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International market concentration of fresh blueberries in the period 2001—2020

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There were no studies about the structure of the international fresh blueberry market in developing countries for contributing to the development of strategies and policies for the production, imports, and exports of fresh blueberries in the involved countries. The purpose of the study was to evaluate the structure of the international fresh blueberry market in the period 2001–2020. The research design was non-experimental, and longitudinal, with trends on per capita consumption, the market concentration index, and a multiple linear regression model. It was concluded that per capita consumption is led by Canada and the USA and that the concentration indices of the four main countries [CR(4)] of production, imports, and exports went from very high concentration levels to high concentration levels. The eight main countries [CR(8)] of production and exports were at a very high level and imports went from a very high level to a high level; in addition, the Herfindal–Hirschman-Index (HHI) of production was at a highly concentrated level: (a) highly concentrated level in imports in the period 2001–2018, (b) moderately concentrated from 2019 in imports, (c) highly concentrated in exports in the period 2001–2009, (d) moderately concentrated in exports in the period 2010–2018, and (e) not concentrated in exports as of 2019; in addition, the multiple linear regression model showed that per capita consumption, market share, price, and production contribute with 94.3% of the explanation of the variability of fresh blueberry exports. Finally, it was recommended to study the blueberry consumption habits and access restrictions to other international markets for increasing blueberry exports.

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Introduction

The blueberry industry has sustained growth in the last 20 years and blueberries reach consumers as a quality product that satisfies their desires and needs, thanks to the efforts of public and private entities (Brazelton, 2020). The demand for good quality blueberries has driven consumer interest in understanding blueberry flavor chemistry (Qian et al., 2022) and fresh fruit consumers value their flavor through taste and aroma highly (Ferrão et al., 2022) jointly with their various benefits for people's health (Assunção-Júnior et al., 2022).

The modern consumer is concerned about food safety, health, and environmental sustainability (Massaglia et al., 2018). Therefore, agricultural production and organic food are increasing throughout the world and blueberries are one of the products recognized by consumers because they have properties that benefit human health (Massaglia et al., 2018). Likewise, the blueberry is a fruit recognized for its high nutritional value, such as anthocyanins, flavonoids, vitamin C, minerals, and dietary fibers, among others; in addition, blueberries have properties to prevent chronic diseases such as obesity, diabetes, and cancer (Song et al., 2020).

The agricultural industry in developing countries has great potential to alleviate poverty, but some agricultural policy projects implemented by governments have not been successful due to the fact that local agricultural markets are controlled by a small group with great power in the market (Nugroho, 2021). Therefore, the lack of market information in the agricultural sectors of developing countries in Latin America, the Caribbean, Asia, and Africa is caused by an oligopsonic market system, which gives the power for manipulating the market and hide information from certain participants (Nugroho, 2021). Consequently, knowledge of the market structure and the establishment of competition have great importance for decision-making in economic policies (Ukav, 2017), finding many concentration indices for determining market structures; however, the most widely used are the company concentration index CR(k) and the Herfindahl–Hirschman (HHI) index (Ukav, 2017).

Massaglia et al. (2018) investigated the perception of Italian consumers about the eco-label in fresh blueberries and its possible impact on the market and recommended that research must be carried out in the international context for analyzing the consumption of blueberries in different European countries. In this sense, the present investigation evaluated the structure of the international market for fresh blueberries in the period 2001–2020, due to the importance of the development of agriculture and fresh products in the international market. In addition, few studies have been carried out about the structure of the fresh blueberry market at a global level.

Literature review

Studies of blueberry production, exports, and imports. The blueberry has gained popularity in the last decade and the cultivation of this fruit of wild origin has increased notably throughout the world, mainly due to new trends in healthy consumption (Pérez et al., 2022). Likewise, the USA leads the world production of blueberries, and together with Canada, Chile, and Peru, these countries represent 75% of the total area of the world for the production of blueberries; in addition, Europe has 1.55 million small farms dedicated to the cultivation of blueberries (Pérez et al., 2022).

Blueberry industry leaders established in Europe, North America, Chile, and Argentina are renewing, expanding, and investing in new technologies for presenting quality products to the demands of the future (Brazelton, 2020). Likewise, the new blueberry industries such as Morocco, Mexico, Peru, and Southern Africa have the opportunity for investing adequately in varieties, infrastructure, and technology with the future in mind (Brazelton, 2020).

The world production of blueberries is led by the USA, Canada, and Chile and exports are led by Canada and Chile; therefore, the production of blueberries in Chile has become one of the main ones in the world (Almonacid, 2018). Likewise, Hortifrut was the main world producer of organic blueberries and the second company in the production of berries and had a presence in the USA, China, Chile, Mexico, Guatemala, Argentina, Uruguay, Spain, Brazil, and Peru (Almonacid, 2018). In addition, Blanke and Yuri (2020) indicated that Chile registered 105,000 tons in the 2017–2018 season, mainly because it has four temperate zones for fruit production and it has 15,600 ha for blueberries.

In 2016, 1.2 billion pounds of blueberries were produced worldwide, of which 54.2 million were produced in Europe: (a) 40% were produced in Southern Europe, (b) 34% were produced in Northern Europe, and (c) 26% was produced in the East Europe (Peano et al., 2017; Brazelton, 2016). Italy has experienced significant growth with a production of 3.9 million pounds from 2010 until 2016 (Peano et al., 2017; Brazelton, 2016). Likewise, The Netherlands, the Nordic countries, Germany, Austria, and Switzerland have had a market growth of more than 25% per year (Peano et al., 2017; Brazelton, 2016).

According to the 2019 Peruvian national agricultural survey, conducted by the National Institute of Statistics and Informatics (INEI), a blueberry production of 86,852 tons (Tn) was recorded, mainly in the following regions: (a) La Libertad (66,857 tons), (b) Lambayeque (11,804 tons), (c) Lima (6020 tons), (d) Ancash (1528 tons) and (e) Ica (653 tons), with a market share of the production of 77%, 14%, 7%, 2%, and 1%, respectively; likewise, the harvested hectares were: (a) 7477 in La Libertad, (b) 1361 in Lambayeque, (c) 823 in Lima, (d) 218 in Ancash, and (e) 88 in Ica, with a total of 9966 ha in the four departments. In addition, Retamales et al. (2014) explained that Chile has become an important player in the blueberry industry, becoming the most important supplier of fresh fruit out of season for the northern hemisphere, passing from US$ 30 million (around 4000 tons) in 2000 to US$ 380 million (94,000 tons) in 2011.

Shi et al. (2011) explained that according to specialists from the United States Department of Agriculture (USDA), since 2000 there has been rapid growth in the fresh blueberry market. Thus, there has been a rapid increase in the per capita consumption of fresh blueberries as opposed to frozen blueberries which has not shown a trend growth since 1992. Likewise, blueberries have not grown in Georgia in the USA since a quarter of a century ago; but, the blueberry industry has grown in area, production, performance, and farm value in the last decade, becoming the second most important crop in the State of Georgia, due to that the value was US$ 144 million in 2002 and for the year 2009 amounted to US$ 366.3 million (Fonsah et al., 2011).

Market structure studies. The Herfindahl–Hirschman Index (HHI) and the company concentration index CR(k) are the most widely used indicators for measuring market or industry concentration (Kvålseth, 2018; Ruiz et al., 2017; Navarro et al., 2013). Therefore, it is essential that the relationships of these indices are correct, clear, and reliable; furthermore, it is important for economists and policy planners (Kvålseth, 2018). Likewise, the HHI has been used to calculate the degree of concentration of the export basket of the countries and the concentration or diversification of the markets (Prada and García, 2016).

The HHI is one of the indicators of commercial dynamism that determines the degree of concentration or diversification of the

market, weighing the weight of each product and country in the total of its trade (Durán and Alvarez, 2011). Finally, the HHI follows an economic theory that relates the behavior of an industry and the performance of the market with the structure of the industry (Grosche et al., 2020) and permits to measurement of market concentration in order to apply antitrust regulations (Brezina et al., 2009).

Several authors used the HHI for measuring the structure of the international export market by exportable supply, economic sectors, and destination markets (Ortikov et al., 2019; Macías Badaraco et al., 2019; Del Rosal, 2019; Hersen et al., 2019; Coelho et al., 2018; Costa et al., 2018; Prada and García, 2016; Prada et al., 2016), who demonstrated the existence of market concentration or diversification. Several authors also used the HHI for measuring the structure of the international market by producing, exporting, and importing countries, considering the following products: (a) sparkling wine (exports were highly concentrated in a single country, while imports were not concentrated) [Thome and Paiva, 2020], (b) sheep meat (production and imports were not concentrated, while exports were highly concentrated in two countries) [Ramírez-López et al., 2020]; and (c) palm oil (a highly concentrated market) [Navarro et al., 2013].

Other authors used the HHI for measuring the concentration of industries: (a) electricity, gas, steam, and water (Brezina et al., 2009); (b) banking sector (Brezina and Pekár, 2013); (c) insurance companies (Brezina et al., 2016); and (d) air transport (Grosche et al., 2020). For these reasons, the HHI is a tool used for measuring the concentration or diversification of industries within a country and in the international market.

Market concentration. Market concentration has increased in recent decades (Leigh, 2023). In this sense, institutions that operate in more concentrated markets are more stable than those that are in less concentrated markets (Tran et al., 2023). That is, institutions improve and have greater market power in a less competitive and more concentrated environment (Duong and Dang, 2023), or vice versa when a market becomes less concentrated due to that it is more competitive (Wei et al., 2023). However, in an environment of greater exchange rate volatility, industries with greater competition have lower annual inflation of prices of goods produced and sold by the producer on average compared to industries with less competition (Torun and Yassa, 2023). Likewise, market concentration measured through the HHI is inversely proportional to productivity; that is, when the HHI decreases, productivity increases and vice versa (Rodríguez-Castelán et al., 2023). Furthermore, it is theoretically known that mergers between companies can increase prices, harm consumers, and increase entry barriers and therefore greater market concentration (Rabbani, 2023).

Trade policy and competitiveness. Exogenous factors imposed by consumer markets through tariff preferences and subsidies for domestic production granted by developed countries, through a strategic trade policy, distort the market and generate imperfect competition for some agricultural products (Absell, 2022). In this sense, trade policies related to tariffs, quotas, and subsidies affect global supply chain networks; that is, these policies imposed on the demand side benefit the national producer and harm the foreign producer of final goods. On the supply side, it improves the competitiveness of national suppliers of raw materials but harms national producers of final goods (Feng et al., 2022). However, despite the costs and benefits, companies that participate in exports tend to improve the competitiveness of their products and expand their foreign networks; in addition, they increase their purchases of intermediate inputs from foreign suppliers (Kang and Whang, 2023). Therefore, the trade policy of developing countries must promote production, employment, and technological innovation, and reduce the relationship of dependency to address inequalities between trading partners; in addition, commit to an inclusive trade policy, oriented to sustainable development, the progress of the population, and the creation of global value chains as a competitiveness strategy (Tosoni and Sanchium, 2023; Sanguinet et al., 2022).

Methods

The problem with this scientific investigation was that no research has been found regarding the structure of the international fresh blueberry market in developing countries, which has not contributed to the decision-making of State policies and companies for their production, import, and export. It is important for the sustainable development of agriculture and the consumption of fresh products that contribute to human health. In this sense, the general purpose was to evaluate the structure of the international fresh blueberry market in the period 2001–2020.

For calculating per capita consumption, historical data in tons of world blueberry production, imports, and exports in the period 2001–2020 was used; likewise, the quantities of harvested areas in hectares (ha) and yield in kilograms per hectare (kg/ha) obtained from the Food and Agricultural Organization (FAO) of the United Nations were taken into account. The population data were obtained from the World Bank (WB) for the entire period. Prices per ton were obtained from the International Trade Center (ITC) (2017). In addition, the [CR (k)], the HHI, and the Theil Entropy indices (E) of production, imports, and exports were calculated with statistical data in tons obtained from the FAO. Finally, the study variables were standardized into indexes for determining the multiple linear regression model of blueberry exports.

$$\text{Index} = \frac{\left(X_j - \overline{X}_w\right)}{S_w} \tag{1}$$

where: X_j: study variable of a country "j" for the product; $\overline{X}_w$: average of study variable of the world "w" for the product

For calculating the per capita consumption of sheep meat, Ramírez-López et al. (2020) took into account production, imports, and exports in tons (t) and population (number of inhabitants of a country). In this sense, for calculating the per capita consumption (PC) of blueberries per person in each country (expressed in kg/year), the following mathematical equation was used:

$$\text{CP}_j^t = \left[\frac{\left(P_j^t + M_j^t\right) - X_j^t}{\text{Pobl.}_j^t}\right] \tag{2}$$

where P_j^t: country production; M_j^t: country imports; X_j^t: country exports; Pobl._j^t: country population; j: country of study; t: year of study

For the calculation of the concentration index [CR (k)], the participation of blueberry producing, importing, and exporting countries was taken into account, considering k as four and eight, as shown in the equation:

$$\text{CR}(k) = \sum_{j=1}^{k}\left[\frac{P_j^t}{P_w^t} * 100\right] \tag{3}$$

$$\text{CR}(k) = \sum_{j=1}^{k}\left[\frac{M_j^t}{M_w^t} * 100\right] \tag{4}$$

$$\mathrm{CR}(k) = \sum_{j=1}^{k} \left[\frac{X_j^t}{X_w^t} * 100 \right] \quad (5)$$

where $\frac{P_j^t}{P_w^t} * 100$: share of production (%) of country "j" and year "t", with respect to the world "w"; $\frac{M_j^t}{M_w^t} * 100$: share of imports (%) of country "j" and year "t", with respect to the world "w"; $\frac{X_j^t}{X_w^t} * 100$: share of exports (%) of country "j" and year "t", with respect to the world "w".

The concentration indexes [CR (4)] and [CR (8)] of the main producing, importing, and exporting countries of blueberries in tons were calculated based on the theory of Bain (1959), as cited by Coelho et al. (2018). The results of the calculations were the following: (a) the structure is low when the four largest exporting countries have a market share of ≤35%, (b) it is moderately low between 35% and 50%, (c) it is moderately high between 50% and 65%, (d) it is high between 65% and 75%, and (e) it is very high >75%. In addition, when the eight countries with the largest market share are measured: (a) the structure is low if they have a market share of less than or equal to 45%, (b) it is moderately low between 45% and 70%, (c) it is moderately high between 70% and 85%, (d) it is high between 85% and 90%, and (e) it is very high >90%.

For calculating the HHI, the squared participation of the production, imports, and exports of blueberries were considered, where (n) is the number of countries as shown in the equation:

$$\mathrm{HHI} = \sum_{j=1}^{n} \left[\frac{P_j^t}{P_w^t} * 100 \right]^2 \quad (6)$$

$$\mathrm{HHI} = \sum_{j=1}^{n} \left[\frac{M_j^t}{M_w^t} * 100 \right]^2 \quad (7)$$

$$\mathrm{HHI} = \sum_{j=2}^{n} \left[\frac{X_j^t}{X_w^t} * 100 \right]^2 \quad (8)$$

where: $\left[\frac{P_j^t}{P_w^t} * 100\right]^2$: production share (%) squared for country "j" and year "t", with respect to the world "w"; $\left[\frac{M_j^t}{M_j^t} * 100\right]^2$: import share (%) squared for country "j" and year "t", with respect to the world "w"; $\left[\frac{X_j^t}{X_w^t} * 100\right]^2$: export share (%) squared for country "j" and year "t", with respect to the world "w".

The HHI is often used for measuring market concentration and is calculated by summing the squares of the market shares of individual companies ranging from 0 in markets without concentration to 10,000 in markets in which a company has 100% market share [monopoly] (US Department of Justice and the Federal Trade Commission, 2010). They are generally classified into three tiers: (a) non-concentrated markets with an HHI below 1500, (b) moderately concentrated markets with an HHI between 1500 and 2500, and (c) highly concentrated markets with an HHI above 2500 (US Department of Justice and the Federal Trade Commission, 2010).

For calculating the Theil Entropy indices (E) the (−) sums of the participations multiplied by their natural logarithm of blueberry production, imports, and exports were considered, where: (n) is the number of countries as shown in the equations:

$$E = -\sum_{j=1}^{n} \left[\frac{P_j^t}{P_w^t} * 100 \right] * \ln \left[\frac{P_j^t}{P_w^t} * 100 \right] \quad (9)$$

$$E = -\sum_{j=1}^{n} \left[\frac{M_j^t}{M_w^t} * 100 \right] * \ln \left[\frac{M_j^t}{M_w^t} * 100 \right] \quad (10)$$

$$E = -\sum_{j=1}^{n} \left[\frac{X_j^t}{X_w^t} * 100 \right] * \ln \left[\frac{X_j^t}{X_w^t} * 100 \right] \quad (11)$$

where:

$\left[\frac{P_j^t}{P_w^t} * 100\right]$: participation of the production (%) of the country "j" and year "t", in respect to the world "w"; $\left[\frac{M_j^t}{M_w^t} * 100\right]$: participation of the production (%) of the country "j" and year "t", in respect to the world "w"; $\left[\frac{X_j^t}{X_w^t} * 100\right]$: participation of the production (%) of the country "j" and year "t", in respect to the world "w"; ln: natural logarithm.

The Theil Entropy index (E) is an inverse measure of concentration indices (Lis-Gutiérrez, 2013). That is, in economic terms, an index E equal to 0 ($E = 0$) indicates a very high concentration (Coelho Junior et al., 2019). The average growth rate (AGR) evaluates the growth of market imports as shown in the following equation:

$$\mathrm{TCP}\left(M_j^t\right) = \left[\sqrt[\frac{1}{t-t_0}]{\frac{M_j^t}{M_j^{t_0}}} - 1 \right] * 100 \quad (12)$$

where: M_j^t: value of imports in the market j of the last year t. $M_j^{t_0}$: value of imports of the market j of the initial year t_0. $t-t_0$: number of study years, if it is "n" years, then $t-t_0 = n-1$.

The market share (P) is evaluated with the next equation:

$$P\left(M_j^t\right) = \frac{M_j^t}{M_w^t} * 100 \quad (13)$$

where M_j^t: value of imports of the market j. M_w^t: value of imports of the product of the world "w".

The market share rate (MSR) index is determined by the study years of the market.

The average growth rate (AGR) index and the MSR are calculated with the following equations:

$$\text{AGR index} = \frac{\left(\mathrm{AGRM}_j - \mathrm{X\bar{A}GRM}_w\right)}{\boldsymbol{\sigma}\mathrm{AGRM}_w} \quad (14)$$

$$\text{MSR index} = \frac{\left(\mathrm{MSRM}_j - \mathrm{X\bar{M}SRM}_w\right)}{\boldsymbol{\sigma}\mathrm{MSRM}_w} \quad (15)$$

where: $\mathrm{X\bar{A}GRM}_w$: is the mean of the AGR of the world "w" for the product. $\boldsymbol{\sigma}\mathrm{AGRM}_w$: is the standard deviation of the AGR of the world "w" for the product. $\mathrm{X\bar{M}SRM}_w$: is the mean of MSR of the world "w" for the product. $\boldsymbol{\sigma}\mathrm{MSRM}_w$: is the standard deviation of MSR of the world "w" for the product. AGR and MSR indexes will be taken into account for the international market segmentation.

Results and discussion

Results. For determining the per capita consumption of blueberries (kg/person), the production of 45 countries, imports from 130 countries, and exports from 102 countries (amounts taken from FAO in tons) have been considered. The per capita consumption of blueberries in the world has had increasing behavior in the study period. Table 1 shows the 10 main consuming countries in the order of the year 2020. Canada has positioned itself as the main consumer, because it increased its consumption from 2.6 kg in 2001 to 7.4 kg in 2020, followed by Estonia which

Table 1 Annual per capita consumption of the top 10 blueberry countries (kg/person).

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Canada	2.6	2.5	3.3	3.2	3.1	3.7	3.6	4.6	5.0	4.4	5.5	6.1	5.6	7.8	7.0	9.3	7.4	7.2	8.5	7.4
Estonia	0.0	0.0	0.0	0.5	0.8	1.0	1.3	0.8	2.4	0.8	1.1	0.0	0.0	0.0	0.1	0.7	0.1	0.1	0.3	2.9
USA	1.2	1.3	1.4	1.5	1.4	1.6	1.5	1.8	1.7	1.8	2.0	2.2	2.4	2.4	2.5	2.7	2.4	2.7	2.6	2.6
Lithuania	2.8	2.8	3.0	2.1	2.9	2.7	2.2	1.4	0.8	0.5	0.5	0.5	0.4	0.5	0.6	0.8	0.5	0.3	0.6	1.5
Netherlands	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.3	0.6	0.4	0.5	0.7	0.9	0.6	0.9	0.7	1.3	1.5
Poland	0.8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.1	0.1	0.2	0.2	0.5	0.7	1.3
Chile	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.5	0.0	0.2	0.3	0.2	0.4	0.7	1.1	1.1
Portugal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.4	0.6	0.8	0.8	1.2	1.1
Austria	0.1	0.1	0.2	0.2	0.3	0.2	0.2	0.2	0.3	0.3	0.3	0.1	0.4	0.3	0.4	0.2	0.3	0.6	0.8	0.9
Norway	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.5	0.9	0.8	0.7	0.8	0.9	0.8	0.8	0.9

Source: Own calculations based on production, imports, and exports data in Tn of FAO (2021), available at https://www.fao.org/faostat/en/#data. World Bank's (2022) population data was used to calculate per capita consumption from 2001 to 2020, available at https://datacatalog.worldbank.org/search/dataset/0037996/StatisticalPerformance-Indicator.

increased its consumption from 0.5 kg in 2004 to 2.9 in 2020. The United States of America was in third place because it increased its consumption from 1.2 kg in 2001 to 2.6 kg in 2020. It should be noted that the average growth rate of the annual per capita consumption (APCAGR) for these countries in the study period was 6.9%, 130.3%, and 4.3%, respectively. In addition, the APCAGRs in the following countries were: Lithuania (6.4%), Netherlands (16.1%), Poland (27.6%), Chile (279.6%), Portugal (599.3%), Austria (28.5%), Norway (113.2 %), Switzerland (14.2%), Spain (21.4%), and Germany (37%).

Figure 1 shows the concentration index [CR (k)] of the production, imports, and exports of blueberries. In 2004, the four main producers [CR (4)] were the United States, Canada, France, and Turkey, the year in which the market share of the United States of America was the highest in the study period (63.7%). These countries concentrated 92.5% of the market and the eight main producing countries [CR (8)] were led by the aforementioned countries, followed by Chile, Spain, Lithuania, and Poland, countries that concentrated 96% of the market. By 2020, the four main producing countries [CR (4)] were the United States, Canada, Peru, and Chile, which concentrated 84.1% of the market, and the eight main producing countries [CR(8)] led by countries before mentioned, followed by Poland, Mexico, Spain, and Portugal, countries that concentrated 95.4% of the market. In this period, the concentration of the producing countries [CR (4)] decreased by 8.4% and [CR (8)] had an insignificant variation.

The four main importing countries [CR (4)] were the United States, Canada, the United Kingdom, and The Netherlands in 2008. These countries concentrated 91.6% of the market, the highest in the period and the eight main importing countries [CR (8)] led by the aforementioned countries (followed by Germany, Austria, France, and Estonia) concentrated 96% of the market. By 2020, the four main importing countries [CR (4)] were the United States, the Netherlands, Germany, and Canada, which concentrated 72.8% of the market, and the eight main importing countries [CR (8)] led by countries mentioned above, followed by the United Kingdom, Spain, Poland, and France concentrated 88.7% of the market. In this period, the level of concentration of importing countries [CR (4)] decreased by 18.8% and the concentration of [CR (8)] fell by 7.2%.

Finally, the four main export countries [CR(4)] in 2008 were Canada, the United States, Chile, and Poland, which concentrated 93.5% of the market, the highest of the study period. The eight main export countries [CR (8)] led by the aforementioned countries (followed by the Netherlands, France, Belgium and Spain) concentrated 97% of the market. By 2020 the four main export countries [CR (4)] were Peru, Chile, The Netherlands, and Canada, which concentrated 70% of the market and the eight main export countries [CR (8)] led by the aforementioned (those mentioned above followed by the United States, Spain, Morocco, and Poland) concentrated 93.2% of the market. In this period, the concentration of the exporting countries [CR (4)] decreased by 23.5% and the concentration of [CR (8)] fell by 3.8%.

Therefore, based on Bain's theory (1959), cited by Coelho et al. (2018), the structure is high when the four largest countries [CR (4)] have between 65 and 75% of the market and the structure is very high when they have a market share greater than 75%. Likewise, the structure is high when the eight largest countries [CR (8)] have between 85 to 90% of the market and the structure is very high when they have a market share greater than 90%. In this sense, the market structure of fresh blueberries was found at a very high concentration level with [CR (4)] and [CR (8)].

The fresh blueberry import market in tons went from a concentration level [CR (4)] and [CR (8)] very high to a high level, in the study period; that is, the structure of the international blueberry market in production has remained

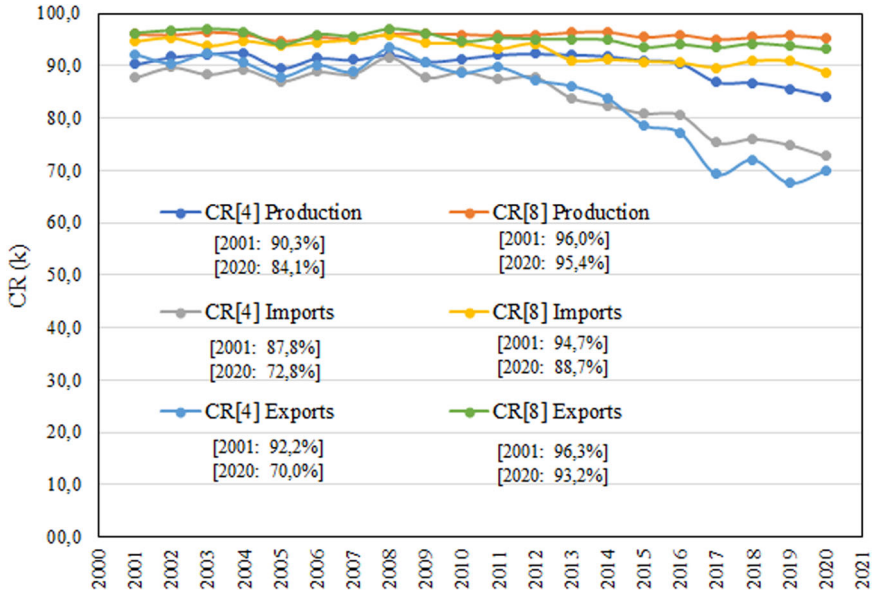

Fig. 1 Concentration index CR (*k*) of production, imports, and exports of blueberries. *Source*: Own calculations based on FAO (2021)'s data (production, imports, and exports data in Tn), available at https://www.fao.org/faostat/en/#data.

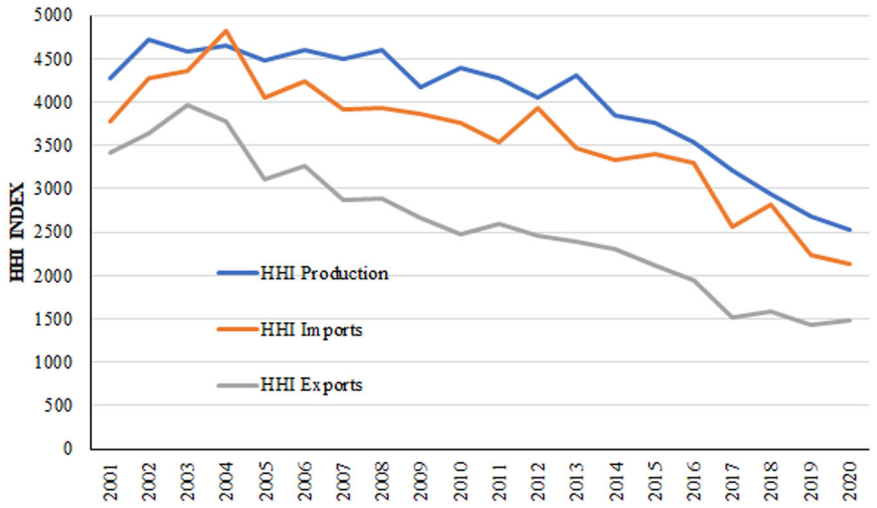

Fig. 2 Herfindahl–Hirschman Index (HHI) of blueberry production, imports, and exports. *Source*: Own calculations based on FAO (2021)'s data (production, imports, and exports data in Tn), available at https://www.fao.org/faostat/en/#data.

in a very high concentration; for its part, the structure of the international fresh blueberry market in imports has been decentralized because more countries are importing this product. In addition, the market structures of the fresh blueberry exports of the [CR (4)] and [CR (8)] were at a high and very high level of concentration, respectively; that is, the international fresh market for export blueberries was with a tendency to be a decentralized market as more countries participate in exports.

Figure 2 shows the Herfindahl–Hirschman (HHI) index of production, imports, and exports. The HHI of the production was 4717 in 2002, the highest of the study period, the year in which the market share of the United States of America also was the highest in the study period (65.1%). The HHI of the production was 2534 in 2020, the lowest of the period, the year in which the market share of the United States of America also was the lowest of the study period (43.1%). In addition, it is observed that the HHI of production was found above 2500, but with a tendency to decrease.

With respect to the level of import concentration, the HHI of imports in 2004 was 4816, the highest in the study period, the year in which the market share of the United States of America was the highest in the period (66.8%). By 2020, the HHI of imports fell to 2133, the lowest concentration level of the period, the year in which the market share of the United States of America was the lowest in the period (40.9%). In addition, it is observed that the HHI of imports has decreased as more countries increased their blueberry imports.

Finally, with respect to the level of export concentration, the HHI of exports was 3975 in 2003, the highest of the study period, the year in which Canada's market share was the highest in the period (56.7%). For 2019, the HHI of exports fell to 1429, the lowest of the period, the year in which the participation of the five main export countries represented 77.8%. It is worth mentioning that the HHI of exports found a tendency to a decentralized market as more countries participate in exports.

Based on the U.S. Department of Justice and the Federal Trade Commission (2010), the market structure of blueberry production

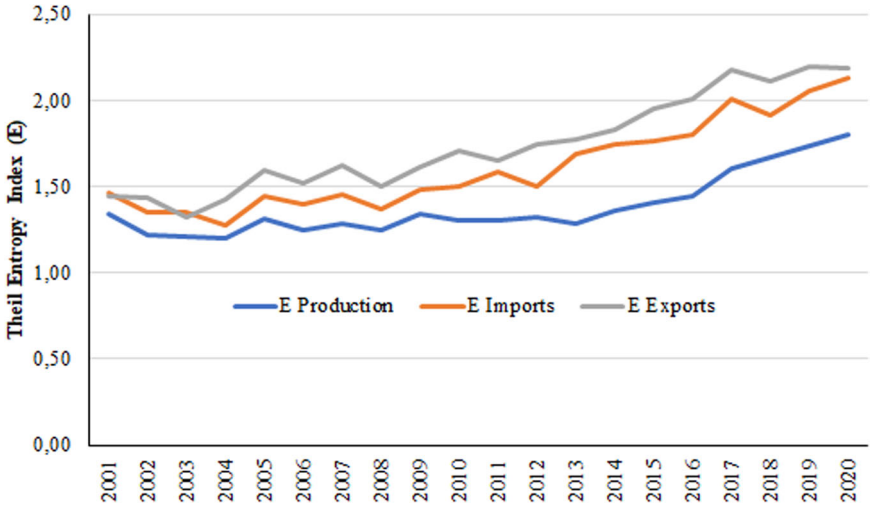

Fig. 3 Theil Entropy Index (E) of blueberry production, imports, and exports. *Source*: Own calculations based on FAO (2021)'s data (production, imports, and exports data in Tn), available at https://www.fao.org/faostat/en/#data.

in the study period was at a highly concentrated level being over 2500; however, it is observed that it is a tendency to become a moderately concentrated structure. On the other hand, the international market structure of fresh blueberry imports was found at a highly concentrated level in the period 2001 to 2018 and from 2019 it fell to a moderately concentrated level; that is, greater participation of countries in imports of this product was found.

Finally, the international exports market structure was at a highly concentrated level in the 2001–2009 period; however, in the 2010–2018 period (except in 2011), 2500 was exceeded, being at a moderately concentrated level; in addition, since 2019 it fell to an unconcentrated level because the HHI was below 1500. Therefore, the structure of the international fresh blueberry market in exports was at an unconcentrated level because more countries are participating in exports.

Figure 3 shows the Entropy index of Theil (E) of production, imports, and exports. This index is an inverse measure to concentration indices; that is, Theil's entropy index (E) is closer to zero (0) when the level of concentration of the rates [CR (k)] and HHI are very high and the Entropy index of Theil (E) is the ride from zero (0) when the concentration level is lower.

For determining the model of fresh blueberry exports, the data were first standardized by year into indices and then the averages of the indices of 32 countries that have information on all variables were calculated, as shown in Table 2. Likewise, multiple linear regression was used as shown in the following equation:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \mathcal{E} \quad (16)$$

where: Y is the exports index; β_0 is the constant; $\beta_{1,2...7}$ is the coefficients; X_1 is the per capita consumption index; X_2 is the production index; X_3 is the performance index kg/ha; X_4 is the harvested area index (ha); X_5 is the price index; X_6 is the average participation index (API); X_7 is the average growth rate index (AGRI) and Ɛ is the error term.

For explaining the behavior of the dependent variable "exports" or "Y" with its seven independent variables, the multiple linear regression model was used with IBM SPSS version 25 software. For this purpose, the stepwise method was used. In this sense, the software considered the following independent variables: (a) per capita consumption index, (b) price index, (c) average participation index (API), and (d) production index. However, this method did not consider the following variables: (a) yield index kg/ha, (b) harvested area index (ha), and (c) average growth rate index (AGR index).

Table 3 shows the summary of the multiple linear regression model, in which the explanatory (independent) variables are: (1) per capita consumption index, (2) price index, (3) API index, and (4) production index; on the other hand, the exports variable was considered as dependent. In the fourth model, an adjusted $R^2 = 0.943$ is observed, which means that the variability of the exports variable is explained in 94.3% of the cases by the four explanatory variables. Furthermore, the model shows a Durbin–Watson of 1.537 which indicates that there is no autocorrelation. Durbin–Watson values vary between 0 and 4, with a value of 2 meaning that the residuals are uncorrelated (Field, 2017; Groebner et al., 2018) and values <1 or >3 are cause for concern as a very conservative rule of thumb (Field, 2017).

Table 4 shows the ANOVA of the model with the four explanatory variables. The results are very significant for the prediction of the dependent variable because the model has an $F = 128.543$ and $p < 0.001$.

Table 5 shows the coefficients of the model together with the variance inflation factors (VIF), which allows us to verify that there is no multicollinearity, due to that they are between 1.092 and 1.869 (theoretically the criterion to take into account is that no value should be >10, but close to 1). In this sense, the multiple linear regression model is expressed in the following equations:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \mathcal{E} \quad (17)$$

$$y = -0.035 + 0.551 x_1 + 0.470 x_2 - 0.179 x_3 + 0.143 x_4 + \mathcal{E} \quad (18)$$

where X_1 is the per capita consumption index; X_2 is the average participation index (API); X_3 is the price índex; X_4 is the production index and Ɛ is the error.

For the coefficients of the regression model, the "t" scores indicate that the variables taken into account contribute significantly to the prediction model and that the values obtained can be generalized to the population (t: 9.886; 11.412; −2.432; 2.148; $p < 0.005$).

Discussion

The per capita consumption of fresh blueberries began to grow in the year 2000 (Shi et al., 2011), mainly driven by consumers looking for fresh products of good quality, flavor, taste, aroma, new lifestyles, health care environment, and for the benefits to people's

Table 2 Indices of "Exports" (dependent variable) and their independent variables.

No.	Countries	Indexes							
		Exports	Consumption per capita	Production	Performance (kg/ha)	Area harvested	Price	API	AGRI
1	Canada	4.5	5.3	1.8	2.8	3.3	−0.9	1.7	−0.6
2	USA	2.7	1.8	4.8	3.4	3.7	−0.2	2.4	−0.5
3	Lithuania	−0.3	1.5	−0.3	−0.6	−0.1	0.0	−0.3	−0.6
4	The Netherlands	0.4	0.1	−0.2	0.4	−0.3	0.9	1.8	−0.1
5	Poland	0.1	−0.1	−0.2	−0.2	0.0	0.0	0.3	−0.2
6	Chile	2.8	−0.3	0.2	0.2	0.4	0.2	5.6	−0.5
7	Portugal	−0.3	−0.1	−0.3	−0.7	−0.3	0.4	−0.3	0.0
8	Austria	−0.3	0.0	−0.3	−0.7	−0.4	0.1	−0.4	0.1
9	Norway	−0.3	0.0	−0.3	−0.6	−0.4	0.2	−0.4	−0.7
10	Swiss	−0.3	−0.1	−0.3	0.0	−0.4	0.2	−0.4	−0.5
11	Spain	0.2	−0.1	−0.2	1.2	−0.3	0.8	2.2	−0.1
12	Germany	−0.2	−0.1	−0.2	−0.2	−0.2	0.1	−0.1	−0.3
13	Peru	0.5	−0.3	−0.1	−0.3	−0.2	−0.1	1.8	3.9
14	Slovenia	−0.3	−0.3	−0.3	−0.7	−0.4	0.2	−0.4	0.0
15	Denmark	−0.3	−0.2	−0.3	−0.7	−0.4	0.5	−0.4	−0.5
16	New Zealand	−0.2	0.1	−0.3	−0.1	−0.3	1.8	−0.1	−0.5
17	Finland	−0.3	−0.2	−0.3	−0.8	−0.4	−0.7	−0.4	−0.5
18	Belgium	−0.2	−0.3	−0.3	−0.7	−0.4	1.0	−0.1	−0.3
19	Slovakia	−0.3	−0.3	−0.3	−0.8	−0.4	−0.1	−0.4	0.3
20	Croatia	−0.3	−0.3	−0.3	−0.8	−0.4	−0.6	−0.4	1.7
21	Italy	−0.3	−0.3	−0.3	0.5	−0.3	0.8	−0.2	−0.3
22	Türkiye	−0.3	−0.2	−0.2	0.5	−0.4	−0.6	−0.4	1.5
23	North Macedonia	−0.3	−0.3	−0.3	0.0	−0.4	−0.9	−0.4	−1.2
24	Sweden	−0.2	−0.4	−0.3	−0.5	−0.4	−0.7	−0.2	−0.7
25	France	−0.2	−0.1	−0.2	0.0	−0.1	0.7	−0.1	−0.3
26	Russian Federation	−0.3	−0.3	−0.3	−0.2	−0.3	−0.9	−0.4	0.1
27	Bulgaria	−0.3	−0.3	−0.3	−0.1	−0.4	−0.4	−0.4	−1.1
28	Belarus	−0.2	−0.1	−0.3	−0.2	−0.3	−0.9	−0.4	−0.5
29	Ukraine	−0.2	−0.3	−0.3	0.1	−0.3	−0.7	−0.4	−0.3
30	Romania	−0.3	−0.3	−0.3	0.5	−0.3	−0.4	−0.3	0.2
31	Latvia	−0.2	0.2	−0.3	−0.3	−0.3	−0.6	−0.3	−0.4
32	Morocco	0.0	−0.5	−0.3	−0.1	−0.4	−0.2	0.3	0.2

Data were constituted by average indices.

Table 3 Summary of the model.

Model	*R*	R^2	Adjusted R^2	Standard error of the estimation	Durbin-Watson
4	0.975[a]	0.950	0.943	0.261177972057144	1.537

[a]Predictors: (constant), per capita consumption, API, price, production
Dependent variable: exports

Data were obtained with the processing in the IBM SPSS Statistics 25.

Table 4 ANOVA of the model.

Model		Sum of squares	Gl	Mean square	*F*	Sig.
1	Regression	35.074	4	8.768	128.543	0.000[a]
	Residual	1.842	27	0.068		
	Total	36.915	31			

Dependent variable: Exports
[a]Predictors: (constant), per capita consumption, API, price, production

Data were obtained with the processing in the IBM SPSS Statistics 25.

health (Qian et al., 2022; Ferrão et al., 2022; Assunção-Júnior et al., 2022; Massaglia et al., 2018; Peano et al., 2017); that is, the cultivation of blueberries has increased in the world due to the new trends of healthy consumption (Pérez et al., 2022); consequently, the blueberry industry had sustained growth in the last 20 years (Brazelton, 2020). In this sense, the results of the study of the structure of the international blueberry market showed growth in production, imports, and exports that are consistent with the growth of the industry at the international level.

Knowledge of the market structure and competition is important for decision-making in economic policies (Ukav, 2017); especially in the agricultural industry because it has great potential to alleviate poverty in developing countries and the lack of information does not allow better decisions to be made (Nugroho, 2021). In other words, the study of the structure of the international blueberry market is important for

Table 5 Coefficients of the model.

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.	Collinearity statistics	
		B	Desv. error	Beta			Tolerance	VIF
1	(Constant)	−0.035	0.048		−0.722	0.477		
	Per capita consumption	0.551	0.056	0.540	9.886	0.000	0.618	1.617
	API	0.470	0.041	0.563	11.412	0.000	0.759	1.318
	Price	−0.179	0.074	−0.109	−2.432	0.022	0.916	1.092
	Production	0.143	0.066	0.126	2.148	0.041	0.535	1.869

a. Dependent variable: Exports

Data were obtained with the processing in the IBM SPSS Statistics 25.

decision-making by public and private entities of producing countries on issues of agricultural policies, for exporting countries to diversify destination markets, and to know the trend of the per capita consumption, and for importing countries to meet the needs of people and strengthen trade ties with supplier countries. Therefore, although there are many concentration indices, the most widely used are the company concentration index CR (k) and the Herfindahl–Hirschman (HHI) index (Ukav, 2017).

The blueberry industry leaders are in North America, Europe, Chile, and Argentina; however, new industries in Peru, Morocco, Mexico, and Southern Africa have the opportunity for the investment with the future in mind (Brazelton, 2020). In this study, three clusters were found for 2020: (1) North America (consisting of the United States of America and Canada) represented 63.6% of production, 48.9% of imports, 21.1% of exports, and 74.2% of the consumption of blueberries; (2) Europe (consisting of Germany, Poland, Spain, The Netherlands, Portugal, Austria, Switzerland, Norway, Lithuania, and Estonia) represented 9.6% of production, 34.7% of imports, 25.5% of exports, and 14% of the blueberry consumption; and (3) South America (consisting of Chile and Peru) represented 20.5% of production, 43.4% of exports, and only 2.6% of blueberry consumption. It should be noted that the market shares of the 10 countries in 2020 were >90% in production, imports, and exports; likewise, they had an AGR of 5.6%, 11.2%, and 10.6% in the study period, respectively.

The agricultural industry is growing at a faster rate than other sectors of the economy and has great potential in developing countries (Nugroho, 2021); however, 100% of the companies dedicated to the production of blueberries are in the hands of the largest companies in Latin American countries; in addition, according to information on foreign trade from Latin America and the world (Veritrade, 2023), the concentration index of the four exporting companies [CR (4)] shows a concentrated structure: Ecuador (99.9%), Colombia (96.3%), Uruguay (83.5%), Argentina (70.9%), Mexico (67.8%), Peru (43.8%), Chile (43.6%), and one of the companies with the greatest presence within the main exporters was Hortifrut in the period 2014–2022. These results are in agreement[- with Almonacid (2018), who indicated that Hortifrut is the main blueberry-producing company with a presence in the United States, China, Chile, Mexico, Guatemala, Argentina, Uruguay, Spain, Brazil, and Peru; that is, the barriers to entry into the blueberry industry remain high for new companies. Likewise, exports of fresh blueberries are mainly: (1) by sea in refrigerated containers: Peru (96.8%), Chile (88.2%), Ecuador (81.3%), and Colombia (80.3%); (2) by air: Uruguay (60.9%) and Argentina (55.43%); and (3) by road: Mexico (96.8%).

One of the purposes of developing countries is to diversify destination markets because diversification maximizes the exportable supply and reduces the impact of fluctuations in the international market (Macías Badaraco et al., 2019); however, for Latin American countries, the concentration index of the four main destination countries [CR (4)] shows a concentrated structure: Peru and Colombia (91.1%), Chile (86.6%), Argentina (85.1%), and Uruguay (70.6%). Mexico has a destination country (USA) that concentrates 95.6% and Ecuador has 2 destination countries that concentrate 99.7%. The United States of America is the main destination market.

The percentages of exports to the USA from Latin American countries are the following: Mexico (95.6%), Colombia (84.7%), Argentina (58.5%), Peru (52.8%), Chile (52.3%), and Uruguay (43.5%). Ecuador's destination market is the Netherlands, with 87.1% of its exports. The diversification of exports is measured and related to the volume exported by the destination country (Del Rosal, 2019); therefore, the policies implemented for promoting diversification have not had the expected effects, so it is essential to design new guidelines to promote diversification (Prada et al., 2016).

Sufficient export knowledge, export commitment, and product adaptation can increase export performance (Negeri and Ji, 2023); that is, contribute to the growth of the export sector. In this sense, sales volume, market share, and market share growth contribute to export performance (Moreno et al., 2008). Therefore, the mathematical model of the dependent variable exports determined four explanatory variables: (a) per capita consumption, (b) market share, (c) price, and (d) production; That is, these four variables explain 94.3% of the variability in fresh blueberry exports, with per capita consumption (55.1%) and market share (47%) as the variables that contribute the most to explaining the variability of exports (see Table 3).

Conclusions

The main countries with the highest growth in per capita consumption of blueberries in the world in the period 2001–2020 were Canada and the USA. Likewise, European countries such as Estonia, Lithuania, The Netherlands, Poland, Portugal, Austria, and Norway were found within the top ten countries with the highest per capita consumption. In other words, the growth of blueberry per capita consumption is driven by the modern consumer with new lifestyles and connoisseurs of the products for their properties that benefit human health.

In 2020, the USA and Canada represented 63.6% of the production, 48.9% of the imports, 21.1% of the exports, and 74.2% of the consumption of blueberries in the world. On the other hand, 10 countries of the European continent: Germany, Poland, Spain, The Netherlands, Portugal, Austria, Switzerland, Norway, Lithuania, and Estonia represented 9.6% of production, 34.7% of imports, 25.5% of exports, and 14% of blueberry consumption in the world.

Two South American countries (Chile and Peru) represented 20.5% of the production, 43.4% of the exports, and only 2.6% of the consumption of blueberries in the world. In this sense, various potential opportunities exist in the production and export of blueberries for developing countries in the face of a growing demand for blueberries in the international market.

Regarding the concentration index [CR (4)] and [CR (8)], the structure of the international market for the production and

imports of blueberries went from very high levels of concentration to high levels, due to the entry of new players in production and the greater role played by European countries in world imports. Likewise, the structure of the international export market found a tendency towards a decentralized market, considering that more countries participate in exports.

Regarding the HHI, the structure of the international market for blueberry production tended to become a moderately concentrated structure. The structure of the international blueberry import market became moderately concentrated, due to the greater participation of countries in imports of this product. The international market structure of blueberry exports tended towards a decentralized or diversified market. The Theil Entropy index (*E*) [reverse measure] confirmed the demonstrated aspects of the concentration indexes.

The trade policy of developed countries is based on providing tariff preferences to developing countries; in this sense, the bilateral and multilateral trade agreements signed between Canada, the United States of America, and the European Union with some Latin American countries (Chile, Peru, Colombia, Mexico, among others) must provide balance in the global value chain of blueberries, without distorting the market with quotas and subsidies (Absell, 2022; Feng et al., 2022) or through companies that operate in different countries, as is the case of Hortifrut, the main producer of organic blueberries worldwide with presence in the United States of America, China, Chile, Mexico, Guatemala, Argentina, Uruguay, Spain, Brazil, and Peru (Almonacid, 2018).

The trade policies of both blocs must be oriented towards supply and demand; that is, thinking about blueberry producers, so that production is sustainable and generates progress for the population (Tosoni and Sanchium, 2023; Sanguinet et al., 2022) and stagnation in production does not occur as was the case in Argentina and Uruguay, thinking about consumers, the quality of blueberries, and their health benefits (Assunção-Júnior et al., 2022), and because greater market concentration can increase prices and entry barriers (Rabbani, 2023) for new companies in the blueberry industry. Therefore, a less concentrated blueberry industry occurs because the market is more competitive (Wei et al., 2023) and competitiveness in the blueberry industry would benefit all actors in the global value chain.

The multiple linear regression model demonstrated that per capita consumption, market share, price, and production contribute to the variability of fresh blueberry exports. In this sense, companies and countries that are seeking to diversify their exports must take these factors into account.

The study allowed us to evaluate the evolution of per capita consumption and the structure of the international fresh blueberry market of production, imports, and exports, which provided information at a quantitative level. Therefore, the results could be used for decision-making in public policy regarding foreign trade. However, the consumption habits of the countries with the highest per capita consumption and entry barriers to other international markets have not been studied, which limits to provision of comprehensive information on the international fresh blueberry market.

The study of blueberry consumption habits in the main international markets is recommended for future research, taking the 10 main producing, importing, and exporting countries as samples. Furthermore, developing countries are suggested to take into account the factors of the found model for decision-making and for improving their exports and contributing to the development of the fresh blueberry industry.

Data availability

All data generated or analyzed during this study are included in this published article.

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Author contributions

RMH: introduction, methodology, results (calculations and analysis), discussion, and conclusion. His contribution share was 55%. FCNS: conceptualization and literature review. Her contribution share was 5%. ARR: multiple linear regression analysis and comments about its results. His contribution share was 5%. EAAP: introduction, methodology, statistical analysis, discussion, conclusion, English translation, and proofreading. His contribution share was 35%.

Competing interests

The authors declare no competing interests.

Ethical approval

Ethical approval was not required because this study did not include information involving human beings. Additionally, all the collected information was public.

Informed consent

Informed consent was not required because this study did not include information involving human beings.

Additional information

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