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Availability, accessibility, and intake of vegetables native to Mexico

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ABSTRACT

Objective: to analyze the intake of vegetables native to Mexico from 1980 to 2020, based on the food security approach.

Methodology: the availability and accessibility dimensions of food security were taken into consideration for this study; in addition, descriptive statistics and regression models were used.

Results: the apparent national intake of native vegetables increased during the study period, reaching 6.821 million tons in the year 2020, while the *per capita* intake was 148 grams in the same year. The actual income and the quarterly family expenses on vegetables, pulses, and seeds decreased from $1,890 Mexican pesos in 1980 to $1,082 Mexican pesos in 2020.

Study Limitations/Implications: the food utilization and stability dimensions that encompass food safety were not included in the study.

Conclusions: public food security policies must promote the production and intake of vegetables native to Mexico and increase the actual income of the most vulnerable Mexican families, facilitating accessibility to these products.

Key words: food security, food production, income.

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INTRODUCTION

Food security means that people have physical and economic access to nutritious food that does not damage their health. It implies the food availability, accessibility, utilization, and stability (FAO, 2013). Sometimes, food security is related to the regulation and control of food supply chains, nutritional insecurity, hunger, food trade, and food insecurity (Jones *et al.*, 2013; Leroy *et al.*, 2015; Burchi and Muro, 2015).

Food insecurity means poor food quality and lack of diversity in the physical availability, low accessibility, inappropriate utilization, and unstable accessibility to food (CONEVAL, 2019). Food security is important because an undernourished population is less economically productive (Jones *et al.*, 2013) and cannot participate in social and political life. Food security is a human right and must be sustainable (Burchi and Muro, 2015). Consequently, agricultural producers must use ecofriendly systems (Berry, 2015).

Several methodologies deal with food security, and they take into account food availability, accessibility, utilization, and stability (Jones *et al.*, 2013). The following

indicators were used: GDP, inflation, unemployment, wages, production, food demand, value chains, soil use, input costs, population, food expenses, education, indigenous households, marginalization, and subsidy indicators (Cruz *et al.*, 2022).

Food insecurity has been measured by such surveys as the Latin-American and Caribbean Food Security Scale (ELCSA) (Carmona *et al.*, 2017). However, alternative measurements of food security have been validated through alternative methodologies, including the use of correlation coefficients or regression models (Hoddinott, 2009; Jrad *et al.*, 2010).

These methodologies show that food security is related to food production (vegetables). In addition, this research used the dimensions established by the FAO, along with various indicators. Mexico is the center of origin of various agricultural products. The native vegetable production value amounts to 10.94% of the Gross Domestic Product (GDP) of the primary sector (SIAP-SIACON, 2020; World Bank, 2020). In addition, agricultural activities are a source of employment. Vegetables are a healthy source of food for Mexicans and some native produce stands out in international markets. Consequently, focusing on food security will help to determine the policies that should be implemented in the production, intake, and trade of native vegetables.

The hypothesis of this study was that, based on the food security focus, the intake of native vegetables can be explained by the production and the demand, as well as by the contrast between the income and the amount that a given household spends on vegetables, pulses, and seeds. The objective of this study was to analyze the intake of vegetables native to Mexico, using a food security focus and taking into account the availability and accessibility of the said vegetables.

MATERIALS AND METHODS

The following statistical variables were used in the analysis of the native vegetable availability and accessibility: maximum values, minimum values, averages, variances, standard deviation, coefficient of variation, growth rates, index numbers, and coefficient of correlation. In addition, regression models and trend analyses were developed (Infante and Zárate, 2012; Gujarati and Porter, 2010; Greene, 2018). The resulting statistical data provided the measurements used to characterize the two food security dimensions evaluated in this study.

In the first section (vegetable availability dimension), production (tons, t) was compared with domestic consumption (t). The national apparent consumption (NAC; production + importation − exportation) and individual consumption (NAC/population/360 days) were used to determine the demand. In addition, the value of the native vegetable production and the GDP of the primary sector were compared. The data about the production, the imports, and exports, the Mexican population, and the GDP of the agricultural sector were obtained from the Servicio de Información Agroalimentaria y Pesquera (SIAP-SIACON), the FAOSTAT, the INEGI, and the World Bank, respectively.

In the second section, the accessibility of vegetable intake was analyzed, including the following variables: quarterly actual income, transferences, and total actual expenses (beverages, tobacco, vegetables, pulses, and seeds). Data were obtained from the reports

of the National Household Income and Expenditure Survey (ENIGH) and the Consumer Price Index (CPI) of the INEGI.

The structure of the analysis allowed an understanding of the availability of vegetables native to Mexico, because the production figures were compared with the domestic apparent consumption of these products. Studying the income and expenses of the families led to the identification of the economic resources of the families and how much they spend in vegetables, pulses, and seeds.

The list of the domesticated and collected vegetable species in Mexico were obtained from the inventory of the Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO, 2008) and from the catalogue of native vascular plants of Mexico (Villaseñor, 2016). The analysis period was from 1980 to 2020. Accessibility (income and expenses) was only studied from 1984, due to the lack of data from previous years. The production, income, and expenses values were indexed based on the constant prices of 2018.

RESULTS AND DISCUSSION

Availability of Vegetables Native to Mexico

According to the SIAP-SIACON (2020), the production of vegetables native to Mexico plays a major role, contributing $90.601 billion Mexican pesos (2018 constant prices). Consequently, this sector is an important source of employment and produces 80.59% of the total vegetable production ($112,417 Mexican pesos) in 1,821,790 ha.

The volume and exports of the production of native vegetables recorded an increasing trend throughout time, while imports showed a slight decreasing trend (Figure 1). The increase of the first two variables can be explained by the adoption of free trade policies, introduced during the 1980s. These policies modified the food intake and production patterns of the country. Sánchez *et al.* (2019) reported that vegetable exports amounted to 10.29% of the total international exports in 2013. The crops that stood out were tomato, chili, squash, and bean.

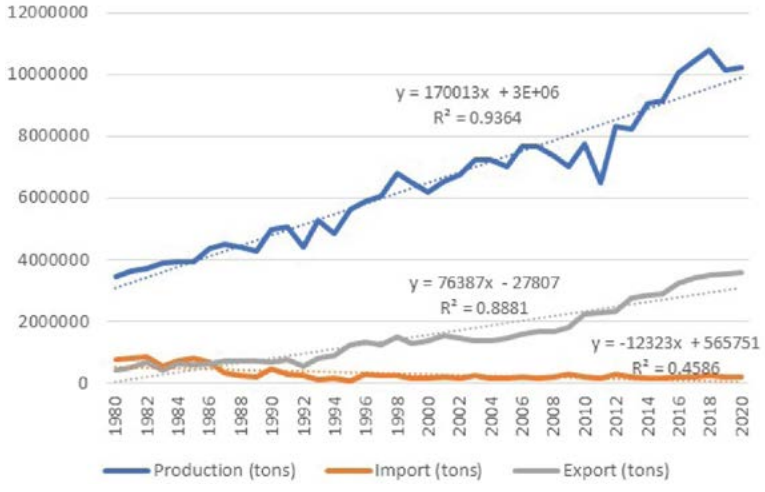

Figure 1. Production and trade of vegetables native to Mexico.

The minimum native vegetable production amounted to 3.462 million t in 1980, while the maximum native vegetable production reached 10.797 million t in 2018, and, in 2020, 10.236 million t were recorded. The vegetable produce that recorded the highest growth rates from 1980 to 2020 were: chayote (*Sechium edule*) (7,752.33%), chía (*Salvia hispanica*) (3,293.30%), and prickly pear (*Opuntia ficus-indica*) (969.86%). Meanwhile, the vegetables with the lowest growth rates included tomato (*Solanum lycopersicum*) (154.76%), sunflower (*Helianthus annuus*) (71.92%), and bean (*Phaseolus* spp.) (11.83%) (Table 1).

Some products have remarkable growth rates; however, they do not make up an outstanding proportion of the total production. For example, in 2020, chayote and chía recorded 2.08% and 0.05% growth rates, respectively. The vegetables that stood out included tomato (32.93%), chili (27.53%), bean (10.33%), prickly pear (8.43%), and squash (7.77%), which are part of the basic diet of Mexico. Chipilín (*Crotalaria longirostrata*) and jaltomate (*Jaltomata procumbens* C.), two native products consumed by Mexicans, are not included in governmental statistics.

Some products in Table 1 are not included in the NAC analysis. Consequently, the total production of these vegetables is used to meet the domestic market demand. Bean producers did not meet the demand during the study period: 95,371 t were imported in 2020 and the NAC decreased 16.94% from 1980 to 2020. A similar situation was faced by sunflower producers. Santos *et al.* (2017) pointed out that the lowest bean importation volume reached 2,909 t in 1992, while the highest bean importation volume amounted to 482 million t in 1982. These authors attributed the loss of production profitability and competitiveness to this phenomenon.

The NAC of the native vegetables increased from 3.781 million t in 1980 to 6.821 million t in 2020 (80.38% growth). The average daily individual consumption was 155 g in 1980, 160 g in 1990, 140 g in 2000, 139 g in 2010, and 148 g in 2020. From 1980 to 2020, the *per capita* intake of vegetables decreased by 4.31%. These results are the consequence of the immediate accessibility to low nutritional and high caloric food among the population, who disdain nutritional food, such as vegetables.

López and Alarcón (2018) pointed out that the *per capita* consumption of vegetables was 112 g in 1994 and 160 g in 2014. In addition, they mentioned that vegetable intake increases along with the age of the population.

Meanwhile, the production and intake of native vegetables are located in certain regions of the country, including: pipitza (Puebla, 148 t), huazontle (Puebla, 6,180; Tlaxcala, 298), quelite (Baja California, 2,245; Puebla, 22; Sonora, 544), pápalo (Guerrero, 4,597; Morelos, 1,209; Puebla, 1,008), and chilacayote (Mexico City, 40; State of Mexico, 996; Morelos, 718) (SIAP-SIACON, 2020). For example, chipilín is mainly produced and consumed in Chiapas. In order to increase the intake of these vegetables, their use should be promoted in the whole country.

Accessibility of the Population to Vegetables

In order to gain food accessibility and food intake in Mexico, the families need to earn a robust income to purchase this type of native vegetables. However, although the total actual income *per capita* has increased, the actual quarterly income of a Mexican family

Table 1. Production and National Apparent Consumption of native horticultural products in Mexico (tons).

Concept	Product / year	1980	1990	2000	2010	2020
Volume of production	Tomato (*Solanum* spp.)	1323148	1878415	2084443	2277791	3370827
	Chili (*Capsicum* spp.)	691264	850415	1428768	1942256	2818443
	Bean (*Phaseolus* spp.)	945358	1287610	887868	1157195	1057157
	Prickly pear (*Opuntia* spp.)	80640	174630	404460	723815	862733
	Pumpkin (*Cucurbita* spp.)	192547	332250	471350	533540	795299
	Green tomato (*Physalis philadelphica* Lam)	156915	271648	580247	719849	766515
	Jicama (*Pachyrhizus erosus* L.)	42374	87286	121665	184271	238980
	Chayote (*Sechium edule* J.)	2716	56316	128887	144413	213269
	Sweet potato (*Ipomoea batatas* L.)	19560	34116	52365	51064	75396
	Sunflower (*Helianthus annuus* L.)	4846	90	70	3797	8331
	Papalo (*Porophyllum macrocephalum*)	1138	392	2390	7459	6815
	Huazontle (*Chenopodium berlandieri* subsp. *Nuttalliae*)	1131	1442	1526	3568	6478
	Amaranth (*Amaranthus hypochondriacus* L.)	-	646	4240	3870	5625
	Chia (*Salvia hispánica* L.)	147	-	750	2914	4988
	Quelite (*Amaranthus cruentus* L.)	-	338	1841	1533	2812
	Epazote (*Dysphania ambrosioides*)	576	1010	1045	1606	2434
	Pipitza (*Porophyllum calcicola*)	-	140	105	208	148
	Chilacayote (*Cucurbita ficifolia* B.)	88	2382	2477	1423	-
Imports	Bean (*Phaseolus* spp.)	444306	330471	87661	117470	143635
	Sunflower (*Helianthus annuus* L.)	320111	114635	21802	13441	16299
	Chili (*Capsicum* spp.)	172	2445	13967	34030	29811
	Pumpkin (*Cucurbita* spp.)	-	-	1292	66	1945
	Tomato (*Solanum* spp.)	233	8034	44091	33049	255
Exports	Tomato (*Solanum* spp.)	373097	393237	689997	1509616	1826715
	Chili (*Capsicum* spp.)	22411	146154	339963	653863	1173331
	Pumpkin (*Cucurbita* spp.)	47674	162151	327419	47200	547450
	Bean (*Phaseolus* spp.)	2138	210	7091	30253	48264
	Sweet potato (*Ipomoea batatas* L.)	-	-	-	-	10732
	Sunflower (*Helianthus annuus* L.)	125	9	10	58	-
National Apparent Consumption	Chili (*Capsicum* spp.)	669025	706706	1102772	1322423	1674924
	Tomato (*Solanum* spp.)	950284	1493212	1438537	801224	1544366
	Bean (*Phaseolus* spp.)	1387526	1617871	968438	1244412	1152527
	Pumpkin (*Cucurbita* spp.)	144873	170099	145223	486406	249794
	Sweet potato (*Ipomoea batatas* L.)	19560	34116	52365	51064	64664
	Sunflower (*Helianthus annuus* L.)	324832	114716	21862	17180	24630

Source: own elaboration with data from SIAP-SIACON and FAO (consultation date January 20, 2023).

decreased during the study period, falling from $49,731 Mexican pesos in 1984 to $46,830 Mexican pesos in 2020 (Table 2). The total actual income per family decreased along with the size of the households.

When measuring the degree of association between the demand for native vegetables and the quarterly total actual income of Mexican families, a −0.2437878 negative correlation was obtained —*i.e.*, while the quantity variable increases, the income variable decreases.

The quarterly purchasing power of a Mexican family in 1984 ($49,731 Mexican pesos) would have allowed them to buy 45.96 times more vegetables than in 2020. Meanwhile, the income of a Mexican family in 2020 ($46,830 Mexican pesos) only covered 43.28 times this requirement —*i.e.*, the purchasing power of Mexican families has decreased because the actual family income has decreased.

The quarterly average income of the Mexican families during the study period was $50,009 Mexican pesos, $10,907 out of which came from government support and remesas

Table 2. Household income and expenditure by quarter at constant 2018 prices.

Year	Home size	Total current income	Total current income per person	Transfers	Gini coefficient	CME	SFBT	EFBCOH	SANB	TS	SVLS
1984	5.10	49731	9751	15498	0.425	34874	16116	7181	1935	1152	1890
1989	4.93	50800	10304	10097	0.469	34171	13884	8895	1227	851	1712
1992	4.72	56302	11928	13886	0.475	35558	12859	5817	1263	1086	1737
1994	4.60	58316	12677	11722	0.477	35900	12253	6844	1318	1101	1499
1996	4.52	42461	9394	10183	0.456	28461	10333	4255	1024	850	1328
1998	4.30	43588	10137	11005	0.476	29235	10071	4139	1169	797	1340
2000	4.16	50164	12059	12511	0.481	33915	10292	4725	1275	834	1116
2002	4.12	48747	11836	10596	0.454	33297	10236	5598	1163	1001	1110
2004	4.03	49456	12269	11260	0.460	36736	12531	5912	1192	949	1189
2006	3.96	55293	13977	11827	0.445	37401	11099	4683	1168	1019	1177
2008	4.00	54568	13628	11105	0.467	32556	11055	4472	1059	1124	1191
2010	3.88	47638	12291	10387	0.445	32553	10732	4896	1022	1103	1176
2012	3.72	48084	12939	11269	0.453	32397	11078	4741	1054	1311	1445
2014	3.79	46573	12301	10140	0.450	31063	10650	4470	998	1205	1065
2016	3.67	51887	14138	8057	0.449	31358	11021	2420	764	1120	980
2018	3.60	49724	13812	7625	0.426	31954	11254	2568	759	1123	1005
2020	3.55	46830	13191	8257	0.415	27841	10593	1415	795	1169	1082

Source: own elaboration with the ENIGH and with the INPC of the INEGI. CME = Current monetary expenditure; SFBT = Spending on food, beverages and tobacco; SFBT = Spending on food, beverages and tobacco; EFBCOH = Expenditure on food and beverages consumed outside the home; SANB = Spending on alcoholic and non-alcoholic beverages; TS = Tobacco spending. SVLS = Spending on vegetables, legumes and seeds.

(money transfers sent to the families). The maximum vegetable quarterly expense was $1,890 Mexican pesos and the minimum was $980 Mexican pesos. The highest dispersion regarding the mean was recorded by expenses in food and beverages consumed outside the households (37.08%), alcoholic and non-alcoholic beverages (24%), vegetables, pulses, and seeds (21.02%) (Table 3).

The expenses of a family in vegetables, pulses, and seeds and alcoholic and non-alcoholic beverages recorded a decreasing trend through time, while the expenses in tobacco registered a slightly increasing trend (Figure 2).

Although the NCA of native vegetables has doubtlessly increased over the years, the expenses in vegetables, pulses, and seeds decreased by 42.77% from 1980 to 2020. This decrease can be explained by the changes in the consumption patterns and the decrease in the actual prices of vegetables: consumers pay lower prices and producers receive lower prices for their products.

Table 3. Statistical analysis of household income and expenses by quarter.

Concept	Maximum	Minimum	Mean	Median	Variance	Standard deviation	Coefficient of variation
Total current income	58316	42461	50009	49724	18312268.42	4279.28	8.56
Transfers	15498	7625	10907	11005	3899263.42	1974.66	18.10
Current monetary expenditure	37401	27841	32898	32556	7725086.83	2779.40	8.45
Spending on food, beverages and tobacco	16116	10071	11533	11055	2491956.97	1578.59	13.69
Expenditure on food and beverages consumed outside the home	8895	1415	4884	4725	3280774.83	1811.29	37.08
Spending on alcoholic and non-alcoholic beverages	1935	759	1129	1163	73398.92	270.92	24.00
Tobacco spending	1311	797	1047	1101	21409.12	146.32	13.98
Spending on vegetables, legumes and seeds	1890	980	1297	1189	74245.65	272.48	21.02

Source: own elaboration with data from the ENIGH (1984-2020).

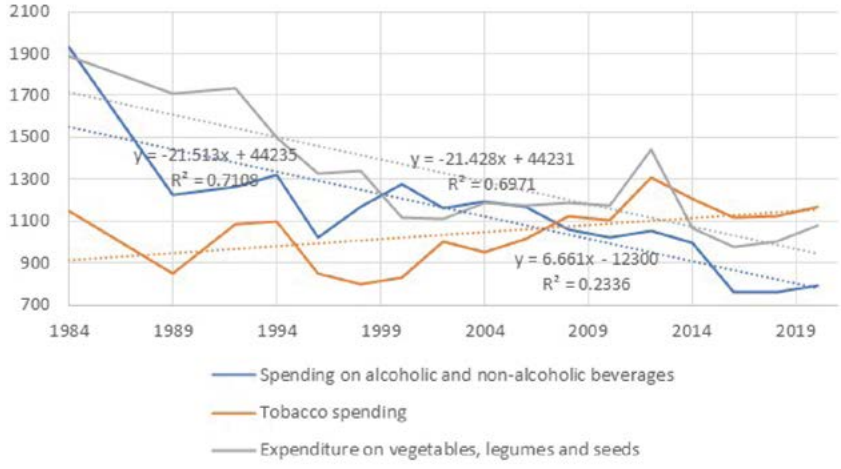

Figure 2. Quarterly expenses of Mexican families in beverages, tobacco, and vegetables.

The expenses in vegetables, pulses, and seeds had a slightly decreasing trend, in terms of the proportion of the income spent in food. The maximum and minimum proportions recorded were 13.50% and 8.89% in 1992 and 2016, respectively. The quarterly vegetable expenses per person decreased (17.78%) from $371 Mexican pesos in 1984 to $305 Mexican pesos in 2020 (Table 4).

The volume of the native vegetable production has certainly increased. The vegetable production value, as a proportion of the agricultural GDP in Mexico, has recorded the following results: 9.53% in 1980, 10.85% in 2000, and 10.94% in 2020 (SIAP-SIACON, 1980-2020; World Bank, 1980-2020). Consequently, the value of the native vegetable production has stagnated in comparison with the added value generated by the primary sector. Ayala *et al.* (2012) pointed out that the vegetable subsector accounted for 16% of the 2007-2010 domestic production. They concluded that the subsector is profitable and that it has a great dynamism.

The native products that stand out in the exportation sector are tomato, chili, squash, bean, sweet potato, and sunflower. Meanwhile, bean is one of the main imported foods (143,635 t beans in 2020), while chili impots increased from 172 t in 1980 to 29,811 t in 2020.

Table 4. Household spending on food by quarter (constant 2018 prices).

Year	Spending on food, beverages and tobacco (% of total current income)	Spending on alcoholic and non-alcoholic beverages (% of spending on food and tobacco)	Tobacco spending (% of spending on food and tobacco)	Spending on vegetables, legumes and seeds (% of spending on food and tobacco)	Growth rate of expenditure on vegetables, legumes and seeds (%)	Spending on vegetables, legumes and seeds per person (pesos)
1984	32.41	12.01	7.15	11.73	-	371
1989	27.33	8.84	6.13	12.33	−9.39	347
1992	22.84	9.83	8.45	13.50	1.41	368
1994	21.01	10.76	8.98	12.23	−13.70	326
1996	24.34	9.91	8.22	12.85	−11.40	294
1998	23.10	11.61	7.91	13.30	0.89	312
2000	20.52	12.38	8.11	10.84	−16.68	268
2002	21.00	11.37	9.78	10.85	−0.53	270
2004	25.34	9.52	7.57	9.49	7.11	295
2006	20.07	10.52	9.18	10.61	−0.98	298
2008	20.26	9.58	10.16	10.77	1.14	297
2010	22.53	9.52	10.28	10.95	−1.27	303
2012	23.04	9.51	11.83	13.04	22.92	389
2014	22.87	9.38	11.31	10.00	−26.28	281
2016	21.24	6.94	10.16	8.89	−8.03	267
2018	22.63	6.74	9.98	8.93	2.62	279
2020	22.62	7.50	11.04	10.21	7.58	305

Source: own elaboration with data from the ENIGH and with the INPC of the INEGI.

The NAC of native vegetables increased during the study period; however, the per capita consumption slightly decreased, from 155 g in 1980 to 148 g in 2020. The household quarterly expense in vegetables, pulses, and seeds (as proportion of the total actual income) decreased from 3.80% in 1980 to 2.31% in 2020. The monthly per capita expense in vegetables was $123.52 in 1984, $108.59 in 1994, $89.43 in 2000, $101.11 in 2010, and $101.56 Mexican pesos in 2020. Mundo *et al.* (2019) mentioned that Mexican families spent an average of $215.75 Mexican pesos/month in fruits and vegetables in 2018 (*versus* $93 Mexican pesos/month spent in native vegetables). The authors related the expenses with education, money transfers, and marginalization.

CONCLUSIONS

Food security in Mexico can be strengthened increasing the value of the vegetable products that have their origin center in the country. This situation would preserve the phenotype and genetic value of the plants, strengthen the agricultural production, and produce highly nutritional food for the society.

The value of the vegetable production could be increased improving productivity and providing appropriate fixed prices for producers. The native vegetable production will continue to meet the short-term demand, except in the case of the bean and sunflower production. Agricultural policies must be applied to increase the production of beans, chili, and other native vegetable products, consequently favoring exportations.

The decreasing trend in the per capita vegetable consumption will continue in the medium term. Policies aimed to promote the intake of healthy food, such as vegetables, should be implemented. In order to improve the intake of native vegetables, the actual income of the families should increase; consequently, new employments with higher income are required, as well as direct transfers, particularly for the most vulnerable population of the country.

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REFERENCES

Ayala-Garay, A. V., Schwentesius-Rindermann, R. & Carrera-Chávez, B. (2012). Hortalizas en México: competitividad frente a EE.UU. y oportunidades de desarrollo. *Revista de Globalización, Competitividad y Gobernabilidad, 6*(3), 70-88.

Berry, E. M., Dernini, S., Burlingame, B., Meybeck, A. & Conforti, P. (2015). Food security and sustainability: can one exist without the other? *Public Health Nutrition, 18*(13), 2293-302. http://dx.doi.org/10.1017/S136898001500021X

Burchi, F. & Muro, P. (2015). From food availability to nutritional capabilities: Advancing food security análisis. *Food Policy*, 60, 10-9. http://dx.doi.org/10.1016/j.foodpol.2015.03.008

Carmona-Silva, J. L., Paredes-Sánchez, J. A. & Pérez-Sánchez, A. (2017). La Escala Latinoamericana y del Caribe sobre Seguridad Alimentaria (ELCSA): Una herramienta confiable para medir la carencia por acceso a la alimentación. *Revista Iberoamericana de las Ciencias Sociales y Humanísticas, 6*(11). http://dx.doi.org/10.23913/ricsh.v6i11.118

Comisión Nacional para el Conocimiento y Uso de la Biodiversidad. (2008). Capital natural de México. Vol. I: Conocimiento actual de la biodiversidad. CONABIO.

Consejo Nacional de Evaluación de la Política de Desarrollo Social. (2019). ¿Qué funciona y qué no en seguridad alimentaria? CONEVAL.

Cruz-Sánchez, Y., Baca-Moral, J., Ramírez-García, A. G. & Monterroso-Rivas, A. I. (2022). Enfoques metodológicos de Evaluación de seguridad alimentaria en México. *Revista de Filosofía, 39*(100), 530-51. https://doi.org/10.5281/zenodo.6028687

Greene, W. H. (2018). Econometric Analysis. Eight Edition. Pearson Education. New York, the United States. 1126 p.

Gujarati, D. N. & Porter, D. C. (2010). Econometría. 5ta ed. Mc Graw Hill. D. F., México. 921 p.

Hoddinott, J. (1999). Choosing Outcome Indicators of Household Food Security. International Food Policy Research Institute.

Instituto Nacional de Estadística y geografía. (2023). Encuesta Nacional de Ingresos y Gastos de los Hogares (ENIGH), 1984-2020. https://www.inegi.org.mx/programas/enigh/nc/2020/

Instituto Nacional de Estadística y geografía. (2023). Índice Nacional de Precios al Consumidor (IPC), 1980-2020. https://www.inegi.org.mx/app/indicadores/?tm=0#D628194

Instituto Nacional de Estadística y geografía (INEGI). (2023). Población total de México 1980-2020. https://www.inegi.org.mx/temas/estructura/

Infante-Gil, S. & Zárate-Lara, G. P. (2012). Métodos estadísticos. Tercera ed. Colegio de Postgraduados. Estado de México, México. 610 p.

Jones, A. D., Ngure, F. M., Pelto, G. & Young, S. L. (2013). What Are We Assessing When We Measure Food Security? A Compendium and Review of Current Metrics. *American Society for Nutrition*, 4, 481-505. http://dx.doi.org/10.3945/an.113.004119. 481

Jrad, S., Nahas, B. & Baghasa, H. (2010). Food Security Models. Ministry of Agriculture and Agrarian Reform of Syria.Leroy, J. L., Ruel, M., Frongillo, E. A., Harris, J. & Ballard, T. J. (2015). Measuring the Food Accesibility Dimension of Food Security: A Critical Review and Mapping of Indicators. *Food and Nutrition Bulletin, 36*(2), 167-95. http://dx.doi.org/10.1177/0379572115587274

López-González, F. & Alarcón-Osuna, M. A. (2018). Cambio generacional del consumo de frutas y verduras en México a través de un análisis de edad-periodo-cohorte 1994-2014. *Población y Salud en Mesoamérica, 15*(2). https://doi.org/10.15517/psm.v15i2.28458

Mundo-Rosas, V., Unar-Munguía, M., Hernández-F M., Pérez-Escamilla, R. & Shamah-Levy, T. (2019). La seguridad alimentaria en los hogares en pobreza de México: una mirada desde el acceso, la disponibilidad y el consumo. *Salud Pública de México, 61*(6), 866-75. https://doi.org/10.21149/10579

Organización de las Naciones Unidas. (2013). Seguridad y soberanía alimentaria. FAO.

Sánchez-Gómez, C., Caamal-Cahuich, I. & Valle-Sánchez, M. (2019). Exportación hortofrutícola de México hacia los Estados Unidos de América. *Estudios Sociales, 29*(54). https://doi.org/10.24836/es.v29i54.766

Santos-Ramos, M., Romero-Rosales, T. & Bobadilla-Soto, E. E. (2017). Dinámica de la producción de maíz y frijol en México de 1980 a 2014. *Agron. Mesoam, 28*(2), 439-53. https://doi.org/10.15517/ma.v28i2.23608

Secretaría de Agricultura y Desarrollo rural. (2023). Servicio de Información Agroalimentaria y Pesquera (SIAP-SIACON), 1980-2020. https://www.gob.mx/siap/documentos/siacon-ng-161430

The World Bank. (2023). Agriculture, forestry, and fishing, value added 1980-2020. https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS

United Nations of Food and Agriculture Organization (FAOSTAT). (2023). Crops and livestock products 1980-2020. https://www.fao.org/faostat/es/#data/TCL

Villaseñor, J. L. (2016). Checklist of the native vascular plants of Mexico. *Revista Mexicana de Biodiversidad*, 87, 559-902. https://doi.org/10.1016/j.rmb.2016.06.017