v. 4, n. 20, 2024

Scientific Journal of Applied Social and Clinical Science

ANALYSIS OF FOOD SELF-SUFFICIENCY IN CORN IN THE PAPALOAPAN REGION, OAXACA, MEXICO

Rafael Rodríguez Hernández
Socioeconomics Program, ``Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias`` (INIFAP), Experimental Field: ``Valles Centrales de Oaxaca``, Mexico
ORCID: 0000-0003-2723-0781

Pedro Cadena Iñiguez
Socioeconomics Program, ``Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias`` (INIFAP), Experimental Field: ``Centro de Chiapas``, Mexico
ORCID: 0000-0003-3929-5822

Rafael Ariza Flores
``Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias`` (INIFAP), ``Centro de Investigación Regional Pacífico Sur``, Oaxaca, Mexico
ORCID: 0000-0001-5764-2723

Eduardo José Cabrera Torres
Bovine and milk program, ``Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias`` (INIFAP), Experimental Field: ``Chetumal``, Quintana Roo, Mexico
ORCID: 0000-0002-6661-9717

Mariano Morales Guerra
Socioeconomics Program ``Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias`` (INIFAP), Experimental Field: ``Valles Centrales de Oaxaca``, Mexico
ORCID: 0000-0002-4810-818X

José Gabriel Berdugo Rejón
Socioeconomics Program, ``Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias`` (INIFAP), Experimental Field: ``Mocochá``, Yucatán, Mexico
ORCID:0000-0001-9923-1889

Abstract: The Papaloapan region of the state of Oaxaca, Mexico is an important producer of grains, mainly corn, production is carried out in two spring-summer and autumn-winter sowing cycles, allocating an annual surface of 62,000 hectares with a production of 176,857 tons and an average yield of 2.8 t ha-1. Given the need to move towards self-sufficiency in food production, mainly corn, a study was carried out with the purpose of analyzing the current production and consumption situation and determining the deficits or surpluses in production and how far the food self-sufficiency in the region. For this, official statistical sources were consulted and consumption estimates were made for both the population and livestock, taking into account the main species in the region and the Food Self-Sufficiency Index (IDA) was calculated. The results indicated that the region is self-sufficient in the production of corn for human consumption, although there are very deficient municipalities such as Tuxtepec and Loma Bonita, local production manages to supply the demand of the urban and rural centers of the region; However, when animal consumption was considered, the region became deficient, so to cover the total need for grain it is necessary to increase yields to more than 5.0 t ha-1, almost double what is currently obtained, so The importance of increasing the productivity of this grain is highlighted, which is part of the goals of the Technical Support Strategy of the Production for Well-being Program.
Keywords: Production, consumption, dependence, yield, corn.

INTRODUCTION

Food self-sufficiency is the ability to produce the majority of the food that a nation or household needs, and to rely on it to satisfy its food needs (FAO, 2009 cited by García-Salazar et al., 2023), that is, It is a necessary condition under which the nutritional needs of a population, country or region are covered and satisfied through local agri-food production (Martínez, 2016). This condition is achieved when production is equal to or greater than consumption and is necessary to the assurance of food supply to the population, on the contrary, when this condition does not exist, that is, when production fails to supply demand, the region or country finds itself in a situation of food dependence; as is the case of Mexico, whose condition of dependence on corn imports that has developed in recent years places it in an unfavorable position in the face of exogenous changes (Moreno-Saénz et al., 2016); The acquisition of food abroad leads the country to a situation of vulnerability, since domestic consumption is subject to both the domestic production crisis and fluctuations in international prices (Torres and Rojas, 2020), therefore The concept of food self-sufficiency has gained special relevance in current policy towards the countryside, since within the National Development Plan food self-sufficiency is identified as a priority within the economic component of the federal government (National Development Plan, 2019-2024).

Corn is the main food of Mexicans since it represents the most important component of the daily diet, mainly in the form of "tortillas", but there is a wide variety of other culinary forms of consumption such as "tamales", "atoles", refreshing drinks, desserts, to name a few, resulting in high human consumption; In this regard, the SIAP (2018) reported a per capita consumption of 336.6 kg, however, according to data from the United States Department of Agriculture (USDA) cited by Miller Magazine (2023), 17.3 million were imported in the 2022/23 cycle. t of corn, mainly yellow, since imports of white corn were minimal. Grain consumption in our country was 44.3 million tons and national production was 27.4 million tons, so national production failed to cover consumption. The forecast is that in the 2023/24 cycle, imports will amount to 18.2 million tons and consumption will grow to 46.2 million tons. This situation raises the importance of reinforcing the mechanisms that encourage production and productivity.

Food self-sufficiency at the community level means that each production unit, each locality and/or region manages to produce what it consumes, so as not to depend on other communities or regions for food, since this situation implies vulnerability in local living systems. by allocating part of the family income to the acquisition of the grain, which incidentally, coming from abroad, may have different nutraceutical characteristics than the grain of native varieties (Fernández et al., 2013; Figueroa et al., 2013; González-Cortés et al., 2016), for this reason, it is necessary to analyze the current situation of production and consumption as a frame of reference to dimension the challenges and perspectives of the Technical Support Strategy (EAT) of the Production for Wellbeing Program (PpB) in the region, whose main objective is to achieve or at least contribute to achieving food self-sufficiency in corn and other food grains (Cadena et al., 2024).

The Papaloapan region in the state of Oaxaca, Mexico is important for its contribution to the state economy through the value of production, mainly in the primary sector, this contribution of the region amounts to 35% of the total state value, this is possible thanks to its various agro-climatic and geographical location potentials that allow good production in general and even

increase it and contribute to the food self-sufficiency of the state. The objective of this work was to analyze the situation of food self-sufficiency in corn for human and animal consumption in the Papaloapan region of the state of Oaxaca and determine the production and target yields to achieve it.

MATERIALS AND METHODS

The Papaloapan region is one of the eight regions of the state of Oaxaca; It is located in the northern part of the state between the coordinates 18° 06'00" North latitude and 96° 07'00" West longitude, it limits to the north with the state of Veracruz (with which it is closely linked culturally and commercially) and the state of Puebla; It borders to the east with the Cañada Region; to the West with the state of Veracruz and to the South with the Sierra Norte Region, it covers an area of 8,496.79 km^2 and is subdivided into 21 municipalities grouped into two districts: Tuxtepec and Choapam (Figure 1).

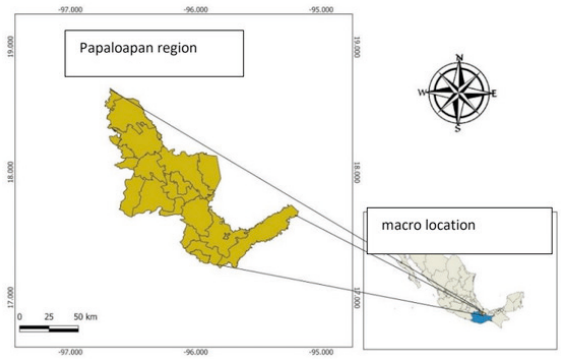

Figure 1: Location of the Papaloapan region in the state of Oaxaca, Mexico.

As a first instance, statistics were consulted from official sources regarding planted area, harvested area, production and grain yield for the 2020 agricultural year. The analysis was carried out on two levels, first, considering human consumption and later incorporating animal consumption. Human consumption was estimated taking into account the number of inhabitants over three years of age reported by INEGI (2020) by municipality, a data that was multiplied by the annual per capita consumption of 336.6 kg reported by (SIAP-SAGARPA, 2018).

$$CH = Hab \times 336.6$$

Where: CH = Human consumption, Hab = Number of inhabitants over 3 years old.

Total human consumption was estimated by adding the human consumption of each municipality.

$$CHT = \sum_{i=1}^{n} CH1 + CH2 + CH3 + \cdots CHn$$

Where: CHT = Total human consumption, CH = Human consumption in municipality n, n = Number of municipalities belonging to the region.

To obtain animal consumption, the average consumption in kilograms of the most common species found in each municipality was taken into account. For this purpose, the data reported by the literature was taken as a basis, thus, the consumption of corn in cattle It is estimated at 10 kg/day (Mendoza, 2016), in sheep the daily consumption is 0.3 kg (Galaviz et al., 2011), goats consume an average of 1 kg/day (Toro et al., 2014), Regarding pigs, the reported consumption is 2 kg/day (Bauza et al., 2018). In the case of bovine consumption, an adjustment was made because in the region livestock farming is classified as dual-purpose, that is, milk and meat production, with no specialized livestock farming, so daily grain consumption was reduced to the third part in relation to a specialized livestock farm reported by Mendoza (2016), this adjusted data was multiplied by the number of heads of livestock at the municipal level. For the other species considered, this adjustment was not made.

$$CAE = Cd \times Nc \times 365$$

Where: CAE = Animal consumption per species, Cd = Corn consumption per day

Nc = Number of heads.

The total animal consumption of the region was estimated by adding the consumption for each species considered, that is:

$$CAT = \sum_{i=1}^{n} CAE1 + CAE2 + CAE3 + \cdots CAEn$$

Where: CAT = Total animal consumption, CAE = Animal consumption by species, n = Species considered.

Once the total grain consumption was estimated, the deficit or surplus presented by the municipalities was estimated, which was calculated using the arithmetic difference between production and consumption.

$$A = P - CT$$

Where: A = Self-sufficiency, P = Production, CT = Total consumption

According to García-Salazar et al., (2023), the Food Dependency Index (IDA) was estimated in two modalities, one for human consumption and the other for human consumption plus animal consumption. Cruz et al., (2021) use this index to analyze food self-sufficiency in wheat and rice in a macroeconomic manner, that is, at the country level. This index was obtained by dividing imports (which in our case was the deficit) by the total annual consumption of corn in year a multiplied by 100; this is:

$$IDA_a = (D_a/CT_a)100$$

Where: IDA = Food dependency index in year a, D = Corn deficit in year a, CT = Total corn consumption in year a.

In those municipalities that presented a grain deficit, the target yield to achieve to achieve self-sufficiency was estimated, considering the same sales prices, which is another variable that can act as an incentive to increase production (Cruz et al., 2021), to To do this, the total consumption in year a was divided in tons by the planting area in hectares in year a and this way the yield gap was determined.

$$RM_a = CT_a/SS_a$$

Where: RM = Target yield in year a in t/ha, CT = Total consumption in year a in t, SS = Area planted in year a in ha.

RESULTS AND DISCUSSION

PRODUCTION

According to SIAP data (2020), corn production in the region is carried out in two production cycles: autumn-winter and spring-summer; The area planted and harvested of corn in the autumn-winter cycle was 26,464 ha, without presenting a damaged area, having a production of 82,906.40 t with an average yield of 3.13 t ha^{-1}. In the spring-summer cycle, 35,215 hectares were planted, of which 35,137 hectares were harvested, having a damaged area of 78 hectares with a production volume of 92,014.39 t, in this cycle a lower yield was obtained than in the autumn-winter, 2.62 t ha^{-1}. . The 21 municipalities that make up the region participate in grain production, some to a greater extent than others, depending on the productive vocation of the soils and the farmers' decision on the crop to be carried out.

It is observed that the municipality of San Juan Bautista Valle Nacional recorded a production of 24,456.25 t harvested in an area of 5,805 ha, with a yield of 4.21 t ha^{-1}, while in the municipality of Ayotzintepec the highest yield of 5.29 t ha^{-1}; a production of 16,402.46 t in 3,102 harvested ha; The municipality of Santa María Jacatepec had a production of 18,437.8 t in 4,422 ha harvested with a yield of 4.17 t ha^{-1}, these municipalities being the ones that presented the highest yields and production. The municipality of San José Independencia presented the lowest level of production with 492 t in 727 hectares with a yield of 0.68 t ha^{-1} (Table 1).

CONSUMPTION

Regarding human consumption, Table 2 presents the level of consumption by municipality, where it is observed that the highest consumption occurred in Tuxtepec with almost 54,000 t per year, followed with quite a difference by the municipality of Acatlán de Pérez Figueroa with 15,203 t. In general, a direct relationship can be seen between the size of the population and the level of consumption, a logical situation given by the greater concentration of the population in urban centers.

Total human consumption in the Papaloapan region, Oaxaca reached 168,052.41 t of grain per year, consumption carried out by a total population of 499,266 inhabitants. Regarding the deficit or surplus of corn, the largest deficit occurred in the municipality of San Juan Bautista Tuxtepec with more than 40,000 t annually, which is explained because that is where the largest urban population is concentrated, production was only 13,644.90 t. It is followed by the municipality of Acatlán de Pérez Figueroa with a deficit of almost 12,000 t annually and Loma Bonita with a deficit of 8,984.61 t. A total of eight municipalities were in deficit, since current production was not enough to cover the population's consumption; However, 13 municipalities had a surplus, that is, they produce what they consume and still have a difference in their favor. The municipality of San Juan Bautista Valle Nacional stands out with a surplus of more than 16,000 tons of grain, followed by Santa María Jacatepec and Ayotzintepec with significant production volumes and surplus of corn. In general, the Region produced the corn that the population consumed since its production was 174,920.74 t, while the estimated human consumption was 168,052.41 t, with a surplus of almost seven thousand t annually. Regarding the IDA, it is observed in the same Table 2 that the municipality that presented the greatest food dependence on corn for human consumption was Acatlán de Pérez Figueroa with 77.87%, followed by Cosolapa with 75.17% and San Juan Bautista Tuxtepec with 74.58%. while a total of 12 municipalities presented food self-sufficiency with an ADI of zero. The production of these municipalities allows the region in general to present an ADI of zero, that is, it does not present food dependence on corn.

Regarding livestock stocks, Table 3 shows the number of heads of the main species in the region according to data from SIAP (2020). It is observed that in total there were 83,485 heads of cattle, highlighting the municipalities of Tuxtepec, San Juan Cotzocón and Loma Bonita as those with the largest population. There were 72,654 heads of pigs, highlighting the municipalities of San Juan Bautista Valle Nacional, San José Chiltepec and Santa María Jacatepec with the largest stocks. Regarding sheep and goats, stocks were relatively low, with a total of 24,541 heads of sheep and 721 heads of goats.

The table 4 presents the results of the estimates of annual corn consumption by the species considered in the study. Regarding cattle consumption, San Juan Bautista Tuxtepec stands out with 12,622.07 t, followed by San Juan Cotzocón with 10,250.3 t, and Loma Bonita with a consumption of 8,699.78 t, this because they are the municipalities with the largest livestock population. Regarding the consumption of corn by pigs, the municipalities of San Juan Bautista Valle Nacional stand out with 13,621.07 t, San José Chiltepec and Santa María Jacatepec with consumption of more than 6 thousand t; Corn consumption by goats and sheep is significantly lower. Regarding total animal consumption, the municipality with the highest corn consumption was San Juan Bautista Tuxtepec, due to the number of heads of livestock of the four species that this

City	Sown area (ha)	Harvested area (ha)	Production (t)	Performance (t ha^{-1})
San Juan Bautista Tuxtepec	3,539.00	3,539.00	13,644.90	3.86
San Juan Cotzocón	3,825.00	3,805.00	14,439.60	3.79
San Felipe Jalapa de Díaz	5,099.00	5,099.00	7,181.12	1.41
Acatlán de Pérez Figueroa	1,637.00	1,637.00	3,364.40	2.06
San Felipe Usila	4,764.00	4,764.00	6,295.04	1.32
San Juan Bautista Valle Nacional	5,820.00	5,805.00	24,456.25	4.21
San Miguel Soyaltepec	3,926.00	3,926.00	6,868.35	1.75
Ayotzintepec	3,127.00	3,102.00	16,402.46	5.29
Cosolapa	904	904	1,210.67	1.34
San Pedro Ixcatlán	1,533.00	1,533.00	2,160.52	1.41
Loma Bonita	1,364.00	1,364.00	4,793.77	3.51
San Lucas Ojitlán	5,691.00	5,691.00	8,846.16	1.55
San José Chiltepec	1,479.00	1,479.00	5,017.51	3.39
Santa María Jacatepec	4,440.00	4,422.00	18,437.80	4.17
San José Independencia	727	727	492.02	0.68
San Juan Comaltepec	1,048.00	1,048.00	2,648.96	2.53
San Juan Lalana	4,687.00	4,687.00	17,351.94	3.7
San Juan Petlapa	1,010.00	1,010.00	2,706.10	2.68
Santiago Choápam	1,469.00	1,469.00	2,955.34	2.01
Santiago Jocotepec	3,495.00	3,495.00	7,988.88	2.29
Santiago Yaveo	2,095.00	2,095.00	7,659.00	3.66
Total	61,679.00	61,601.00	174,920.79	2.70

Table 1: Corn production in the municipalities of the Papaloapan region, Oaxaca in the autumn-winter 2019/2020 and spring-summer 2020 production cycles.

City	Production (t)	Population (inhabitants)	Human consumption (t)	Deficit (t)	IDA (%)
San Juan Bautista Tuxtepec	13,644.90	159,452	53,671.54	-40,026.64	74.58
San Juan Cotzocón	14,439.60	22,444	7,554.65	6,884.95	0.00
San Felipe Jalapa de Díaz	7,181.12	28,500	9,593	-2,411.88	25.14
Acatlán de Pérez Figueroa	3,364.40	45,167	15,203.21	-11,838.81	77.87
San Felipe Usila	6,295.04	12,191	4,103.49	2,191.55	0.00
San Juan Bautista Valle Nacional	24,456.25	23,067	7,764.35	16,691.90	0.00
San Miguel Soyaltepec	6,868.35	38,682	13,020.36	-6,152.01	47.25
Ayotzintepec	16,402.46	6,857	2,308.07	14,094.39	6.11
Cosolapa	1,210.67	14,488	4,876.66	-3,665.99	75.17
San Pedro Ixcatlán	2,160.52	10,368	3,489.87	-1,329.35	38.09
Loma Bonita	4,793.77	40,934	13,778.38	-8,984.61	65.21
San Lucas Ojitlán	8,846.16	22,185	7,467	1,379.16	0.00
San José Chiltepec	5,017.51	11,310	3,807	1,210.51	0.00
Santa María Jacatepec	18,437.80	9,682	3,258.96	15,178.84	0.00
San José Independencia	492.02	3,684	1,240.03	-748.01	60.32
San Juan Comaltepec	2,648.96	3,116	1,048.85	1,600.11	0.00
San Juan Lalana	17,351.94	16,989	5,718.50	11,633.44	0.00
San Juan Petlapa	2,706.10	3,117	1,049.18	1,656.92	0.00

Santiago Choápam	2,955.34	5,242	1,764.46	1,190.88	0.00
Santiago Jocotepec	7,988.88	14,198	4,779.05	3,209.83	0.00
Santiago Yaveo	7,659.00	7,593	2,555.80	5,103.20	0.00
Total	174,920.79	499,266	168,052.41	6,868.38	0.00

Table 2: Human consumption, production, deficit and ADI for human consumption of corn by municipality in the Papaloapan region, Oaxaca.

City	Cattle	Pigs	Goats	Sheep	Total
San Juan Bautista Tuxtepec	11,527	4,655		6,981	23,163
San Juan Cotzocón	9,361	1,851	112	398	11,722
San Felipe Jalapa de Díaz	3,510	2,351		185	6,046
Acatlán de Pérez Figueroa	5,443	4,483		2,311	12,237
San Felipe Usila	1,320	2,179		105	3,604
San Juan Bautista Valle Nacional	5,456	18,659		2,196	26,311
San Miguel Soyaltepec	3,070	2,494	327	2,589	8,480
Ayotzintepec	2,803	1,267		15	4,085
Cosolapa	533	2,066		340	2,939
San Pedro Ixcatlán	1,982	2,112		114	4,208
Loma Bonita	7,945	2,538		3,549	14,032
San Lucas Ojitlán	3,435	4,378		124	7,937
San José Chiltepec	4,201	8,369		1,666	14,236
Santa María Jacatepec	3,885	8,352		2,718	14,955
San José Independencia	309	1,029		473	1,811
San Juan Comaltepec	239	253		86	578
San Juan Lalana	6,212	2,616		86	8,914
San Juan Petlapa	214	285	124	93	716
Santiago Choápam	221	314	106	87	728
Santiago Jocotepec	4,085	1,724		203	6,012
Santiago Yaveo	7,734	679	52	222	8,687
Total	83,485	72,654	721	24,541	181,401

Table 3: Number of heads of four species of livestock in the municipalities of the Papaloapan region, Oaxaca.

CIty	Cattle (t)	Pigs (t)	Goats (t)	Sheep (t)	Total consumption (t)
San Juan Bautista Tuxtepec	12,622.07	3,398.15		764.41	16,784.63
San Juan Cotzocón	10,250.30	1,351.23	40.88	43.58	11,685.99
San Felipe Jalapa de Díaz	3,843.45	1,716.23		20.25	5,579.93
Acatlán de Pérez Figueroa	5,960.09	3,272.59		253.05	9,485.73
San Felipe Usila	1,445.40	1,590.67		11.49	3,047.56
San Juan Bautista Valle Nacional	5,974.32	13,621.07		240.46	19,835.85
San Miguel Soyaltepec	3,361.65	1,820.62	119.35	283.49	5,585.11
Ayotzintepec	3,069.29	924.91		1.64	3,995.84
Cosolapa	583.64	1,508.18		37.23	2,129.05
San Pedro Ixcatlán	2,170.29	1,541.76		12.48	3,724.53
Loma Bonita	8,699.78	1,852.74		388.61	10,941.13

San Lucas Ojitlán	3,761.33	3,195.94		13.57	6,970.84
San José Chiltepec	4,600.10	6,109.37		182.42	10,891.89
Santa María Jacatepec	4,254.08	6,096.96		297.62	10,648.66
San José Independencia	338.36	751.17		51.79	1,141.32
San Juan Comaltepec	261.71	184.69		9.41	455.81
San Juan Lalana	6,802.14	1,909.68		9.41	8,721.23
San Juan Petlapa	234.33	208.05	45.26	10.18	497.82
Santiago Choápam	242.00	229.22	38.69	9.52	519.43
Santiago Jocotepec	4,473.08	1,258.52		22.22	5,753.82
Santiago Yaveo	8,468.73	495.67	18.98	24.3	9,007.68
Total	91,416.08	53,037.42	263.16	2687.13	147,403.79

Table 4: Annual animal consumption of corn by livestock species in the Papaloapan region, Oaxaca.

City	Human consumption (t)	Animal consumption (t)	Total consumption (t)	Deficit (t)	IDA (%)
San Juan Bautista Tuxtepec	53,671.54	16,784.63	70,456.17	-56,811.27	80.63
San Juan Cotzocón	7,554.65	11,685.99	19,240.64	-4,801.04	24.95
San Felipe Jalapa de Díaz	9,593	5,579.93	15,172.93	-7,991.81	52.67
Acatlán de Pérez Figueroa	15,203.21	9,485.73	24,688.94	-21,324.54	86.37
San Felipe Usila	4,103.49	3,047.56	7,151.05	-856.01	11.97
San Juan Bautista Valle Nacional	7,764.35	19,835.85	27,600.20	-3,143.95	11.39
San Miguel Soyaltepec	13,020.36	5,585.11	18,605.47	-11,737.12	63.08
Ayotzintepec	2,308.07	3,995.84	6,303.91	10,098.56	0.00
Cosolapa	4,876.66	2,129.05	7,005.71	-5,795.04	82.72
San Pedro Ixcatlán	3,489.87	3,724.53	7,214.40	-5,053.88	70.05
Loma Bonita	13,778.38	10,941.13	24,719.51	-19,925.74	80.61
San Lucas Ojitlán	7,467	6,970.84	14,437.84	-5,591.68	38.73
San José Chiltepec	3,807	10,891.89	14,698.89	-9,681.38	65.86
Santa María Jacatepec	3,258.96	10,648.66	13,907.62	4,530.19	0.00
San José Independencia	1,240.03	1,141.32	2,381.35	-1,889.33	79.34
San Juan Comaltepec	1,048.85	455.805	1,504.66	1,144.31	0.00
San Juan Lalana	5,718.50	8,721.23	14,439.73	2,912.21	0.00
San Juan Petlapa	1,049.18	497.82	1,547.00	1,159.10	0.00
Santiago Choápam	1,764.46	519.425	2,283.89	671.46	0.00
Santiago Jocotepec	4,779.05	5,753.82	10,532.87	-2,543.99	24.15
Santiago Yaveo	2,555.80	9,007.68	11,563.48	-3,904.48	33.77
Total	168,052.41	147,403.79	315,456.20	-140,535.41	44.55

Table 5: Total consumption, deficit and ADI of corn in the municipalities of the Papaloapan region, Oaxaca.

municipality has. It is followed in importance by the municipalities of San Juan Cotzocón, San Juan Bautista Valle Nacional, Loma Bonita and Santiago Yaveo. The annual animal consumption of corn at the regional level was estimated at 147,403.79 t.

Regarding total consumption (human and animal), Table 5 presents the results where San Juan Bautista Tuxtepec presented the highest consumption with a total of 70,456.17 t of corn, followed by San Juan Bautista Valle Nacional with 27,620.20 t, and Loma Bonita with a consumption of 24,719.51 t. The total consumption of corn in the region considering human and animal consumption was 315,456.20 t. Likewise, the largest grain deficits occurred in San Juan Bautista Tuxtepec with -56,811.27 t, Acatlán de Pérez Figueroa with -21,324.54 t, Loma Bonita with -19,925.74 t and. The total deficit of the region, considering human and animal consumption, was 140,535.41 t, which is covered with imports from other parts of the country and abroad; This behavior where the impact of animal consumption is observed agrees with Araujo (2021).

The IDA that shows the level of food dependence was 44.55% at the regional level, highlighting the municipalities of Acatlán de Pérez Figueroa with 86.37%, followed by Cosolapa with 82.72% and Loma Bonita with 80.61%; Only six municipalities did not present food dependence since their ADI was zero, which indicates that they are self-sufficient for both human and animal consumption, these are Ayotzintepec, Santa María Jacatepec, San Juan Comaltepec, San Juan Lalana, San Juan Petlapa and Santiago Choápam. As a reference, Ramírez-Juárez (2022) mentions that the coefficient of agricultural self-sufficiency in Mexico (which measures the percentage of national consumption of basic grains covered by national production) in recent years has deepened, going from 76% in 2013, to 64.4% in 2018, which indicates that the Papaloapan region presented similar food dependence as the national average.

TARGET RETURNS

To cover human consumption, it is practically not necessary to increase the average regional yield of 2.70 t ha^{-1} that is currently available since a production is obtained that manages to cover local human consumption, only a minimum increase in 0.02 t ha^{-1} to cover the claims rate, which is also low in the region. At the municipal level there are differences in this sense, for example, municipalities that have a large urban population such as Tuxtepec and Loma Bonita, if they aspire to food self-sufficiency in corn, require a yield on the same planted area of 15.17 and 10.10 t ha^{-1} respectively. In this sense, it is difficult for these municipalities that constitute urban poles to be self-sufficient in corn, hence the importance of the local market to supply them. This is where the functionality of short markets or short marketing circuits stands out, as proposed by Catrip-Pintor et al. al., (2020); Surely a large part of the production, for example from Valle Nacional, goes to Tuxtepec to partially cover this consumption of the urban population. Regarding productivity, each municipality has its own performance gap, but municipalities that are deficient require significant increases (Table 6).

To cover total consumption (human and animal), the situation was totally different, because consumption increased considerably, there were grain deficits in most municipalities, that is, animal consumption significantly increased grain deficits in municipalities, because this region is classified as livestock, Tuxtepec and Loma Bonita continue to stand out as the most deficient, these require a yield of 19.91 and 18.12 t ha^{-1} respectively. Regarding the feasibility of increasing productivity,

City	Current performance	Yield required to cover human consumption	Performance required to cover total consumptionl
	(t ha^{-1})	(t ha^{-1})	(t ha^{-1})
San Juan Bautista Tuxtepec	3.86	15.17	19.91
San Juan Cotzocón	3.79	1.98	5.03
San Felipe Jalapa de Díaz	1.41	1.88	2.98
Acatlán de Pérez Figueroa	2.06	9.29	15.08
San Felipe Usila	1.32	0.86	1.50
San Juan Bautista Valle Nacional	4.21	1.33	4.74
San Miguel Soyaltepec	1.75	3.32	4.74
Ayotzintepec	5.29	0.74	2.02
Cosolapa	1.34	5.39	7.75
San Pedro Ixcatlán	1.41	2.28	4.71
Loma Bonita	3.51	10.1	18.12
San Lucas Ojitlán	1.55	1.31	2.54
San José Chiltepec	3.39	2.57	9.94
Santa María Jacatepec	4.17	0.73	3.13
San José Independencia	0.68	1.71	3.28
San Juan Comaltepec	2.53	1	1.44
San Juan Lalana	3.7	1.22	3.08
San Juan Petlapa	2.68	1.04	1.53
Santiago Choápam	2.01	1.2	1.55
Santiago Jocotepec	2.29	1.37	3.01
Santiago Yaveo	3.66	1.22	5.52
Total	2.7	2.72	5.11

Table 6: Target corn yields by municipality to cover human and animal consumption in the Papaloapan region, Oaxaca.

the acidity of the region's soils is a condition for cultivation. The high aluminum content limits the use of organic matter, hence specific management is required for such conditions.

CONCLUSIONS

The Papaloapan region of the state of Oaxaca is self-sufficient in corn for human consumption due to the area planted and the yields achieved. With the current average yield, production is sufficient to cover the consumption of the population. However, when animal consumption is considered, The region becomes significantly deficient, which is reflected in high rates of food dependency, so to achieve food self-sufficiency, yields above 5.11 t ha-1 on average are required. Due to the high consumption by the animal population, it is advisable to look for feeding alternatives that at least partially replace corn in the supplementation diets for the predominant species, especially cattle.

REFERENCES

Araujo A.L.A. (2022). **Demanda, oferta y precio de maíz amarillo en Mexico 2012-2021**. Revista Mexicana de Agronegocios, 50, pp. 197-208.

Bauza R., S. Dalel y R. Barreto. (2018). **Respuesta productiva de cerdos en engorde a la sustitución de maíz por sorgo en su dieta**. Universidad de la República de Uruguay. pp.125-131.

Cadena I.P., R. Ariza F., M. Morales G., R. Rodríguez H. y J.G. Berdugo R. (2024). **Rural development with agroecological emphasis for highly marginalized areas in Mexico; the bet for the paradigm change**. Brazilian Journal of Development. 10 (2): 01-27.

Catrip-Pintor, A.K., J.A. Hernández-Flores, & J.A. Méndez-Espinoza. (2020). **Tipología de circuitos cortos de comercialización en mercados y tianguis periurbanos de la región de Cholula, Puebla**. Revista de alimentación contemporánea y desarrollo regional, 30(56): 1-25. https://doi.org/10.24836/es.v30i56.995.

Cruz H.K.L., R. Valdivia A., M.A. Martínez D. y J.M. Contreras C. (2021). **Autosuficiencia alimentaria en Mexico: precios de garantía versus pagos directos al productor**. Revista Mexicana de Ciencias Agrícolas. 12(6): 981-990.

Fernández S.R., L.A. Morales Ch. y A. Gálvez M. (2013). **Importancia de los maíces nativos de Mexico en la dieta nacional. una revisión indispensable**. Revista. Fitotecnia Mexicana, 36 Supl. 3-A: 275 – 283.

Figueroa C.J. de D., D. E. Narváez G., A. Mauricio S., T. Suketoshi, M. Gaytán M., J. de J. Véles M., F. Rincón S., y F. Aragón C. (2013). **Propiedades físicas del grano y calidad de los grupos raciales de maíces nativos (criollos) de Mexico**. Revista Fitotecnia mexicana, 36(Supl. 3-a), 305-314. Recuperado en 06 de junio de 2024, de http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0187-73802013000500007&lng=es&tlng=es.

Galaviz R.J., J.L. Zaragoza R. y V. Corona J. (2011). **Alimentación para ovinos de la región nor-poniente de Tlaxcala**. Folleto técnico No. 46. Inifap. pp. 8-16.

García-Salazar J.A., R. Ramírez J., E. Avila S. y B.A. Ramírez B. (2023). ¿Es posible disminuir la dependencia alimentaria de maíz en **Mexico?**. Revista Fitotecnia. Mexicana, 46 (3): 299-307.

González-Cortés N., H. Silos-Espino, J.C. Estrada Cabral, J.A. Chávez-Muñoz, & L. Tejero-Jiménez. (2017). **Características y propiedades del maíz (*Zea mays* L.) criollo cultivado en Aguascalientes, México**. Revista Mexicana de Ciencias Agrícolas, 7(3), 669–680. https://doi.org/10.29312/remexca.v7i3.326.

INEGI. (2015). **Censo de Población y Vivienda**. Mexico.

Martínez S.L. (2016). **Seguridad alimentaria, autosuficiencia y disponibilidad del amaranto en Mexico**. Revista Problemas del desarrollo, 186(47): 107-132.

Mendoza M., G. D. (2016). Alimentación de ganado bovino con dietas altas en grano. Universidad Autónoma Metropolitana. pp. 45-49.

Miller magazine. (2023). **El mercado de grano de Mexico**. Revista Molinero, No. 24 (julio-agosto). Recuperado el 12 de abril 2024 en https://millerspanish.com/blog/el-mercado-de-grano-de-mexco-558.

Moreno-Saénz L.I., S. González A. y J.A. Matus G. (2016). **Dependencia de Mexico a las importaciones de maíz en la era del TLCAN**. Revista Mexicana de Ciencias Agrícolas, 7(1): 115-126.

Poder Ejecutivo Federal. (2019). **Plan Nacional de Desarrollo 2019-2024**. Pp. 55-58.

Ramírez-Juárez J. (2022). **Seguridad alimentaria y la agricultura familiar en Mexico**. Revista Mexicana de Ciencias Agrícolas, 13(3): 553-565.

SIAP-SAGARPA. (2018). **Atlas agroalimentario 2012-2018, Mexico**. pp. 28-103.

SIAP. (2020). **Anuario estadístico de la producción ganadera**. Mexico.

Torres F. y A. Rojas M. (2020). **Seguridad alimentaria y sus desequilibrios regionales en Mexico**. Problemas del desarrollo, 51 (201): 57-83.

Toro P., S.; I. Tovar L., J. Jaimes J. (2014). **Efecto del nivel de ensilado de maíz en la dieta sobre el consumo y digestibilidad de la materia seca, la producción y compasión química de la leche en cabras en lactación avanzada**. Unidad Regional de Zonas Áridas, Universidad Autónoma Chapingo. pp. 190-192.