for processing (Table 81).

Table 81. Most important fruit cultivars for processing

Fruit species	Cultivar	Use
1	2	3
Apples (*Pyrus malus*)	‘Budimka’ ‘Delicious’ ‘Kolačara’	Clear juices, compotes, marmalades, purees, jellies, concentrates, dried apple products
Pears (*Pyrus communis*)	‘Williams Christ Birne – Bartlett’ ‘Beure Bosc.’ ‘‘Cure’ ‘Passe Crassane’	Dried pear products, compotes, jams, pulpy juices, clear juices, *pekmez* preserves, thin preserves

1	2	3
Plums (*Prunus domestica*)	'Požegača' 'Agen 707' 'Stanley' 'Valjevka' 'Althanova – Procharzova Renkloda'	Dried plum products, compotes, jams, pulpy juices, clear juices, *pekmez* preserves, thin preserves, candied plum products
Sour cherries (*Prunus cerasus*)	'Heimanns Konservenweichel' 'Montmorency' 'Rexelle' 'Spaniche Glakirsche' 'Kelleriis 14' 'Čačanski rubin'	Clear juices, pulpy juices, concentrates, jams, marmalades, compotes, thin preserves, jellies, frozen sour cherry products, candied sour cherry products
Apricots (*Prunus armeniaca*)	'Magiar Kajszi' 'Kecskei Rozsa' 'Luiset' 'Royal' 'Breda' 'Stark Early Orange'	Pulpy juices, compotes, jams, marmalades, dried apricot products, frozen apricot products, candied apricot products
Peaches (*Persica vulgaris*, *Prunus persica*)	'Redhaven' 'Regina' 'Halehaven' 'Redtop' 'Elberta' 'Cresthaven' 'J. H. Hale' 'Fayette'	Pulpy juices, compotes, jams, marmalades, pasteurized pulps, frozen peach products, candied peach products
Strawberries (*Fragaria ananasa*)	'Senga Sengana' 'Wadenswil 8' 'Villamette' 'Tardiva di Romagnia' 'Gorella'	Compotes, clear juices, pulpy juices, syrups, jellies, jams, marmalades, frozen strawberry products
Raspberries (*Rubus ideaeus*)	'Malling Promise' 'Malling Exploit' 'Valjevka' 'Gradina' 'Podgorina'	Pulpy juices, clear juices, frozen raspberry products, concentrates, jellies, syrups

(Source: Niketić Aleksić, 1989; Lukač Bulatović, 2014)

The consumption of basic raw materials in fruit processing depends on the type and quality of basic raw materials, processing procedures and packaging methods (Tables 82 and 83).

Table 82. Consumption of basic raw materials in compote production

Compote	Unit of mass	Per 1,000 units of production			
		Jar		Can	
		0.370	0.720	1/1	5/1
Plum compote with stones					
Fresh plums	kg	260	504	700	3,500
Apricot halves compote					
Fresh apricots	kg	275	540	750	3,750
Sour cherry compote with stones					
Fresh sour cherries	kg	300	580	800	4,000
Pitted sour cherry compote					
Fresh sour cherries	kg	388	756	1,050	5,250
Peach halves compote					
Fresh peaches	kg	385	750	1,040	5,200
Pear compote					
Fresh pears	kg	5,100	1,000	1,380	6,900

a) *(Source: Niketić Aleksić, 1989; Lukač Bulatović, 2014)*

Table 83. Consumption of basic raw materials in frozen fruit production

Frozen fruits	Unit of mass	Per 1,000 kg of production
Frozen strawberries		
Fresh strawberries	kg	1,160
Frozen raspberries		
Fresh raspberries	kg	1,080
Frozen sour cherries with stones		
Fresh sour cherries	kg	1,090
Frozen plum halves		
Fresh plums	kg	1,250
Frozen blueberries		
Fresh blueberries	kg	1,065

(Source: Niketić Aleksić, 1989; Lukač Bulatović, 2014)

Fruits can be semi-processed (and used for further processing) or processed (into finished products). Therefore, there are two types of fruit

products: semi-processed and processed (or finished) fruit products. Semi-processed fruit products include semi-processed and canned fruits suitable for further processing throughout the entire year, i.e. in and out of season *(Milić, Radojević, 2002)*. To maintain a continuous production of certain fruit products (such as jellies, pulps, purees, concentrated juices, fresh juices, frozen fruits, etc.), harvested fruits should be prepared for preservation, preserved by chemical, hot or cold processing, and stored under favourable conditions until the final production process.

1. Fruit puree is a semi-processed fruit product made by mashing fresh fruits and/or fruit pulps. It is commonly preserved by pasteurization or freezing. Chemically preserved fruit purees are widely used in marmalade production (mostly from pome fruits), whereas frozen fruit puree blocks are used in pulpy juice production.
2. Pulp is a semi-processed fruit product containing whole fruits or pieces of fruit preserved by pasteurization or chemical preservation (with a 90:10 ratio between fruits and preservative solution utilized). Pulps can be made from all fruit crops, but stone and berry fruits are mostly favoured in pulp production. Fruit pulps preserved by formic acid are suitable for processing into juices and syrups, whereas fruit pulps preserved by sulphuric acid or sulphur dioxide can be used in jam and marmalade production. The quality of fruit pulps is assessed by their dry matter content, preservative content, ratio between fruits and preservative solution, and preservation of the genuine fruit colour, aroma and appearance.
3. Raw fruit juice is semi-processed fruit juice preserved by chemicals. It is obtained by pressing fresh fruits, frozen fruits or canned fruit pulps (usually using raspberries, blackberries, strawberries and sour cherries). Raw fruit juice is suitable for processing into syrups, concentrated juices and jellies. Pure fruit juice (or 100% fruit juice) is a semi-processed fruit product made by pressing fresh and/or frozen fruits, subsequently preserved by pasteurization. It has far greater application in clear and cloudy juice production than raw fruit juice. Pure fruit juice is commonly made from pome, berry and small stone fruits (namely sweet and sour cherries). In contrast to raw fruit juice (which is preserved by adding preservatives), pure fruit juice is preserved by physical means, i.e. pasteurization.

4. Concentrated fruit juice is a semi-processed fruit product made by removing some of the water from fruit juice, pure fruit juice or juice puree. It is preserved solely by physical means. Concentrated fruit juice can be clear, cloudy or pulpy. All fruit crops containing flavonoids (namely anthocyanins, flavones and flavonols) are suitable for clear concentrated juice production: apples, grapes, sour cherries, blackberries, strawberries and blueberries.

According to the rate of freezing, *Vračar (2001)* argues that frozen fruits can be produced using the following cold processing procedures:

- freezing (a process of freezing at a rate exceeding 1 h),
- flash-freezing (a process of freezing at rates from 10 to 60 min),
- instant-freezing (a process of freezing at a rate less than 10 min).

Nowadays, frozen fruits are increasingly used for both fresh consumption and processing, i.e. as raw materials in the production of jellies, juices, concentrates, beverages, desserts, confectionery products, etc. Only fruits with intense colour, pleasant aroma and proper texture, i.e. at consumption maturity, are suitable for freezing *(Lovrić i Piližota, 1994)*.

Berry fruits are frozen either individually, using flash freezing procedures to meet the IQF (individually quick frozen) standards, or in packages of specific size, with sugar or sugar syrup added to preserve the colour and aroma of frozen fruits.

Prior to storage, some fruit crops require precooling at lower temperatures (but above 0 ^{0}C) for a period of several hours. Precooling entails quickly removing the heat from freshly harvested fruits before transportation, storage and processing. Accordingly, the loss in quality of perishable fresh fruits is minimized while prolonging their storage and shelf life.

Precooling can be performed using hydrocooling, forced-air cooling, vacuum-cooling and contact icing. In combination with controlled atmosphere storage, these precooling methods can further lengthen the storage and shelf life of fresh fruits. However, some fruit species such as apricots, oranges and lemons are fairly sensitive to controlled atmosphere storage. Table 84 shows storage regimes for different fruit crops in a conventional refrigeration facility and in a controlled atmosphere.

Table 84. Storage of fruits

Fruit species	Conventional refrigeration storage			Controlled atmosphere storage*			
	T (^{0}C)	Relative humidity (RH) (%)	No of days	T (^{0}C)	CO_2 (vol %)	O_2 (vol %)	No of days
Apples							
'Boskoop'	3-4	92-95	150-180	3-4	2-3	3	180-210
'Jonathan'	3-4	90-93	150	3-4	3	3	180
Pears							
'Gute'	-1 - 0	92-95	120	-1 - 0	3-4	3	210
'Wiliams Christ'	0-1	92-95	60-90	-1-0	3-4	3	210
Peaches	-1-0	90-93	14-42	-1-0	2-3	2	42
Apriocot	1-0	90-93	20	0	2,5	2,5	30
Plums	-1-1	90-93	7-42	0	3	3	14-42
Sour cherries	-1	90-93	10	0	5	3	21
Strawberries	0-2	87-90	5	0-1	4	3	90
Raspberries	0	90-93	3	–	–	–	–

(Source: Lovrić, 1991)

* Relative humidity is the same in both types of storage considered

Finished fruit products include processed fruit products ready for consumption. On balance, even some fruit products suitable for both human consumption and further processing (especially in the food industry) are considered finished fruit products.

1. All fruit crops can be made into compote (namely apples, pears, quinces, peaches, apricots, plums, sour cherries, grapes, etc.). Compote is made of pasteurized whole fruits or pieces of fruit in sugar syrup. Either single fruit or a mixture of fruits can be used for compotes. However, fruits made into compote should be at a maturity stage of approximately 80%, which is of crucial importance to compote production *(Niketić-Aleksić, 1988).*
   The quality of compotes is assessed by their flavour, aroma, colour (which should be identical to the colour of fruits used), and ratio between the fruit content and the compote liquid.
2. Fruit salad is a mixture of different types of chopped fruit (fresh, frozen or pasteurized) served in syrup or their own juices. Common ingredients used in fruit salads include peaches, pears, pineapples, grapes and sour cherries.

3. Fruit jelly is made by cooking down fresh-squeezed or semi-processed fruit juice with sugar, pectins and acids in order to obtain a product with the consistency of jelly. All fruit crops containing water-soluble pigments can be made into jelly, especially those with pronounced aromatic properties such as raspberries, strawberries, citrus fruits, etc.
4. Marmalade is a jelly made by cooking down fresh or semi-processed mashed fruits with sugar, pectins and acids (namely citric and malic acids). It is usually produced from semi-processed fruit products such as fruit pulps and purees (90%). Either single fruit (namely peaches, rose hips, Cornelian cherries, currants, etc.) or a mixture of fruits can be made into high-quality marmalade.
5. Jam is a jelly made by cooking down fruits of the same species (fresh, frozen or canned) with sugar or preservatives. Whole fruits or pieces of fruit should be suspended in this transparent jelly, thus easily discernible and recognizable. A number of fruit crops can be made into jam, especially stone fruits such as plums, sour cherries, sweet cherries, apricots and peaches. Berry fruits such as strawberries, blackberries and currants are also suitable for quality jam production. Moreover, demands for low-calorie and diabetic jams have been recently increasing worldwide.
6. Thin preserve (*slatko* in Serbian) is made by cooking down whole fruits or pieces of fruit of even technological maturity with syrup. High-quality fruit pulps preserved by SO_2 can also be made into thin preserve, i.e. *slatko*.
7. Candied fruits are made by immersing whole fresh fruits or pieces of fresh fruit into syrup, or by coating them with sugar or pectin-based preparations. Stone fruits such as sour cherries, sweet cherries, pears and quinces are the most suitable for candying (although even orange peel can be candied). Candied fruits can be used for direct consumption or as an addition to desserts and sweet treats in the confectionery industry.
8. *Pekmez* preserve is made by cooking down both fresh and mashed fruits with or without added sugar (with sugar not exceeding 20%). It is commonly made from plums of the 'Požegača' cultivar.
9. Fruit juice is produced by the mechanical processing of fresh and/or frozen fruits, or by further processing of fruit pulps and/or pure fruit juices preserved solely by physical means. It can also be made by adding water to concentrated fruit juices so as to replenish the exact amounts of water removed in the course of

their production. Fruit juices are divided into three categories according to their chemical composition, physical properties and production procedures: clear, cloudy and pulpy fruit juices *(Niketić-Aleksić, 1988).*

10. Fruit syrup is made by adding sugar and acids (namely citric and malic acids) to pure fruit juice or fruit concentrate. The dry matter content of fruit syrup should amount to 60%. Natural flavour and aroma concentrates are often added to enhance the flavour and aroma of fruit syrups. Fruit syrups made from raspberries, blueberries, currants, oranges, lemons and a mixture of fruits are especially in high demand.
11. Dried fruits are a finished fruit product used for both direct consumption and further processing into compotes, juices, etc. In addition to preservation purposes, fruits are increasingly dried for economic and nutritional purposes as well. The reduced mass and volume of dried fruits not only reduce their storage and transportation costs, but also facilitate their handling and use, which is of great importance to instant food products. Furthermore, dried fruits have been gaining increased attention as dietetic and organic foods. All fruit crops can be dried, especially plums, grapes, figs and apricots.

    The selection of drying equipment depends on fruit crops dried, the quality of finished products (their size, shape and consistency) and the cost and capacity of dried fruit production. Pome fruits such as apples and pears are best dried under microclimatic conditions, i.e. using dryers.

    When dried, some fruit species such as plums, grapes, sour cherries and sweet cherries are shortly immersed in a solution of NaOH, whereas others are dried in the sun (where possible and favoured by climatic conditions) such as figs, grapes, apricots and plums. Over the past years, brave attempts have been made to harness solar energy for fruit drying purposes using specially designed solar collectors for drying fruits.

The water content of dried fruits depends on fruit species and drying methods employed *(Lovrić, Piližota, 1994)*. Sun-dried fruits rich in sugars have a water content ranging from 15 to 20%. However, fruits lower in sugars and fruit powders (made from fruit purees and/or juices) have water contents of less than 10% and about 2%, respectively.

Lovrić and Piližota (1994) also list the following fruit products:

- Fruit cheese is made by cooking down fruit juice or pulp with sugar, pectins or acids until the consistency of a jelly.
- Fruit butter with no added sugar is made by cooking down fruit puree with fruit juice (or syrup) and various spices (namely cinnamon, nutmeg, etc.). After cooling down, it should be firm and easily spread.
- Fruit butter with added sugar is best made by adding brown sugar instead of refined sugars. Pears, peaches, apricots and plums are usually mashed when made into butter, with lemon juice added at the end of the cooking-down process to intensify the flavour.
- Fruit sauce or dip is made by cooking down fruit pulp with sugar syrup. Pome and stone fruits are very suitable for making into sauce.
- Fruit cream is made from fresh or frozen fruit puree which is, after the addition of ascorbic acid, homogenized, deaerated, pasteurized and hot-filled in glass jars. It can be made from a single fruit puree or a mixture of fruit purees (namely mixed fruit purees).
- Fruit puree is made by mashing and blanching fruits preserved by pasteurization or freezing. It is used as a healthy ingredient in beverages, puddings, cakes, pies, marmalades and jams.

4.1. State and forecast of the industrial production of key semi-processed and finished fruit products in Serbia

A close business relationship between fruit producers and processors is a prerequisite for a regular and adequate supply of raw materials to the processing industry, as well as the assured marketability of fruits produced (which can be used as raw materials in the processing industry). Therefore, the high-intensity fruit production depends crucially on the highly-developed and well-equipped fruit processing industry, which in turn enhances fruit production through the modernization and adaptation of its own capacities. Fruit processing capacities should be closely interconnected with the raw material base due to their high requirements for a safe and continuous raw material supply.

Ensuring an adequate and continuous raw material supply to fruit processors can be discussed from both quantitative and qualitative

perspectives *(Lukač Bulatović, 2010)*. Quantitatively, the lack of raw materials required needs to be addressed in order to optimise the utilization of fruit processing capacities. Supply shortages of raw materials can be a consequence of the poor fruit production structure and low and irregular yields in some years. Qualitatively, the selection and breeding of favourable fruit cultivars is of paramount importance to the quality of fruits produced and fruit products obtained.

The fruit production structure should incorporate an increasing share of fruit varieties and cultivars characterized by high processing usability. Fruit concentrate production should be based on raw materials with high dry matter contents and a harmonious relationship between sugars and acids. In addition to the proper size of fruits, cultivars suitable for freezing are required to yield fruits of consistent and intense colour such as the following raspberry cultivars: 'Willamette', 'Lloyd George', 'Malling Promise' and 'Podgorina'.

Considering that fruits of many species are not favourable raw materials for obtaining high-quality processed fruit products (especially for the international market), the production of industrial fruits (the fruits which is exclusively used for processing) should be enhanced. The high-quality raw materials, with high technological value and standardised quality, ensure the uniformity of processed fruit products. Consequently, the fruit processing industry is constantly supplied by high-quality raw materials at acceptable prices. A number of industrial pear cultivars are primarily used for processing *(Milić, Radojević, 2003).* The largest amounts of industrial pears produced in Serbia are canned (approximately 40%), whereas frozen, processed (into jams, jellies, brandies and juices) and dried pears account for 5-6%, 2-3% and 1-2% of the total Serbian pear production respectively *(Ognjanov, 2003)*. The supply of fruits for processing is rather poor and unvaried in Serbia. The processed fruits are usually fresh fruits with certain flaws, mechanical damages or signs of rot and mouldiness. However, the 'Požegača' plum cultivar, apricots and some smaller fruits are very suitable for processing (into high-quality fruit products), which suggests that the production of fruits for processing should be based on the selection of best fruit cultivars for processing.

The actual production of semi-processed and finished fruit products in Serbia is shown in Tables 85, 86 and 87. In the period 1980-2017, the total production of key semi-processed fruit products in Serbia averaged 43,321 t. The largest volume of production was recorded in frozen fruits (29,070 t) and concentrated fruit juices (6,915 t), which jointly accounted for 83.0% of the total semi-processed fruit production in Serbia in the period under consideration (Table 85).

The Serbian semi-processed fruit production considered increased at an average annual rate of change of 2.01% in the period under consideration. According to the type of semi-processed fruit products, the largest increases in production were recorded in frozen fruits (at an average annual rate of change of 3.20%) and concentrated fruit juices (at an average annual rate of change of 3.04%).

Table 85. Trends in the production of key semi-processed fruit products in Serbia in the period 1980-2017

Indicators	**Production (t)**			
	Fruit pulp and puree - frozen	**Pure fruit juice**	**Concentrated fruit juice**	**Frozen fruit**
Average 1980-2017	2,893	4,444	6,915	29,070
Min.	788	213	53	6,581
Max.	7,634	14,240	22,432	88,155
Annual Rate of Change (%)	-1.15	-7.08	3.04	3.20
Coefficient of Variation (%)	62.39	88.15	77.03	61.93
Average 1980-1999.	3,316	6,628	4,864	22,307
Min.	788	1,306	1,073	6,581
Max.	7,634	14,240	8,495	46,929
Annual Rate of Change (%)	3.32	-8.78	0.12	3.25
Coefficient of Variation (%)	64.39	58.70	46.17	45.93
Average 2000-2017.	2,423	955	4,355	17,329
Min.	990	213	53	18,375
Max.	4,788	8,139	22,432	88,155
Annual Rate of Change (%)	-5.96	-5.09	23.18	8.66
Coefficient of Variation (%)	51.41	225.22	155.19	125.70

Source: Calculation based on Annual Reports of the Statistical Office of the Republic of Serbia

In the period 1980-1999, the Serbian semi-processed fruit production considered averaged 37,115 t. Marked increases in production were

recorded in all the semi-processed fruit products considered, with the exception of pure fruit juice (the production of which decreased at an average annual rate of change of -8.78%). The most marked increases in production were recorded in fruit pulps and frozen purees in the period under consideration (at an average annual rate of change of 3.32%).

In the period 2000-2017, the Serbian semi-processed fruit production considered averaged 25,062 t, indicating a growing trend. According to the type of semi-processed fruit products, the largest increase in production was recorded in concentrated fruit juices (at an average annual rate of change of 23.18%), with significant annual variations in the volume of production (CV = 155.19%).

Frozen fruits claim the largest share of the Serbian semi-processed fruit production. With an average production of 22,307 t in the period 1980-1999 and an average production of 17,329 t in the period 2000-2017, frozen fruits accounted for 60.10% and 69.15% of the Serbian semi-processed fruit production considered, respectively. In the period 2000-2017, the actual production of the remaining semi-processed fruit products considered ranged from 955 t (pure fruit juices) to 4,355 t (concentrated fruit juices).

In the period 1980-2017, the total production of finished fruit products in Serbia averaged 125,652 t. With an average annual production of 106,832 t, fruit juices accounted for 85.02% of the Serbian processed fruit production considered. The actual production of the remaining finished fruit products considered ranged from 2,255 t in dried fruits to 7,850 t in jams (Tables 86 and 87).

Decreases in production were recorded in all the finished fruit products considered, with the exception of fruit juices (the production of which increased at an average annual rate of change of 3.41%). The largest decreases in production were recorded in compotes (at an average annual rate of change of -13.19%) and fruit syrups (at an average annual rate of change of -11.25%).

In the period 1980-1999, the production of finished fruit products in Serbia indicates a downward trend. The largest decreases in production were recorded in dried fruits (at an average annual rate of change of -18.76%) and compotes (at an average annual rate of change of -18.49%). The decreases in production of the remaining finished fruit products considered ranged from an average annual rate of change of -11.23% in syrups to an average annual rate of change of -4.96% in fruit juices. The coefficients computed indicate significant variations in the production of all the finished fruit products considered, especially in the production of dried fruits (CV = 95.47%).

Table 86. Trends in the production of finished fruit products in Serbia in the period 1980-2017

Indicators	Production (t)				
	Fruit juice (clear, cloudy and pulpy)	**Fruit syrup**	**Preserved fruit**	**Jam**	**Dried fruit**
Average 1980-2017	106,832	4,684	4,030	7,850	2,255
Min.	27,029	220	70	3,038	102
Max.	251,057	13,788	15,003	19,178	10,361
Annual Rate of Change (%)	3.41	-11.25	-13.19	-4.26	-3.49
Coefficient of Variation (%)	61.07	106.99	129.50	61.41	106.79
Average 1980-1999.	64,431	8,186	7,232	10,928	2,949
Min.	27,029	1,066	264	3,639	102
Max.	142,496	13,788	15,003	19,178	10,361
Annual Rate of Change (%)	-4.96	-11.23	-18.49	-7.24	-18.76
Coefficient of Variation (%)	47.36	56.54	75.84	44.51	95.47
Average 2000-2017.	153,944	375	224	2,099	703
Min.	41,939	220	70	3,038	111
Max.	251,057	1,706	1,505	6,193	4,575
Annual Rate of Change (%)	6.62	-11.22	-11.41	-0.86	22.67
Coefficient of Variation (%)	39.82	132.06	203.31	37.30	227.99

Source: Calculation based on Annual Reports of the Statistical Office of the Republic of Serbia

In the period 2000-2017, the largest volume of production was recorded in fruit juices (153,944 t), whereas the volume of production of the remaining finished fruit products considered ranged from 224 t in compotes to 2,099 t in jams. The Serbian production of fruit juices and dried fruits increased in the period under consideration, whereas decreases were recorded in the production of all the other finished fruit products considered. The largest decrease in production was recorded in compotes (at an average annual rate of change of -11.41%). The

coefficients of variation computed indicate considerable variability in the production of finished fruit products in Serbia, ranging from 37.30% in jams to 227.99% in dried fruits.

Table 87. Semi-processed and processed fruit production in Serbia in the period 1980-2017

Indicators		**Type of processed fruit**		**Total**
		Semi-processed fruit products	**Finished fruit products**	
Average 1980-2017		43,321	125,652	168,973
Interval of Variation	Min.	38,655	38,655	65,776
	Max.	257,084	257,084	290,247
Annual Rate of Change (%)		2.01	1.86	1.89
Coefficient of Variation (%)		48.42	49.07	42.95
Structure (%)		27.64	72.36	100.00
Share of frozen fruits (%)		67.10	/	17.20
Share of fruit juices (clear, cloudy and pulpy) (%)		/	85.02	63.22

Source: Calculation based on Annual Reports of the Statistical Office of the Republic of Serbia

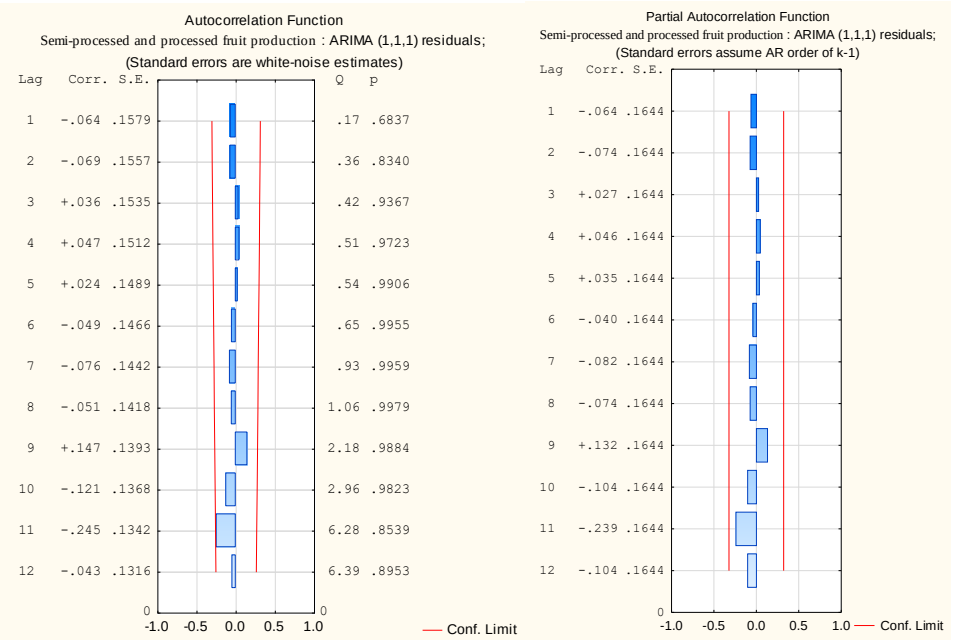
Forecast of semi-processed and processed fruit production in Serbia - using the Statistica 13.3 program, the ARIMA(1,1,1) model was selected for forecasting the total semi-processed and processed fruit production in Serbia, whereas the ARIMA(0,1,1) model was selected for forecasting the volume of fruit juice and frozen fruit production in Serbia. Tables 88, 90 and 92 show the parameters of the ARIMA models employed.

Table 88. Parameters of the model for forecasting the total semi-processed and processed fruit production in Serbia

Paramet.	Input: Semi-processed and processed fruit production (Spreadsheet1 in Workbook1) Transformations: D(1) Model:(1,1,1) MS Residual= 1053E6					
	Param.	Asympt. Std.Err.	Asympt. t(34)	p	Lower 95% Conf	Upper 95% Conf
p(1)	-0.68959	0.207	-3.33485	0.002072	-1.10983	-0.26936
q(1)	-0.88305	0.118	-7.45785	0.000000	-1.12368	-0.64242

Total semi-processed and processed fruit production in Serbia—Residuals

ACF PACF



The forecast values obtained indicate that the increase in the total semi-processed and processed fruit production in Serbia in the period under consideration will continue throughout the entire forecast period (2018-2023). At the end of the forecast period, the expected semi-processed and processed fruit production in Serbia will approximate to 290,000 t (Table 89 and Figure 25).

Table 89. Forecast of the total semi-processed and processed fruit production in Serbia in the period 2018-2023

CaseNo.	Forecasts; Model:(1,1,1) Seasonal lag: 12 (Spreadsheet1 in Workbook1) Input: Semi-processed and processed fruit production Start of origin: 1 End of origin: 38			
	Forecast	Lower 95.0000%	Upper 95.0000%	Std.Err.
39	265937.7	199989.0	331886.4	32451.2
40	275411.1	172727.0	378095.3	50527.5
41	274782.2	150559.5	399005.0	61125.9
42	281119.8	135505.0	426734.6	71652.2
43	284653.4	120302.5	445004.2	79887.4
44	287499.7	108797.5	466202.0	87933.4

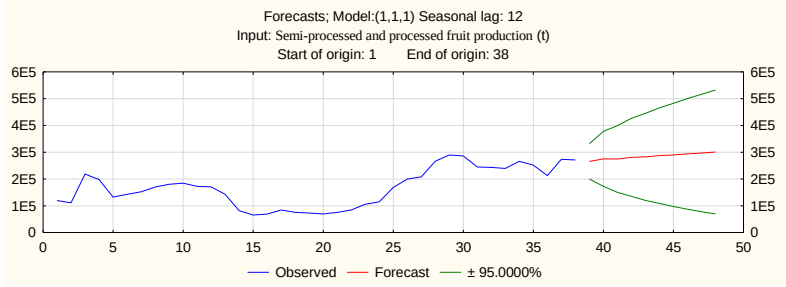


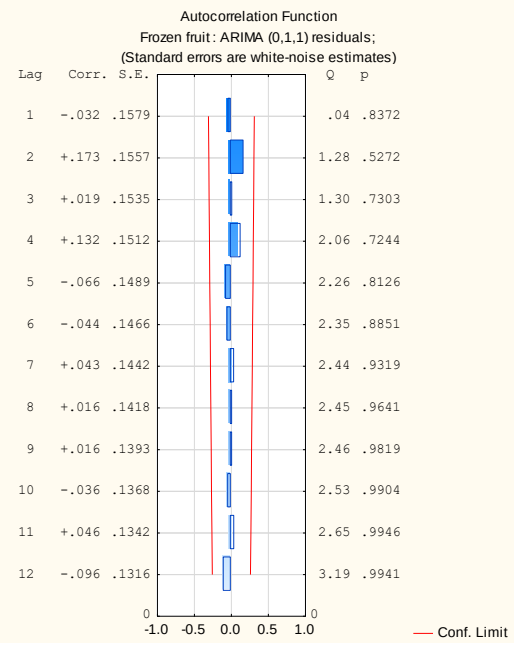
Figure 25. Forecast of trends in the total semi-processed and processed fruit production in Serbia

Table 90. Parameters of the model for forecasting the volume of frozen fruit production in Serbia

Paramet.	Input: Frozen fruit (Spreadsheet1 in Workbook1) Transformations: D(1) Model:(0,1,1) MS Residual= 8721E4					
	Param.	Asympt. Std.Err.	Asympt. t(35)	p	Lower 95% Conf	Upper 95% Conf
Constant	2169.017	1285.163	1.687736	0.100355	-440.004	4778.037
q(1)	0.180	0.146	1.231052	0.226512	-0.117	0.477

Frozen fruits—Residuals

ACF



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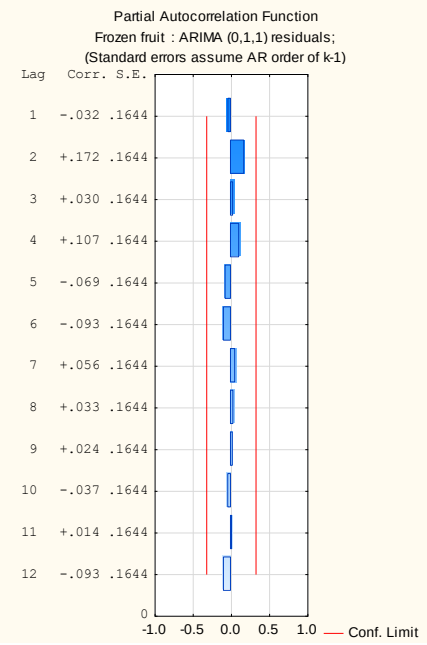

The forecast trend values of frozen fruit production in Serbia indicate an increase throughout the entire forecast period (Table 90 and Figure 26). By the end of 2023, the expected frozen fruit production in Serbia will approximate to 100,000 t, representing an increase of about 70,000 t over the average frozen fruit production in the period under consideration.

Table 91. Forecast of trends in the frozen fruit production in Serbia in the period 2018-2023

Case No.	Forecasts; Model:(0,1,1) Seasonal lag: 12 (Spreadsheet1 in Workbook1) Input: Frozen fruit Start of origin: 1 End of origin: 38			
	Forecast	Lower 95.0000%	Upper 95.0000%	Std.Err.
39	89282.9	70324.05	108241.8	9338.86
40	91452.0	66935.06	115968.9	12076.65
41	93621.0	64591.38	122650.6	14299.54
42	95790.0	62860.43	128719.6	16220.60
43	97959.0	61544.79	134373.2	17937.09
44	100128.0	60534.67	139721.4	19503.08

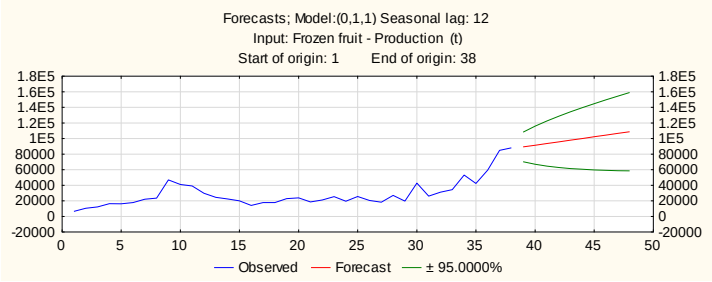

Figure 26. Forecast of trends in the frozen fruit production in Serbia

Table 92. Parameters of the model for forecasting the total fruit juice production in Serbia

Paramet.	Input: Fruit juice (Spreadsheet1 in Workbook1) Transformations: D(1) Model:(2,1,1) MS Residual= 8930E5					
	Param.	Asympt. Std.Err.	Asympt. t(33)	p	Lower 95% Conf	Upper 95% Conf
p(1)	-0.816	0.246	-3.32037	0.002203	-1.32	-0.32
p(2)	-0.141	0.194	-0.72672	0.472519	-0.54	0.25
q(1)	-0.866	0.179	-4.82855	0.000031	-1.23	-0.50

Fruit juice production in Serbia—Residuals

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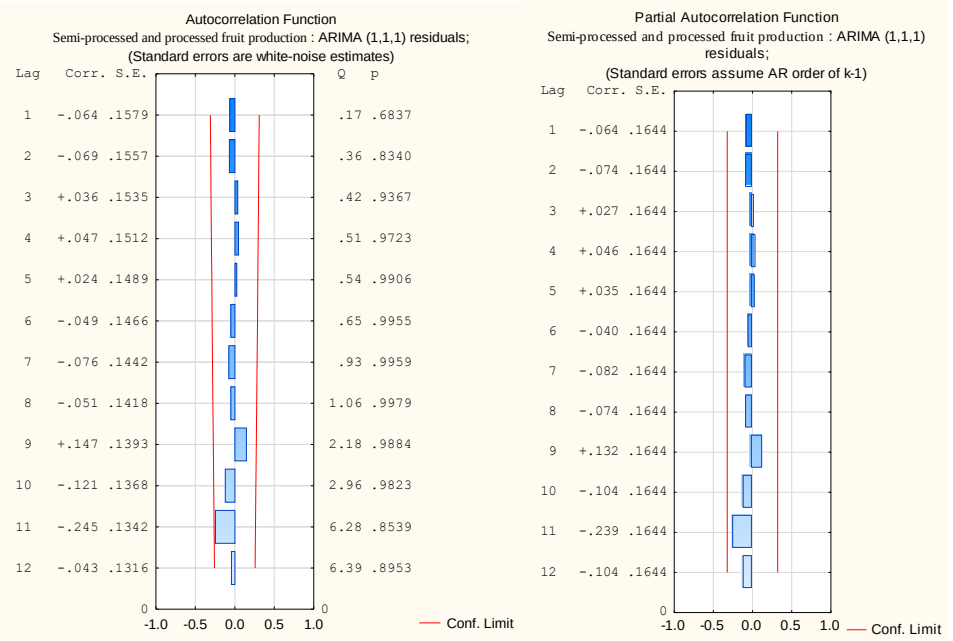

Variations in the volume of Serbian fruit juice production in the period under consideration will continue throughout the entire forecast period. The forecast values obtained indicate alternating annual increases and decreases in the Serbian fruit juice production throughout the entire forecast period (Table 91 and Figure 27). By the end of 2023, the expected fruit juice production in Serbia will approximate to 160,000 t, representing an increase of about 50,000 t over the average fruit juice production in the period under consideration (1980-2017).

Table 93. Forecast of the fruit juice production in Serbia in the period 2018-2023

Case No.	Forecasts; Model:(2,1,1) Seasonal lag: 12 (Spreadsheet1 in Workbook1) Input: Fruit juice Start of origin: 1 End of origin: 38			
	Forecast	Lower 95.0000%	Upper 95.0000%	Std.Err.
39	143450.7	82654.4	204247.1	29882.48
40	157309.0	69146.7	245471.3	43333.32
41	151124.3	48373.7	253875.0	50503.75
42	157668.6	37980.6	277356.5	58828.73
43	156654.0	24547.2	288760.9	64932.84
44	160011.3	15262.4	304760.3	71146.63

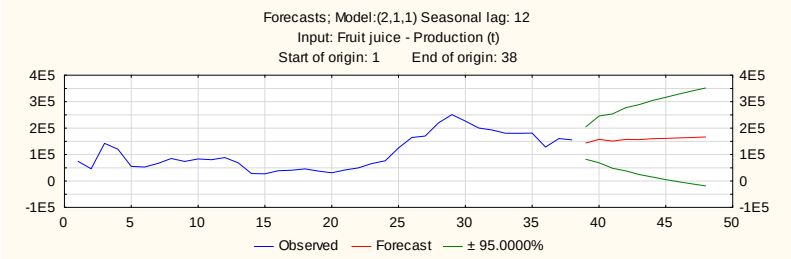

Figure 27. Forecast of trends in the fruit juice production in Serbia

5. CONCLUDING REMARKS

- The industrial value of Serbian fruit production is significantly lower than its potential value, considering highly favourable natural conditions for fruit growing in the country. The total orchard area in Serbia exceeds the country's requirements. The intensification of fruit production should result in both higher yields per unit area and higher volumes of fruit production. Therefore, the intensive production of plums, which are the predominant fruit crop in Serbia, can lead to the same or higher volumes of production per smaller unit area.
- As fruits of many fruit varieties and cultivars are not suitable raw materials for high-quality products, especially those produced for international markets, the production of industrial fruits, i.e. fruits for specific processing procedures, should be increased. This entails producing raw materials of great technological value and of uniform and standard quality, which are consequently processed into products of such quality. Moreover, the fruit processing industry in Serbia would thus be continuously supplied with high-quality raw materials at acceptable prices. The quality of fruits for processing in Serbia is still rather inferior, including mostly fruits unsuitable for fresh consumption due to mechanical damage, moulds or even rot.
- With an average of 240,023 ha, the orchard area accounted for 4.51% of the total utilized agricultural land in Serbia in the period 1960-2018. The Vojvodinian share in the total Serbian orchard area increased in the period under consideration due to the increasing orchard area in Vojvodina and the diminishing orchard area in Central Serbia.
- The total fruit production in Serbia indicates a growing trend in the period under consideration (at an average annual rate of change of 0.96%). The largest volume of production was recorded in plums (454,964 t) and apples (217,431t), which jointly accounted for 67.8% of the total Serbian fruit production. With an average annual production of 178,437 t, Vojvodina accounted for 17.8% of the total fruit production in Serbia. In the period 1960-2018, the fruit production in Vojvodina increased at an average annual rate of change of 1.89%, whereas the share of Vojvodina in the total

Serbian fruit production structure increased at an average annual rate of change of 0.92%.

- The forecast values obtained indicate that the increases in the number of productive fruit trees and the volume of fruit production in Serbia in the period under consideration will continue throughout the entire forecast period. At the end of the forecast period, i.e. by the end of 2023, the total number of productive fruit trees in Serbia will approximate to 79.3 million, whereas the expected fruit production will approximate to 1.19 million tonnes. According to fruit crops, the largest increases in both the number of productive trees and the volume of production are expected in apples.
- In the period 1980-2017, the Serbian semi-processed and processed fruit production considered averaged 168,973 t. Semi-processed and finished fruit products accounted for 27.6% and 72.4% of the total industrial fruit processing in Serbia, respectively. Although there is a wide assortment of fruit products in Serbia (both semi-processed and finished), fruit juices and frozen fruits predominate in the Serbian fruit processing industry.
- The total Serbian semi-processed and processed fruit production considered increased at an average annual rate of change of 1.89% in the period under consideration. The largest increase in production was recorded in fruit juices (at an average annual rate of change of 3.41%). In the period 1980-2018, the largest decreases in production were recorded in compotes (at an average annual rate of change of -13.19%) and fruit syrups (at an average annual rate of change of -11.25%). The coefficients of variation computed indicate considerable variability in the semi-processed and processed fruit production in Serbia, ranging from 61.41% in jams to 106.79% in dried fruits.
- The forecast values obtained indicate an increase in the total semi-processed and processed fruit production in Serbia throughout the entire forecast period (2018-2023). At the end of the forecast period, the expected semi-processed and processed fruit production in Serbia will approximate to 290,000 t. The largest increase in production is expected in frozen fruits. By the end of 2023, the expected frozen fruit production in Serbia will

approximate to 100,000 t, representing an increase of about 70,000 t over the average frozen fruit production in the period 1980-2017.

- The existing industrial processing facilities in Serbia should be better equipped, modernised and specialised in order to produce high-quality fruit products which would meet the demands of particular markets.

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SUMMARY

Considering the importance of fruit production as a raw material source for the fruit processing industry, this monograph attempts to elucidate trends in the development of fruit production and processing in Serbia. It also examines quantitative changes in the production capacity of major fruit species in Serbia in the period 1960-2018 and key semi-processed and finished fruit products in the period 1980-2017. The data and forecasts obtained were utilized for assessing the state and prospects of fruit production and processing in Serbia. A performance analysis of the Serbian fruit production and processing was based on descriptive statistics, whereas ARIMA models were employed for forecast purposes.

In the period 1960-2018, the orchard area accounted, on average, for 4.51% of the total agricultural land in Serbia, indicating a slightly increasing trend (at an average annual rate of change of 0.40%). The share of Vojvodina in the total Serbian orchard area was rather small, but also indicating a growing trend. Vojvodina claimed a 6.39% share in the total Serbian orchard area and a 13.65% share in the total number of productive fruit trees in Serbia in the period under consideration. In the period 1960-2018, the total fruit production in Serbia averaged 992,638 t, indicating an increase at an average annual rate of change of 0.96%. With an average annual production of 178,437 t, Vojvodina accounted for 17.79% of the total Serbian fruit production, indicating a growing trend (at an average annual rate of change of 0.92%).

Throughout the entire period under consideration (1960-2018), plums were the predominant fruit crop in the Serbian fruit production, although indicating a downward trend. Plums claimed a 55.67% share in the total number of productive fruit trees in Serbia and a 46.82% share in the total Serbian fruit production. According to the volume of production, apples and sour cherries ranked second and third, respectively.

Although there is a wide assortment of fruit products in Serbia (both semi-processed and finished), fruit juices and frozen fruits predominate in the Serbian fruit processing industry, jointly accounting for 80.4% of the total Serbian semi-processed and processed fruit production considered. The total Serbian semi-processed and processed fruit production considered increased at an average annual rate of change of 1.89% in the period under consideration. The largest increase in production was recorded in fruit juices (at an average annual rate of change of 3.41%). The coefficients of variation computed indicate considerable variability in

the semi-processed and processed fruit production in Serbia, especially in compotes (CV = 129.50%) and fruit syrups (CV = 106.99%).

The autoregressive–moving-average (ARMA(p,q)) model was employed herein for analysis and forecast purposes (forecasts were made up to 2023). The ARMA model is a combination of the autoregressive (AR) part, which involves regressing the variable on its own legged (past) values, and the moving average (MA) part, which entails modelling the error term as a linear combination of error terms occurring at the same and different times in the past. Provided a time series is not stationary, the autoregressive–moving-average model for an integrated time series (ARIMA(p,d,q)) is used with an integrated (differential) time series $(1-L)^d = \Delta^d$, where d is the smallest number of differentiations required for reaching stationarity.

The forecast values obtained indicate that the increases in the number of productive fruit trees and the volume of fruit production in Serbia in the period under consideration will continue throughout the entire forecast period. At the end of the forecast period, the total number of productive fruit trees in Serbia will approximate to 83 million, whereas the expected fruit production in Serbia will approximate to 1.4 million tonnes. According to fruit crops, the largest increases in both the number of productive trees and the volume of production are expected in apples.

The forecast values obtained indicate an increase in the total semi-processed and processed fruit production in Serbia throughout the entire forecast period (2018-2023). At the end of the forecast period, the expected semi-processed and processed fruit production in Serbia will approximate to 290,000 t. According to both semi-processed and processed fruit products, the largest increase in production is expected in fruit juices.

Keywords: *fruit production and processing, state, forecast, Serbia*

STANJE I PREDVIĐANJE PROIZVODNJE I PRERADE VOĆA U SRBIJI

SAŽETAK

Polazeći od značaja voćarske proizvodnje kao sirovinske osnove za prerađivačku industriju, u ovoj monografiji je učinjen pokušaj detaljnijeg sagledavanja tendencija u razvoju proizvodnje i prerade voća u Srbiji. Analizirane su kvantitativne promene u kapacitetima i ostvarenoj proizvodnji važnijih voćnih vrsta u periodu 1960-2018. godine, kao i važnijih poluprerađevina i gotovih proizvoda od voća u periodu 1980-2017. godine. Na osnovu analize, predviđanja i poređenja date su ocene stanja i perspektive razvoja proizvodnje i prerade voća u Srbiji. Analiza važnijih obeležja proizvodnje voća i prerađevina od voća, u ispitivanim periodima, izvedena je na osnovu deskriptivne statistike, dok su za predviđanje korišćeni ARIMA modeli.

U analiziranom periodu (1960-2018) učešće površina voćnjaka u ukupnim obradivim površinama u Srbiji prosečno je iznosilo 4,51% i ispoljava tendenciju blagog povećanja (prosečna godišnja stopa promene 0,40%). U ukupnim površinama voćnjaka Srbije učešće Vojvodine je skromno, ali sa tendencijom povećanja. Vojvodina ima učešće od 6,39% u ukupnim površinama voćnjaka, odnosno 13,65% u ukupnim rodnim stablima Srbije. U ispitivanom periodu, ukupna proizvodnja voća u Srbiji je iznosila 992.638 tona sa tendencijom povećanja po prosečnoj godišnjoj stopi promene od 0,96%. Sa prosečnom godišnjom proizvodnjom od 178.437 tona, Vojvodina učestvuje sa 17,79% u ukupnoj proizvodnji voća Srbije. Učešće Vojvodine u ukupnoj proizvodnji voća u Srbiji ispoljava tendenciju povećanja (stopa promene 0,92%).

U 2018. u odnosu na 1960. godinu šljiva je bila i ostala vodeća voćna vrsta, mada se njeno učešće smanjuje u voćarskoj proizvodnji Srbije. Šljiva ima učešće od 55,67% u ukupnim rodnim stablima, odnosno 46,82% u ukupno ostvarenoj proizvodnji voća. Na drugom i trećem mestu u strukturi voćarske proizvodnje Srbije su jabuka i višnja.

Iako je asortiman prerađevina od voća (poluprerađevine i gotovi proizvodi) veoma širok, ipak u industrijskoj preradi voća dominira proizvodnja voćnih sokova i smrznutog voća. Spomenute prerađevine od voća učestvuju sa 80,4% u ukupnoj proizvodnji analiziranih prerađevina Srbije. Ukupna proizvodnja prerađevina od voća se povećava po prosečnoj godišnjoj stopi promene od 1,89%. Posmatrano po vrstama prerađevina, najintenzivnije povećanje obima proizvodnje je utvrđeno

kod voćnih sokova (prosečna godišnja stopa promene 3,41%). Izračunati koeficijenti ukazuju na veoma visoka variranja obima proizvodnje, koja su posebno izražena kod kompota (Cv=129,50%) i voćnog sirupa (Cv=106,99%).

Na osnovu podataka analiziranog perioda predviđeno je kretanja posmatranih pojava do 2023. godine. U analizi i predviđanju primenjena je klasa autoregresivnih modela pokretnih sredina (ARMA (p,q)). Kod ove klase modela pretpostavka je da tekuća vrednost (član) serije zavisi od vrednosti prethodnih članova serije, tekuće vrednosti slučajnog procesa i prethodnih vrednosti slučajnog procesa beli šum. Ova klasa modela je kombinacija autoregresionog modela (AR) i modela pokretnih proseka (MA). U slučaju da vremenska serija nije stacionarna primenjuje se autoregresioni model pokretnih proseka za integrisane vremenske serije, *ARIMA(p,d,q)* model, u kome umesto originalne vremenske serije figuriše integrisana (diferencirana) vremenska serija $(1-L)^d = \Delta^d$, gde je *d* najmanji broj diferenciranja kojima se postiže stacionarnost.

Predviđene vrednosti pokazuju da će se tendencija povećanja posmatranih pojava iz analiziranog perioda nastaviti i u periodu predviđanja. Na kraju predikcionog perioda, ukupan broj rodnih stabala biće na nivou od oko 83 miliona, a očekivana proizvodnja voća oko 1,4 miliona tona. Posmatrano po voćnim vrstama, najveće povećanje kako rodnih stabala, tako i obima proizvodnje očekuje se kod jabuke.

U periodu predviđanja očekuje se tendencija stalnog povećanja proizvodnje prerađevina od voća u Srbiji, kroz ceo period. Očekivana ukupna proizvodnja analiziranih prerađevina od voća do kraja 2023. godine biće na nivou od oko 290.000 tona. Posmatrano po vrstama prerađevina od voća, najveće povećanje proizvodnje očekuje se kod voćnih sokova.

Ključne reči: *prozvodnja i prerada voća, stanje, predviđanje, Srbija*

Izvodi recenzija
Monografije
„STANJE I PREDVIĐANJE PROIZVODNJE I PRERADE VOĆA U SRBIJI"

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Monografija *prof. dr Mirjane Lukač Bulatović* predstavlja samostalan naučni rad, koji sveobuhvatno obrađuje problematiku proizvodnje voća i prerađevina od voća, metodološkim postupkom primerenim temi i prihvaćenim u (agro)ekonomskoj nauci. Rezultati istraživanja koje je obavila Mirjana Lukač Bulatović mogu biti od koristi kako za usko-stručni deo naučne javnosti, tako i širem auditorijumu korisnika, prvestveno praktičarima i menadžerima iz agrobiznis sektora, ali i svima onima koji se, na bilo koji način, bave ovom problematikom. Prema tome, ova monografija predstavlja originalan naučni rad, koji pored teoretske ima i praktičnu vrednost. Stoga dajem pozitivnu recenziju monografije pod nazivom *Stanje i predviđanje proizvodnje i prerade voća u Srbiji* autora prof. dr Mirjane Lukač Bulatović i predlažem Komisiji i Naučno-nastavnom veću Poljoprivrednog fakulteta u Novom Sadu da odobri njeno izdavanje.

U Novom Sadu,
18.02.2020. dr Nebojša Novković, *red.prof.*
Poljoprivrednog fakulteta Univerziteta u Novom Sadu

Monografija „Stanje i predviđanje proizvodnje i prerade voća u Srbiji " autora *Mirjane Lukač Bulatović* izdvaja po svom sadržaju i originalnosti u odnosu na slične publikacije. Autor je pokazao da dobro poznaju materiju, a to je izložila u metodološkom, jezičkom, i u tehničkom smislu, koji je na zavidnom nivou. Ova knjiga može biti od koristi studentima redovnih studija, master i doktorskih studija, kao i menadžerima i preduzetnicima koji se već bave ili nameravaju da se bave ovom složenom problematikom. Zato je bez rezerve preporučujem za publikovanje.

U Zemunu,
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Istraživana je veoma značajna i aktuelna problematika, stil pisanja je jasan, primenjene metode su u skladu sa problematikom, a rezultati do kojih se došlo i način njihovog prezentovanja su veoma značajni za širu naučnu javnost i društvenu zajednicu. Imajući u vidu sve navedene aspekte, smatram da ova monografija ispunjava naučne zahteve, kako po sadržaju, tako i po tematici. Prema svim karakteristikama i originalnom pristupu teoriji i praksi, monografija pod naslovom „Stanje i predviđanje proizvodnje i prerade voća u Srbiji“, autora *dr Mirjane Lukač Bulatović*, *vanrednog profesora* Poljoprivrednog fakulteta Univerziteta u Novom Sadu, predstavlja vredno naučno delo. Imajući u vidu sve navedeno, smatram da je navedena publikacija veoma značajna, kako za naučnu, tako i za stručnu javnost i sa zadovoljstvom predlažem da se odobri njeno štampanje i tako učini dostupnom većem broju korisnika.

U Zemunu,
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