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Article

Food sovereignty in the production and marketing of vegetables native to Mexico

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Abstract

The value of horticultural production native to Mexico has grown over time; it was 86.722 billion pesos in 2021. This research aimed to characterize the production and marketing of horticultural products native to Mexico through the food sovereignty approach (1980-2021). The variables were analyzed using descriptive statistics and were supported by trend regression models. The volume of native horticultural production was 10 million 469 thousand tons in 2021, with the production of tomatoes, chilies, beans, husk tomatoes, and squash standing out. Real prices for native horticultural products have declined over time. The apparent national consumption of native vegetables was 3 million 781 thousand tons in 1980 and 6 million 952 thousand tons in 2021; there was, therefore, a growth rate in demand of 83.84%. Self-sufficiency in the production of vegetables, pulses, legumes, and seeds was 150.59%, horticultural trade openness was 9.95%, and the import dependency indicator was 2.27% in 2021. The Mexican Republic must renounce its dependence on a few horticultural products for export and produce the chili and beans necessary to meet the domestic demand required by the country.

Keywords:

consumption, horticultural production, trade.

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Introduction

Countries exercise food sovereignty when they freely decide how they produce and distribute their food in their own territory; according to the Food and Agriculture Organization of the United Nations (FAO, 2013), food sovereignty rests on six pillars: food is more than just a commodity, it respects food suppliers, knows the agrifood chains, controls locally, uses sustainable technologies, and is compatible with natural resources.

Food sovereignty differs from food security, as the latter is based on the availability, access to food, biological utilization, and stability of the three elements mentioned above (FAO, 2013). The concepts of food security and food sovereignty are sometimes used interchangeably or are considered diametrically opposed; the sovereign is understood as the nation-state, a region, a locality, or the people, and it is the one who ensures the well-being of farmers and consumers (Edelman, 2014).

Food sovereignty is an antithesis to corporate forms of food production, managed with the discourse of trade freedom in the World Trade Organization (McMichael, 2014); it is a path for the defense of the peasant pathway as a means to produce food sustainably (Bernstein, 2014).

Food sovereignty is a struggle against a capitalist model based on land alienation, the assignment of specific gender-specific roles, and the commodification of nature and genetic resources (Grey and Patel, 2014). Food sovereignty is a concept that recalls the need to build diversity where the terms of community and ecology come together (Agarwal, 2014).

The food sovereignty movement is not opposed to international trade but rather to the privileged place given to trade in terms of policies and rules in agrifood production (Burnett and Murphy, 2014). Food sovereignty policies focus on an agroecological production model, state protection, counter-hegemonic discourse, food as a human right, local production, hunger generated by inequality, refusal to use genetically modified seeds, access to land, predominance of collective values, and health equity (López, 2015; Weiler *et al*., 2015).

The methodologies to address food sovereignty are numerous; Vergara *et al*. (2022) report that the topic has been studied qualitatively and quantitatively: in the first approach, it is analyzed from the historical, analytical, synthetic, phenomenological point of view and through the case study and concerning the second approach, it has been explained using inferential statistics, multicriteria analysis, multiple linear regression, and multiple equations.

Ayala and Schwentesius (2014) point out that food security and sovereignty can be addressed through the product system approach, the revealed competitiveness index, the calculation of food self-sufficiency, the agricultural trade openness index by product, and the SWOT matrix. Valencia *et al*. (2019) used Johansen's cointegration approach to explain Mexico's food sovereignty of basic grains, obtaining income and price elasticities of import demand, and they concluded that Mexico had lost sovereignty by becoming more dependent on imports.

In Chile, food sovereignty in sustainable food production was analyzed through sampling; the parameters studied were access to resources, production models, transformation and marketing, food consumption and the right to food, and agrarian policies (Franco *et al*., 2021). The objective of the research was to characterize the production and marketing of horticultural products native to Mexico through the food sovereignty approach for the period between 1980 and 2021.

Materials and methods

The variables developed to characterize sovereignty in the production and marketing of horticultural products native to Mexico were analyzed using descriptive statistics (Infante and Zárate, 2012) and with the help of trend regression models (Gujarati and Porter, 2010; Greene, 2018). The statistics used were: maximum value; minimum value; average

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$$\left(\bar{X}=\frac{\sum_{i=1}^{n} X_i}{n}\right)$$

; median (intermediate value of observations); growth rate

$$\left[\left(\frac{\text{Final value}}{\text{initial value}}-1\right)*100\right]$$

; real price

$$\left(\frac{\text{nominal price}}{\text{CPI base 2018}}*100\right)$$

; variance

$$\left(\sigma_X^2=\frac{\sum_{i=1}^{n}(X_i-\bar{X})^2}{n-1}\right)$$

; standard deviation

$$\left(\sigma_X=\sqrt{\sigma_X^2}\right)$$

; coefficient of variation

$$\left(CV=\frac{\sigma_X}{\bar{X}}*100\right)$$

; and correlation coefficient

$$\left(\rho_{XY}=\frac{\text{Cov}(X,Y)}{\sqrt{\text{Var}(X)}\sqrt{\text{Var}(Y)}}=\frac{\sigma_{XY}}{\sigma_X\sigma_Y}\right)$$

The trend line equation y= βX+c was estimated by the ordinary least squares method. Where: X_i and Y_i = observed values, n= total number of observations, nominal price is the current price, CPI base 2018 is the national consumer price index (CPI) with base year 2018, σ_{XY} = covariance between variable X and Y, σ_X = standard deviation of variable X σ_Y= standard deviation of Y, y = predicted value, c= intercept, and β the slope.

The variables used were indicators of national native horticultural production, the evolution of the real prices of native horticultural products (forage products were included), national demand or apparent national consumption (ANC), obtained from the sum of production and imports and exports were subtracted, food self-sufficiency in vegetables native to Mexico (production/production + imports-exports) (Ayala *et al*., 2012; Ayala and Schwentesius, 2014), horticultural trade openness index, calculated with the sum of imports plus exports as a percentage of GDP (Durán and Álvarez, 2008; Ayala *et al*., 2012), horticultural import dependency (imports/production + imports - ending inventory), based on the calculation of the Center for the Study of Sustainable Development and Food Sovereignty (CEDRSSA, 2007).

The list of plant species native to the Mexican Republic, which includes vegetables, pulses, legumes, and seeds, was taken from the inventories of the National Commission for the Knowledge and Use of Biodiversity (CONABIO, 2008) and the checklist of native vascular plants of Mexico (Villaseñor, 2016). The data were obtained from the Agrifood and Fisheries Information Service (SIAP-SIACON, 2023), the Food and Agriculture Organization of the United Nations (FAOSTAT, 2023) and the CPI of the National Institute of Statistics and Geography (INEGI, 2023).

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In the international trade of horticultural products, only those products that have their center of origin in Mexico are considered. Values and prices are at constant 2018 prices, production volumes in tons (t) and areas in hectares (ha).

Results and discussion

Indicators of horticultural production originating in Mexico

The sown area allocated to horticultural production native to Mexico has decreased over time, while the harvested area went from 1 million 753 thousand hectares in 1980 to 2 million 75 thousand hectares in 2021 (Table 1), indicating that there was a growth rate in the harvested area of 18.32%.

Table 1. Horticultural production native t Mexico (1980-2021).

Year	Area sown (ha)	Area harvested (ha)	Area damaged (ha)	Production (t)	Average yield (t ha^{-1})	Production value (thousand pesos at 2018 prices)
1980	2 180 136	1 753 748	4 26 388	3 462 360	6.65	49 576 232
1985	2 327 647	1 997 663	329 590	3 955 162	8.32	54 345 041
1990	2 547 002	2 350 815	194 769	4 977 544	9.85	66 781 656
1995	2 621 264	2 289 687	330 490	5 605 731	13.23	50 184 989
2000	2 470 005	1 840 146	628 850	6 189 953	12.17	51 962 027
2005	2 110 706	1 604 638	504 046	7 077 374	14.43	53 837 898
2010	2 252 592	1 976 519	269 293	7 971 970	15.06	62 785 543
2015	2 091 097	1 952 077	137 261	9 289 297	17.83	72 073 062
2020	2 130 628	1 975 345	155 110	10 467 818	17.97	90 597 684
2021	2 105 722	2 075 045	30 477	10 469 398	17.81	86 722 705

Data from SIAP-SIACON and INEGI's CPI.

The maximum harvested area was 2 million 472 thousand hectares, recorded in 1998, and the minimum was 1 million 228 thousand hectares in 2011. Ayala *et al*. (2012) pointed out that, in vegetables, the area harvested has increased and that production has been favored by the technification of irrigation systems. The volume of native horticultural production had an increasing trend over time; the maximum volume produced was 11 million 5 thousand tons recorded in 2018, and there was a growth rate in production of 202.38%, comparing the years 1980 and 2021.

As the sown area has remained in the order of 2 million hectares, the increase in production volume is explained by increased horticultural yields. Sosa and Ruiz (2017) found that agricultural production (including vegetables, pulses, legumes, and seeds) increased in the period from 1980 to 2015. For their part, Cruz *et al*. (2013) noted that the main factors explaining the growth in the volume of horticultural production between 1994 and 2009 were yields and, to a lesser extent, area.

The maximum yield in horticultural production native to the Mexican Republic was 18.24 t ha^{-1}, recorded in 2018, and the minimum of 6.65 t ha^{-1}, occurred in 1980. The average yield in the study period was 12.98 t ha^{-1}, and the yield growth rate was 167.95% comparing 1980 and 2021. The increases in the yields of native horticultural production are mainly explained by the increases in both the labor and capital factors.

Regarding the value of production, it stood at 49.576 billion pesos in 1980 and at 52.811 billion pesos when Mexico entered the General Agreement on Tariffs and Trade (GATT) in 1986, the value continued to increase and reached 53.433 billion pesos when the country entered the North American Free Trade Agreement (NAFTA) in 1994.

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The highest growth rate of the value of native horticultural production compared to the previous year was 65.84% in 1990, the lowest was -29.01% in 1988; there was a rate of 64.21% comparing the years 1986 and 2021: economic policies of free access to markets had a little significant effect on the growth of the value of native horticultural production.

For 2021, in the sown area, the following crops stood out: beans with 1 million 690 thousand hectares, green chili with 83 thousand hectares, and chihua squash with 70 thousand hectares. As a proportion of the total area sown in the year in question, beans, green chili, and chihua squash accounted for 80.27%, 3.98%, and 3.34%, respectively. In the damaged area, beans stood out with 68.07%, chihua squash with 20.37%, and green chili with 6.19%. On the other hand, the following crops stood out in terms of volume (and represented of the total): tomatoes (31.75%), green chili (23.48%), beans (12.31%), nopalitos (tender cactus) (8.3%), husk tomatoes (7.88%), and zucchini (5.39%); the latter is explained by the fact that these products are the basis of the diet of the Mexican population.

The highest yields in 2021 were obtained in the production of nopalitos (69.8 t ha^{-1}), tomato (69.34 t ha^{-1}), and chayote (65.13 t ha^{-1}); the lowest yields were recorded in beans (0.77 t ha^{-1}), chia (0.76 t ha^{-1}), and chihua squash (0.6 t ha^{-1}). In the total value of native horticultural production, tomatoes stood out with 31.99%, green chili with 23.95%, and beans with 20.83%. No records were found of the production of jaltomate and chipilín.

Behavior of real prices of vegetables native to Mexico

The real prices of native horticultural products have decreased over time; if the prices of 1980 and 2021 are compared, there was a growth rate in the price of zucchini of -47.46%; sweet potato, -40.43%; chayote, -45.67%; green chili, -35.70%; epazote, -10.89%; beans, -43.97%; sunflower, -53.39%; huazontle, -44.20; jicama, -34.50%; pápalo, -79.08%; tomato, -12.38%; husk tomato, -59.49%. In the case of amaranth, it was -83.78% (comparing 1985 and 2021), in chilacayote -83.06% (1990 and 2021), pipicha -87.85% (1990 and 2021); negative growth rates were also recorded in dried chili, forage beans, cowpeas, forage sunflower, and forage nopal.

The decline in the real prices of native horticultural products means that producers receive fewer economic resources for their traded products. Martínez and Martínez (2013) indicated that total factor productivity in agriculture did not grow between 1991 and 2005 and that input prices have grown faster than the price of agricultural products (horticultural products were included in the analysis).

Nevertheless, there were cases of products that had positive growth rates comparing the years 1980 and 2021; for squash, the price went from $6 630.00 to $7 344.00 t^{-1} (rate of 10.77%); chihua squash, $23 937.00 to $26 743.00 t^{-1} (11.72%); chia, $15 702.00 to $50 348.00 t^{-1} (220.65%); nopalitos, $2 617.00 to $3 002.00 t^{-1} (rate of 14.72%). For its part, in quelite, the price was $7 448.00 t^{-1} in 1990 and $10 402.00 t^{-1} in 2021, there was therefore a growth rate of 39.66%.

In the statistical analysis, the maximum prices occurred in amaranth ($106 000.00 t^{-1}), chia ($85 000.00 t^{-1}) and dried chili ($77 000.00 t^{-1}); the minimums were recorded in forage beans ($775.00 t^{-1}), forage sunflower ($480.00 t^{-1}) and forage nopal ($371.00 t^{-1}). Those with the highest variation with respect to the mean were forage sunflower (97.56%), amaranth (88.84%) and pipicha (87.55%) (Table 2).

Table 2. Statistical analysis of the real rural average price ($ t^{-1}).

Product	Maximum	Minimum	Mean	Median	σ^2_x	σ_x	CV
Amaranth	106 274	6 953	21 747	13 791	373 286 136.45	19 320.61	88.84
Zucchini	10 976	5 079	7 130	6 411	2 894 274.27	1 701.26	23.86
Squash	19 921	2 486	8 076	6 840	17 809 023.36	4 220.07	52.25

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Product	Maximum	Minimum	Mean	Median	σ^2_x	σ_x	CV
Chihua squash	55 742	15 510	29 281	26 858	83 971 914.13	9 163.62	31.3
Sweet potato	7 328	3 883	5 183	4 820	993 895.73	996.94	19.23
Chayote	11 122	2 636	4 715	3 643	4 579 534.99	2 139.98	45.38
Chia	85 816	2 793	30 766	24 409	617 058 539.05	24 840.66	80.74
Chilacayote	24 660	3 546	7 206	5 445	23 378 455.77	4 835.13	67.1
Dried chili	77 409	40 472	54 628	52 015	97 716 210.26	9 885.15	18.1
Green chili	18 055	5 940	10 482	9 158	13 727 943.02	3 705.12	35.35
Epazote	8 835	2 458	4 374	4 018	2 066 621.97	1 437.58	32.86
Beans	25 480	9 353	14 893	13 854	16 468 524.69	4 058.14	27.25
Forage beans	999	775	867	851	7 245.45	85.12	9.81
Cowpeas	15 003	5 148	6 684	5 942	5 740 420.4	2 395.92	35.84
Sunflower	17 206	3 029	8 434	7 349	11 158 116.51	3 340.38	39.61
Forage sunflower	3 952	480	1 103	648	1 157 706.62	1 075.97	97.56
Huauzontle	8 446	2 264	3 979	3 573	2 135 448.12	1 461.32	36.72
Jicama	6 222	2 491	3 894	3 676	692 314.03	832.05	21.37
Forage nopal	1 908	371	735	472	258 388.69	508.32	69.19
Nopalitos	10 298	2 069	4 105	3 807	3 491 196.26	1 868.47	45.52
Pápalo	16 060	2 080	5 290	4 254	12 301 621.49	3 507.37	66.3
Pipicha	20 078	1 412	6 868	3 934	36 162 283.09	6 013.51	87.55
Quelite	12 198	2 152	6 059	5 380	7 722 947.34	2 779.02	45.86
Tomato	12 049	5 861	8 592	8 548	2 278 974.05	1 509.63	17.57
Husk tomato	12 628	4 263	7 131	6 421	5 107 423.17	2 259.96	31.69

Data from SIAP-SIACON and INEGI's CPI.

Due to the low prices received by producers in rural areas and the small agricultural areas they own, the income obtained can often not cover the costs they incur in carrying out their productive activities.

National and per capita consumption of horticultural products native to Mexico

In the international trade of vegetables from Mexico, imports had a downward trend in the study period, with the maximum import being 856 984 t in 1982 and the minimum 93 515 t in 1995 (Table 3). Comparing 1980 and 2021, there was a negative import growth rate of -68.21%. The horticultural products imported in 2021 were (and occupied in the total volume): green chili (0.97%), squash (1.01%), sunflower seeds (10.51%), dried chili (15.50%), and beans (72.01%). A total of 444 306 t of beans were imported in 1980 and 175 088 t of beans in 2021 (rate of -60.59%).

Table 3. Apparent national consumption of vegetables native to Mexico and daily per capita consumption (1980-2021).

Year	Imports (t)	Exports (t)	ANC (t)	Population	*Per capita* consumption (g day^{-1})
1980	764 822	445 445	3 781 737	67 561 216	153.36
1985	833 341	603 686	4 184 817	76 030 535	150.8

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Year	Imports (t)	Exports (t)	ANC (t)	Population	*Per capita* consumption (g day^{-1})
1990	455 585	701 761	4 731 368	84 169 571	154.01
1995	93 515	1 257 703	4 441 543	91 843 905	132.47
2000	168 812	1 364 480	4 994 285	98 785 275	138.09
2005	149 194	1 450 879	5 775 689	105 669 369	147.75
2010	198 056	2 240 990	5 929 036	113 748 671	137.78
2015	152 809	2 906 450	6 535 656	121 347 800	143.75
2020	191 944	3 606 491	7 053 272	127 792 286	146.25
2021	243 143	3 760 166	6 952 374	128 972 439	142.92

Data from SIAP-SIACON, FAOSTAT and CONAPO. *Per capita* consumption excluded forage products.

Regarding native horticultural exports, there was an upward trend over time; the maximum volume exported was 3 760 000 t recorded in 2021, and the minimum was 443 000 t in 1983. There was a positive growth rate in the exported volume of 744.14% comparing 1980 and 2021. The native horticultural products exported and their share in the total volume in 2021 were: sweet potato (0.19%), beans (1.03), dried chili (1.12), squash (14.58), green chili (32.45), and tomato (50.63%).

Sánchez *et al*. (2019) reported that tomatoes, chili, squash, and beans stand out in Mexico's horticultural trade, in addition to the fact that there is a trade dependency on the United States of America since more than 90% of horticultural exports go to that country.

Concerning demand, the ANC has increased because the population has increased; it was 6 952 000 t in 2021. The maximum demand was 7 746 000 t in 2018 and the minimum was 3 781 000 t recorded in 1980. There was a growth rate in demand of 83.84% comparing 1980 and 2021. The ANC exceeded production between 1980 and 1986; the deficit in production was 319 377 t in 1980 and 56 003 t in 1986. For the period between 1987 and 2021, production exceeded the ANC; the surplus in production was 408 890 t in 1987, and 3 517 000 t in 2021; the growth rate in the surplus of production was 760.14% comparing the years 1987 and 2021.

Regarding per capita consumption of native horticultural products, the variable showed a slight upward trend over time. The maximum consumption was 164.86 g day^{-1} recorded in 2018, the minimum was 104.18 in 2011 and the average was 145.45 g day^{-1}. There was a negative growth rate in the consumption of native vegetables of -6.81% comparing 1980 and 2021.

The demand for horticultural products native to Mexico is a function of price, income, and population. The correlation coefficient between the quantity demanded of native horticultural products and the average price was -0.44932425 (if the variable of quantity increases, the variable of price decreases), quantity demanded and agricultural GDP 0.72707261, and quantity demanded and population 0.9868969.

Self-sufficiency in the production of vegetables native to Mexico

Self-sufficiency in the production of vegetables native to Mexico showed a growing trend in the study period; ie., Mexican producers have managed to meet the demand for vegetables, pulses, legumes, and seeds that the country needs. In 2021, the demand for horticultural products native to Mexico was met by production by 150.59% (Table 4) in a harvested area of 2 075 000 ha, production of 10 469 000 t and a population of 128 000 000 inhabitants.

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Table 4. Food self-sufficiency, import dependency, and trade openness index of Mexico's native horticultural activity.

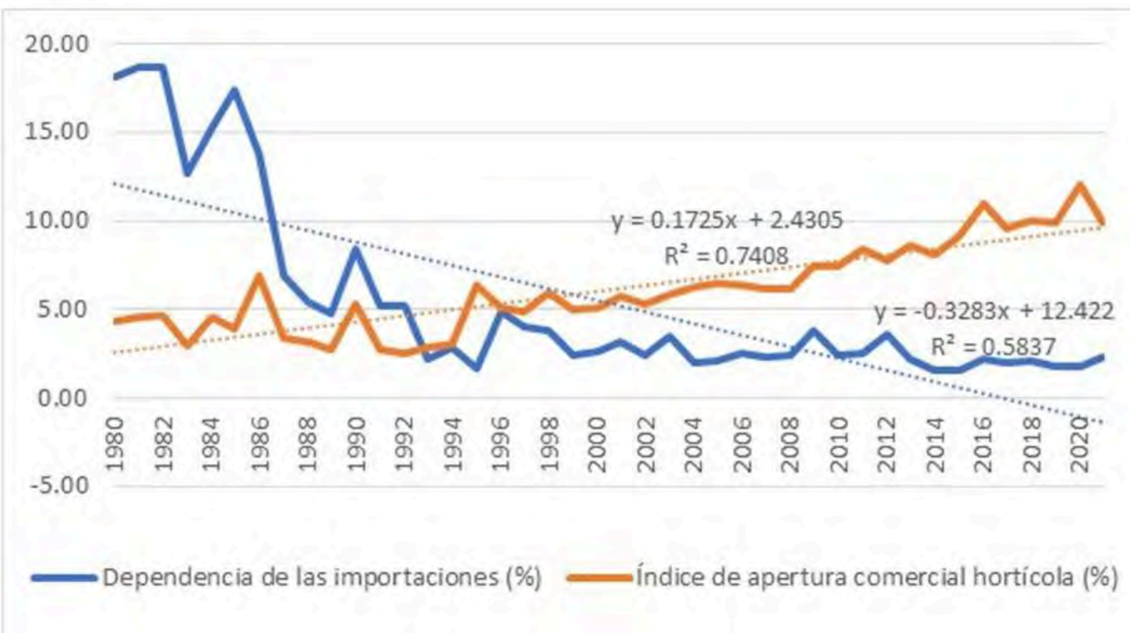
Year	FS (%)	ID (%)	Agricultural GDP (BP)	Imports (BP)	Exports (BP)	HTOI (%)
1980	91.55	18.09	520.138	14.297	8.489	4.38
1985	94.51	17.4	534.201	11.843	9.02	3.91
1990	105.2	8.39	567.777	9.776	20.662	5.36
1995	126.21	1.64	527.896	1.433	32.073	6.35
2000	123.94	2.65	478.612	1.925	22.406	5.08
2005	122.54	2.06	497.31	2.513	29.742	6.49
2010	134.46	2.42	586.171	4.418	39.105	7.42
2015	142.13	1.62	676.3	3.773	57.95	9.13
2020	148.41	1.8	827.807	4.574	94.937	12.02
2021	150.59	2.27	883.859	5.81	82.106	9.95

Data from SIAP-SIACON, INEGI's CPI, World Bank, and FAOSTAT. FS= food self-sufficiency; ID= import dependency; HTOI= horticultural trade openness index; GDP, imports and exports are at constant 2018 prices.

Trade dependency indicators

The horticultural trade openness index has increased over time (Figure 1); the maximum value was 12.02% in 2020, the minimum was 2.5% in 1992, and it went from 4.38% in 1980 to 9.95% in 2021, implying a greater participation of native horticultural products in international trade. The indicator of horticultural import dependency had a downward trend over time; the maximum value was 18.69% in 1981, the minimum value was 1.55% in 2014, and it was 2.27% in 2021.

Figure 1. Trade indicators for native horticultural products.



Of the horticultural products native to Mexico analyzed, in volume, the three main imported products are sunflower seeds, dried chili, and beans, while in exports, they are squash, green chili, and

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tomato. According to Brambila *et al*. (2014), Mexican agriculture transitioned from an agriculture based on grains and industrial products to an agriculture and livestock farming based on chicken, beef, pork, eggs, milk, fruits, and vegetables.

Conclusions

In the medium term, the area allocated to native horticultural production in Mexico is expected to range in an area that covers two million hectares; in contrast, for the same previous period, the production volume, average yield, and value of native horticultural production will continue to increase over time. Agricultural policies should not only focus on traditional crops such as beans, chili, tomatoes, and squash but also on increasing the production of other native crops such as amaranth, chia, chilacayote, huazontle, pápalo, pipicha, quelite, jaltomate, and chipilín.

It is necessary to increase the real prices received by the country's horticultural owners, in addition to granting them direct transfers that are aimed at increasing their incomes. Food policies should be oriented towards promoting the consumption of vegetables that have their center of origin in the country and mentioning the positive effects of their consumption on people's health. With the ratification of the Agreement between Mexico, the United States of America, and Canada in 2020 and the policies managed by the government in power in the field of food, in the short term, it is expected that the indicator of food self-sufficiency in native vegetables will continue to increase, whereas the indicator of horticultural trade openness and the indicator of import dependency are forecast to remain with minimal variations.

The Mexican Republic must reorient its dependence on a few horticultural products for exports; it is necessary to increase the volumes of other native horticultural products that do not appear in total exports; likewise, the production of basic foods such as chili and beans must be guaranteed, so that native horticultural production meets the domestic demand required by the country.

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