Journal of Food and Nutrition Research, 2017, Vol. 5, No. 2, 86-94
Available online at http://pubs.sciepub.com/jfnr/5/2/3

DOI:10.12691/jfnr-5-2-3

Dietary Diversity in Rural Households: The Case of Indigenous Communities in Sierra Tarahumara, Mexico

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Abstract Rural populations have a bigger risk of suffering food and nutrition insecurity, mainly, where the indigenous population prevails. The purpose of this research was to analyse the dietary diversity through the Household Dietary Diversity Score (HDDS) in the indigenous communities of Sierra Tarahumara, State of Chihuahua, Mexico. The representative sample is formed of 123 households and it took place in February and March 2015. The households' characteristics were analysed, followed by a discriminant analysis (DA) by steps inclusion to determine which variables determine best the levels of the dietary diversity. The results show that the average HDDS of food consumption was of 6.89 foods. From the twelve food groups defined in this research, most of the respondents consume less than eight food groups (50.41%). The food groups most consumed by the sample of the study were the cereals (100%); legumes or nuts (96.7%); eggs (78.9%); sugar/honey (78%); oils/fats (77.2%). The DA determined that the variables that best explained the dietary diversity were food spending per capita, casual employment, the Prospera program and the marital status of the head of household. The level of low dietary diversity was the best to classify the DA. This research leads us to observe a consumption pattern of a diet based on carbohydrates that can be related to the nutrient deficiency to indicate family malnutrition. This tool can be used as diagnosis for the analysis of interventions on food and nutritional security.

Keywords: *household, dietary diversity score, access to food, food groups, food security, Mexico*

Cite This Article: Otilia Vanessa Cordero-Ahiman, Eduardo Santellano-Estrada, Alberto Garrido, and Alberto Garrido, "Dietary Diversity in Rural Households: The Case of Indigenous Communities in Sierra Tarahumara, Mexico." *Journal of Food and Nutrition Research*, vol. 5, no. 2 (2017): 86-94. doi: 10.12691/jfnr-5-2-3.

1. Introduction

Food security is still one of the global concerns and its measurement may facilitate the development of policies on the improvement of health [1,2]. Several studies have shown that ingesting a more varied diet is associated with a higher quality diet and proper nutrition around the world. Therefore, the diversity of the diet is an indicator of health related to the quality of the diet and a useful instrument to measure food security [3,4].

Households have food security when they have access throughout the year to the quantity and variety of safe foods that its members require to lead an active and healthy life. At home, food security means the ability to ensure the availability of foods, either because the family produces or buys them, in order to satisfy the needs of all its members [5]. This is why methodological tools have been developed to allow the identification of dietary diversity in the households and individually, such as the Household Dietary Diversity Score (HDDS) elaborated by the FANTA Project (Food and Nutrition Tehcnical Assistence) [6]. The HDDS is a qualitative methodology that has been validated in different countries as an approximate measure of energy consumption per capita of the household [7-12]. It also allows to identify the population's food deficiencies or excesses and it works as a baseline to implement interventions that improve the food consumption in households [6]. This indicator assesses the number of different food groups consumed in the household during a defined reference period, such as the last 24 or 48 hours or the last 7 or 14 days [8,9,13]. A diversified diet is linked to the economic ability of a household to access a variety of foods by obtaining a number of different food groups consumed during a determined period [14].

A varied, nutritional and balanced diet prevents the lack or excess of nutrients in the diet and reduces the malnutrition rates in the population [15]. However, malnutrition is still high in rural populations and they have higher risk of food and nutritional insecurity, mainly where indigenous population prevails [16,17]. For this reason, the need for an analysis on the dietary diversity in rural areas of Mexico emerged, which is related to the high levels of poverty. The Household Dietary Diversity Score (HDDS) was determined as an indicator of the economical access to foods. It was also analysed which are the food groups consumed the most by the indigenous communities of Sierra Tarahumara, State of Chihuahua, Mexico. In addition, the following question of the research was answered: What are the levels of dietary diversity in

the households of the communities of Sierra Tarahumara? This work was undertaken through surveys of households carried out in situ.

2. Materials and Methods

2.1. Study Site

This research was carried out in Sierra Tarahumara that is a mountain chain located in the Sierra Madre in the Mexican State of Chihuahua [18]. It has a number of deep canyons alternating with high subtropical mountains of up to 3,300m above sea level. It is characterised by a great diversity of tropical, subtropical and mild flora and fauna, including a number of unique species on Earth [19]. Sierra Tarahumara is also an area of cultural diversity, since there are four ethnic indigenous groups: Rarámuris o Tarahumaras, Pima, Guarijío and Tepehuanes. Most of the indigenous population is Rarámuri, one of the biggest groups of the indigenous communities in Mexico [19,20]. Despite its significance, there are no studies determining the HDDS of the communities located in Sierra Tarahumara.

2.2. Data Collection

The ethical approval of this research was given by the Research Council of the Centro de Extensión e Innovación Rural del Noroeste (CEIR) of the Universidad Autónoma de Chihuahua, Mexico. The communities of Sierra Tarahumara from Chihuahua were chosen on the basis of their main socioeconomic characteristics. These communities were classified according to the closest distance to the development centre, in this case, the city of Creel (0-3 km, 3-6 km, 6-9 km y 9-12 km). The selection of communities was made from a list of communities provided by the Instituto Nacional de Estadística y Geografía de México (INEGI) (Mexican Institute of Statistics and Geography) [21]. The representative sample was made of 124 households from 38 communities, with a confidence level of 95% and an accuracy rate of 7%. However, the analysis was made with 123 surveys because one of them had to be discarded due to lack of information. All participants of the research gave their informed consent before being surveyed. Each survey was made in person, and since all the surveyed households were formed by rarámuris indigenous, they responded in their dialect; therefore, the authors were assisted by translators from the area. In terms of food preparations in the household, the mother of the family or person in charge of preparing the foods was surveyed, seeking to obtain more information of the consumed foods. The survey was carried out in February and March 2015. The surveys were distributed on different weekdays and different times of the day in order to ensure that every household had the same probability of being surveyed. The pilot test of the survey was performed before the final survey. Along with experts' opinion, the results of the pilot test were used to refine the questions contained in the survey.

2.3. Questionnaire

The survey consisted in the following questionnaires: a) The HDDS, that is based on the food groups proposed by the FANTA [6]; b) the socioeconomic, that provides information about the head and characteristics of the household; and c) the agricultural questionnaire that, among others, provides information about the land tenure and production.

2.4. Analysis of the HDDS

The Household Dietary Diversity Score (HDDS) was obtained from a number of 12 food groups (A. Cereals; B. Roots and tubers; C. Vegetables; D. Fruits; E. Meat/poultry/offals; F. Eggs; G. Fish and seafood; H. Pulses/legumes/nuts; I. Milk and dairy products; J. Oils/fats; K. Sugar/honey and L. Miscellaneous). The applicable values among the groups from letter A to L were "0" or "1". Then, the HDDS was calculated adding the number of each food group consumed at the household, which value varies among 0 and 12.

To use this indicator in the assessment of the improvements of food security, the changes in the HDDS must be compared with levels of dietary diversity. Although there are no established cut-off points regarding the number of food groups used to indicate levels of food diversity, the target score could be established by taking the average of 33% of the households with bigger HDDS (the highest tercile). It is thus that we generated a categorical variable with three levels. 1) Low dietary diversity (1-6 food groups); 2) Medium dietary diversity (7-8 food groups); and 3) High dietary diversity (9-12 food groups). This is useful for the monitoring of the purposes since any increase on the food diversity of the households reflects an improvement on the households diet [6,14].

Finally, the average HDDS indicator was calculated for the total of the demographic sample.

2.5. Statistical Analysis

First of all, some descriptive statistics were obtained related to the different characteristics of the households. The dependent variable was dietary diversity levels, considered as the group variable and it is divided into three categories: Low food diversity = 1; Medium food diversity = 2 and High food diversity = 3. The independent variables were (Table 1):

Secondly, a discriminant analysis was carried out because the dependent variable is qualitative (levels of dietary diversity). It can be classified in groups (low, medium and high dietary diversity) and the belonging to the groups of a set of predictor variable can be predicted (both qualitative and quantitative). The objective is to determine a function that maximises the existing distance between the groups with the DA; this is, to reach a function with a strong power of discrimination between the dietary diversity levels. In particular, we conducted the DA in this research with the steps inclusion method, whereby in each step, all the predictor variables are revised and assessed to determine which is going to contribute more to the discrimination between groups. This is, what set of variables predicts better the dietary diversity of the households [22,23,24]. A DA model is expressed in the following way:

$$D_i = d_{i1}X_1 + d_{i2}X_2 + ... + d_{ik}X_k$$

Where $\boldsymbol{D_i}$ is the score of Fisher's discriminant function, $\boldsymbol{d_i}$ is the coefficient of the discriminant function and $\boldsymbol{X_k}$ is the score of the predictor variable that can be discrete or continuous.

Table 1. The independent variables

Gender:	Dichotomical variable (0, 1), where 0 is woman and 1 man.
Age:	Ordinal variable (17-29 years old, 30-44 years, 45-59 years, 60-74 years, 75-80 years).
Marital status:	Nominal qualitative variable (non-marital cohabitation, married, widower, separated).
Level of education:	Ordinal variable (without education, basic education, secondary education, higher education).
Access to water facilities:	Water used at the households. It has to be mentioned that no household of this research has access to an improved installation of drinking water service. However, this variable studies where the households obtain water. It is a dichotomical variable (0,1), where 1 indicates that the water is obtained from a well and 0 that it is obtained from some river or spring.
	Dichotomical variable that assumes two values -0 and 1- where 0 indicates absence of toilets in the household and 1 indicates that there are toilets in the household.
Electricity:	Dichotomical variable that assumes two values - 0 and 1- where 0 indicates they do not have and 1 they do.
Gas use for cooking:	Dichotomical variable that assumes two values - 0 and 1- where 0 indicates they use firewood and 1 means the use of cooking gas.
Casual employment:	Dichotomical variable (0, 1), where 1 indicates that the head of household has some casual employment and 0, unemployed or self-employed.
Own lands:	The amount of land available that the head of household owns (doesn't have, <1 Ha., 1-2 Ha., >2 Ha.), that is a qualitative variable.
Prospera:	Dichotomical variable (0, 1) that indicates if the families are (1) or not (0) beneficiaries of this social inclusion and conditional cash transfer program.
Size of the household:	The number of members of a household. Continuous variable.
Poverty:	When a person has at least one social deprivation and their income is insufficient to acquire the goods and services to satisfy their Food and non-food needs. Continuous variable.
Extreme poverty:	When a person has three or more social deprivations, in this situation they have an income so low that they could not acquire the nutrients needed to have a healthy life. Continuous variable.
Welfare line:	Monetary value of a basket of basic foods, goods and services. Continuous variable.
Food spendings per capita:	It is defined as the relationship between the total expenditure by the household on foods in relation to the size of the household. We used the food spending per capita as a substitute for the income, since the foods are a significant component of the households' expenditure. It is a continuous variable measured in Mexican pesos.

Source: own elaboration from surveys

The statistical significance of the discriminant function was assessed by the Wilks' lambda test, eigenvalues, canonical correlation and F-statistics. In this case, since the group variable (dietary diversity levels) is composed of three groups, two discriminant functions and two eigenvalues can be extracted. The canonical correlation and eigenvalues' statistics measure the relationship of the discriminant function regarding the total variance. It is expected that the canonical values and eigenvalues to be high, because the power of discrimination of the model will be larger. On the other hand, the Wilks' lambda test is used to check the null hypothesis that populations have the same measures in the discriminant function. Wilks' lambda values are expected to be low, since the effect of the independent variable is more important for the discriminant function. The null hypothesis can be rejected when the value of the test statistic is higher than the F-critical value for the desired significance level. The average values or centroids of each of the functions for each group were also examined. These group centroids will indicate if the discriminant function contributes significantly to the separation of the groups. The main objective of this analysis is to maximise the amount of variation between each group and the overall average for every group, whereas simultaneously, the amount of variation existing inside each group is minimised [22]). This statistical analysis was performed using the software SPSS, version 20.0.

3. Results

3.1. Socioeconomic Characteristics of the Household

The research was conducted in indigenous communities of Sierra Tarahumara of the Mexican State of Chihuahua, finding that 65% of the heads of household are men, whereas 35% are women. The age of most of them varies between 30-44 years old and they are living, mainly, in a marital status of non-marital cohabitation (57.72%). On average, a household is made up of 4.28 members. The heads of household have a low level of education (23.58% with no studies and 61.79% of basic education). On the other hand, it was observed that the households of these communities do not have access to an improved installation of safe water; and 70.73% use water to cook and drink which comes from pits and 29.27% use water which comes from rivers and springs. In terms of sanitation, only 30.89% of people use the toilet as type of sanitation facility, whereas 69.11% have their bowel movements outdoors. 82.11% are not connected to an electricity network and 92.68% use firewood to cook. With regards to the household economy, 34.15% had casual employment and the rest were unemployed or self-employed. 34.96% and 31.73% of households are in the low and medium income terciles, respectively.

Through the line of economic welfare, we could calculate the situation of poverty in which the households of our research were in 2015. We found that 26% and 18.7% live in a situation of poverty and extreme poverty, respectively. However, 24.39% of households, despite they were inside the line of welfare, they had at least one social deprivation. Therefore, they are also located in the poverty category, since they are vulnerable due to social deprivation. 21.95% of the surveyed people do not have lands of their own, while 54.47% have between one and two hectares. 66.67% are beneficiary of the Prospera conditional cash transfer (Table 2).

Table 2. Descriptive statistics of the characteristics of the household

Variables	%	Min.	Max.	Average	SD
Qualitative					
Gender of the head of household:		0	1	0.65	0.48
Woman	34.96				
Man	65.04				
Age:		1	5	2.26	1.01
17-29 years	22.76				
30-44 years	43.09				
45-59 years	22.76				
60-74 years	8.13				
75-80 years	3.25				
Marital status of the head of household:		1	4	1.84	1.12
Non-marital cohabitation	57.72				
Married	14.63				
Widower	13.82				
Separated	13.82				
Level of education:		0	3	0.95	0.71
No studies	23.58				
Primary	61.79				
Secondary	10.57				
Higher	4.07				
Access to water facilities:		0	1	0.71	0.46
Don't have	29.27				
Waterwheel or well	70.73				
Toilet:		0	1	0.31	0.46
Don't have	69.11				
Do have	30.89				
Electricity:		0	1	0.18	0.38
Don't have	82.11				
Do have	17.89				
Gas use for cooking:		0	1	0.07	0.26
Firewood:	92.68				
Gas	7.32				
Income:		1	3	1.98	0.83
Low income tercile	34.96				
Medium income tercile	31.71				
High income tercile	33.33				
Own lands:		0	3	1.60	0.98
Doesn't have	21.95				
< 1 Ha.	9.76				
1-2 Ha.	54.47				
>2 Ha.	13.82				
Casual employment:		0	1	0.34	0.48
No	65.85				
Yes	34.15				
Prospera (CCT):		0	1	0.67	0.47
Non-beneficiary	33.33				
Beneficiary	66.67				
Dietary diversity levels:		1	3	1.89	0.83
Low dietary diversity	39.84				
Medium dietary diversity	30.89				
High dietary diversity	29.27				
Quantitative					
Size of the household		1	14	4.28	1.71
Poverty	26.02	900.00	1650.00	1297.19	242.29
Extreme poverty	18.70	0.00	800.00	495.65	265.40
Welfare line (vulnerable due to social deprivation)	24.39	1,900.00	1,2120.00	3,835.33	2,056.85
Food spendings per capita	100.00	33.33	1,500.00	390.55	2,70.12

Note: Ha= Hectares. Min=Minimum Max=Maximum. DS= Standard Deviation (n=123).
Source: own elaboration from surveys.

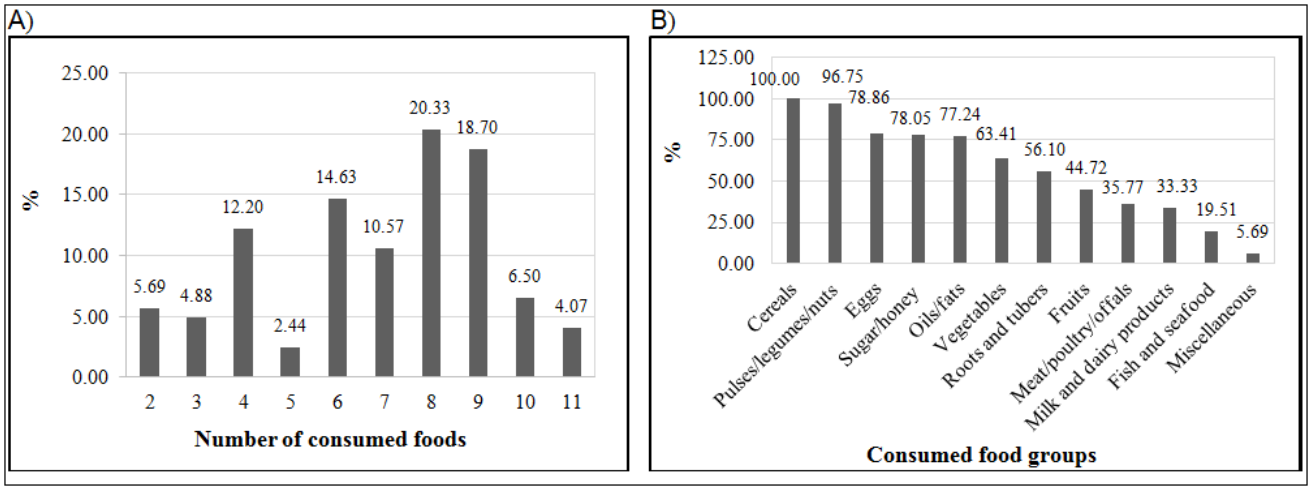

Figure 1. Aspects related to the food consumption pattern of the households (%): (A) Number of consumed foods and (B) Consumed food groups (Source: own elaboration from surveys)

3.2. Access to Food

It was found that 6.50% and 4.07% of the surveyed households consume between 10 and 11 food groups, respectively; whereas 18.70% consume 9, 20.33% consume 8 and most of them (50.41% approximately) consume less than 8 food groups. The most consumed food groups by the households were: cereals (100%); legumes or nuts (96.7%); eggs (78.9%); sugar/honey (78%); oils/fats (77.2%), vegetables (63.4%) and root crops (56.1%). The animal protein, fish, dairy and fruits were consumed the least (Figure 1).

39.84% and 30.89% of the families from the communities of Sierra Tarahumara have a low and medium dietary diversity respectively, while 29.27% of the households have a high dietary diversity (Table 1).

In this research, it was found that the average HDDS stood at the lowest HDDS tercile (6.89), what means that in the indigenous communities of Sierra Tarahumara there is a low dietary diversity. This result was reaffirmed with the discriminant analysis (DA).

3.3. Results of the Discriminant Analysis (DA)

The DA, under the steps inclusion method, identified two statistically significant discriminant functions ($p< 0.05$). Although all the predictor variables of Table 2 were introduced in the model, this DA method determined that the variables that most discriminate the functions were casual employment, the marital status of the head of household, the food spending per capita and Prospera cash transfer variable (Wilks' lambda $p<0.05$). The eigenvalues of the first and second discriminant function were 0.48 and 0.08, respectively. The variances explained by both functions were 85.82% and 14.18%, respectively; and the canonical correlations of both functions were 0.57 and 0.27, respectively. This indicates that the first discriminant function is the one that is going to explain best the model (Table 3). To describe the two canonical discriminant functions, the standardised coefficients were used, to be as follows:

$$D_1 = 0.804\text{Casual\_employment} + 0.641\text{Marital\_status} - 0.475\text{foodexpend\_percap} - 0.266\ \text{Prospera}$$

$$D_2 = 0.795\ \text{Prospera} + 0.518\ \text{Casual\_employment} + 0.454\ \text{foodexpend\_percap} - 0.267\ \text{Marital\_status}.$$

It is clear that for the first standardised discriminant function, the maximum impact in the dietary diversity of the household comes through the casual employment (0.80) and marital status of the head of household (0.64). An increase of a unit of casual employment increments the dietary diversity levels by 0.804 units. This result suggests that, if this type of work increases, the possibility for these households to have a low dietary diversity will also grow. It was also found that an increase in a unit of the marital status enlarges the dietary diversity levels by 0.64 units. This means that the marital status may influence on increasing the low dietary diversity or reducing the others. Likewise, if the food expenditure per capita reduces in a unit, the medium and high dietary diversity levels would diminished by -0.47 units, so the low dietary diversity will get worse. Also, when the cash transfers reduce in a unit, the medium and high dietary diversity also do, increasing the low dietary diversity in -0.27 units. On the second standardised discriminant function, we found that the maximum effect is produced from the cash transfer and casual employment variables. The independent impact is 0.79 and 0.52, respectively.

This indicates that, when the cash transfers increase in a unit, the dietary diversity levels grow in the household in 0.79 units. What it means that the low dietary diversity is reduced, increasing the medium one. However, it is not observed that the high dietary diversity increases. This may occur because despite of having an allowance from the State, this does not meet the food needs of the household. In respect of the casual employment, an increase in a unit of work force increments the dietary diversity levels by 0.52 units, the low dietary diversity descends and the medium diversity grows. However, the high dietary diversity reduces. This may be because if there is no stable employment, the household lives in economic uncertainty. If the food expenditure per capita grows, it is possible that the dietary diversity increases in 0.45 units.

The centroids or average values of each discriminant function showed that the first function discriminates mainly between the household groups with low dietary diversity and the ones with high dietary diversity. For this

function, the average value of low dietary diversity is 0.84, while the average value of high dietary diversity is -0.60. Therefore, the majority of the discriminatory power of this function comes from differentiating between households with low dietary diversity and the group with high dietary diversity. On the other hand, the second discriminant function does not show any significant difference between the households with low dietary diversity and the ones with high dietary diversity. However, it does show a strong ability to differentiate from the groups of households that are with medium dietary diversity with the households with high dietary diversity. Therefore, most part of the discriminatory power of this second function interposes between the differentiation of the households with high dietary diversity and the households with low dietary diversity (Table 3).

In Table 4 it can be observed the classification in which it is assumed that all three groups have the same probabilities in the population. 57% of the original cases have been classified correctly. In the households with low dietary diversity and the ones with high dietary diversity, the rates of correct classification (proportion of successes) are 67.35% and 55.56% respectively. However, the households with medium dietary diversity cannot be properly classified (44.47%). In conclusion, the discriminant functions used in this research describe the clear separation between the high and low dietary diversity types, and they also show that there are significant variations between them.

4. Discussion

The purpose of this research was to analyse the dietary diversity through the Household Dietary Diversity Score in the rural areas of Mexico, specifically of the households in the indigenous communities of Sierra Tarahumara, (State of Chihuahua, Mexico). We applied the HDDS to measure the dietary diversity levels in the households and carried out the estimate of the DA model, by steps inclusion to determine what variables discriminate better the dietary diversity levels.

Table 3. Standardised coefficient of the canonical discriminant functions for the dietary diversity levels

Discriminant functions	Standardised coefficients	Wilks' lambda	Eigenvalues	% of variance	Canonial correlation
Function 1		0.63***	0.48	85.82	0.57
Food spendings per capita	-0.47				
Marital status of the head of household	0.64				
Casual employment	0.80				
Prospera	-0.27				
F1 centroids					
Low dietary diversity	0.84				
Medium dietary diversity	-0.52				
High dietary diversity	-0.60				
Function 2		0.93**	0.08	14.18	0.27
Food spendings per capita	0.45				
Marital status of the head of household	0.27				
Casual employment	0.52				
Prospera	0.79				
F2 centroids					
Low dietary diversity	-0.02				
Medium dietary diversity	0.36				
High dietary diversity	-0.36				

*** $p<0.01$. ** $p<0.05$.
Source: own elaboration from surveys.

Table 4. Classification of the results obtained by the discriminant prediction model for the dietary diversity levels

		Predicted belonging group			Total
Original	Dietary diversity levels	Low dietary diversity	Medium dietary diversity	High dietary diversity	
n	Low dietary diversity	33.00	6.00	10.00	49.00
	Medium dietary diversity	8.00	17.00	13.00	38.00
	High dietary diversity	8.00	8.00	20.00	36.00
%	Low dietary diversity	67.35	12.24	20.41	100.00
	Medium dietary diversity	21.05	44.74	34.21	100.00
	High dietary diversity	22.22	22.22	55.56	100.00

57% of the original cases grouped correctly classified.
Source: own elaboration from surveys.

In Mexico, according to SHCP [25], the minimum wage on 2015 was 70.10 Mexican pesos per day; this is, 2,103.00 Mexican pesos per month, which contrasts with the results from this research, because most of the heads of households were located on the low and medium income tercile. CONEVAL [26], informed that the minimum welfare economic line and economic welfare in February 2015 were of 887.58 and 1,661.54 Mexican pesos respectively. This is in contrast with our findings since the households in our research were found in poverty situation and extreme poverty. This leads us to guess that the households suffer from food insecurity, based on the reason that it is a poverty subcategory; this is the lack of income necessary to buy necessary food to survive in the given conditions [27,28,29,30].

Regarding the measurement of the food access in the households, the HDDS was used, methodology proposed by Swindale and Bilinsky [6]. Our findings indicate that the animal protein, fish, dairy and fruits consumption are poor to the food recommendations made by FAO [14] and WHO [15]. These results are related to other studies. Melgar-Quinonez et al. [31] found in Bolivia, Burkina Faso and Philippines that the lower the expenditure in meats, fruits and dairy are, the bigger is the food insecurity. On the other hand, Vega-Macedo et al. [32] in their research performed in Mexico, they indicated that the severe food insecurity households tend to substitute the high-quality protein sources such as red meat, chicken, fish and milk by lower cost alternatives such as eggs and legumes. Furthermore, as food insecurity increases, the buying of fruits and vegetables decreases. Also, Legwegoh and Hovorka [9] found in Gaborone, Botswana, that people frequently consume more cereals (97.2%), sugar/honey (73%), whereas fish/seafood (12.8%), eggs (23.6%) and beans, peas, lentils or walnuts (27.4%) were the least consumed. Kaiser et al. [33] in the research they performed in the United States with children from California, they found that 60% of the food insecurity households stop consuming fruits and vegetables, reduce the dairy and meat-products consumption. Prada et al. [34] described the consumption pattern of the displaced population in Santander, Colombia. They found that the diet quality was poor, the main sources of animal protein were milk and eggs; less than a third consumed some type of meat and 28.7% of the total of the families consumed vegetable proteins from lentils, dried peas and beans. Vegetables and green legumes satisfied just 15%, while the fruits covered just 12.5%. Therefore, in this research we conclude that the diet of the population of study is quite monotonous and it is characterised by having small variety of foods. Also, we observed a diet with a consumption pattern based on carbohydrates, what may reveal a possible deficiency of essential micronutrients for the human development and hence, there is malnutrition in the household. With these findings, it is ratified that the studied population is in food insecurity conditions.

In this study, the HHDS average was of 6.89, a result that differs from the ones found by De Cock et al. [8] in Limpopo province, South Africa. They reported that the households had an average HDDS of 4.5, whereas Harris-Fry et al. [35] in their research performed with women from the rural area of Bangladesh reported an average of 3.8 food groups. However, what the HDDS means in terms of public health is not clear, since there is no specific cut points [6,14].

The discriminant analysis (DA) used in this research concluded that the best variables to separate the dietary diversity levels were the food spending per capita, the casual employment, the cash transfer variable and the marital status of the head of household. In some studies, there were found significant positive associations between the diversity of the diet and the food spending variable. This is, the diversity of the diet was consistently bigger with the growth in consumption and also, significant associations were observed between the diversity of the diet and other socioeconomic status indicators [13].

We could also observed that in our results from the DA that, the dietary diversity decreases when the heads of family have casual employment. These results are in contrast with Benson [36] who studied poor neighbourhoods of Bangladesh and found that, the households whose members have stable and well-paid employment were less prone to reduce the foods consumption. Therefore, the lack of employment is related to a low food consumption and food insecurity.

On the other hand, the DA also showed that if the cash transfers given by Prospera decreased, the high and medium dietary diversity would decrease too. Prospera is a Mexican conditional cash transfer program, with a national commitment to nutrition, health and education [37]. These findings agrees with FAO et al. [16] who informs that with no public assistance, numerous poor and vulnerable households will suffer lasting deprivations that would result in poverty for future generations. On the other hand, Hidrobo et al. [38] in a research carried out in Ecuador about a transfer program, they found that this program contributed to a rise in foods consumption per capita and hence, to dietary diversity. However, in our research it was found that Prospera has not been able to reach some of the poor households. FAO et al. [16] and Sonnino et al. [39] suggest that fundamentally, this is because the coverage of the social assistance programs is still limited.

According to Maxwell et al. [10], higher scores of the HDDS are indicators of a greater frequency of the foods and dietary diversity, therefore, less food insecurity. However, the DA found a clear difference between the dietary diversity types, being the low dietary diversity the best classified; what means that there are problems with the foods access and hence, food insecurity, thereby verifying the average HDDS.

5. Conclusions

The HDDS is a measurement tool for households food access that can be studied along with another information concerning foods to provide a global image of the food and nutritional security state in a community or in a larger area. The dietary diversity questionnaires should be included more frequently in the surveys about nutritional and food security in order to provide food access indicators in the household.

The availability and food access determines the food security. For this reason, the elaboration of studies to analyse the different factors that involve food security are

very important, since they are part of basic information to carry out interventions to improve the food and food security in order to prevent the poor-diet and nutrient deficiencies related diseases. The determination of the HHDS as economic access indicator to the foods in Sierra Tarahumara allowed to assess the severity of the food-deficit in the population and value the variety of food groups that are consumed.

From the DA, by steps inclusion, we found that the improvement in employment is still an important topic that must continue to be present in the Mexican public policy agenda, since a significant percentage of households have casual employment or are unemployed. Improving the employment status of the heads of household may have positive consequences on the food access, helping the diet to be more diverse and resulting in an improvement of food security.

In addition, we concluded that the conditional transfers, in this case Prospera, would allow the households to increase the food consumption and dietary diversity. Nevertheless, these conditional transfers, by themselves, are not enough to lift people out of food insecurity and poverty, as this depends on other factors as it has been emerged in this research. The government must intervene in aspects such as safe water services access, sanitation, electrical network and health care, which are deficient in the study of research. As well as performing interventions in agriculture, since rural families in a food insecurity situation fundamentally depend on agriculture for their livelihoods. Conditional transfers, along with agricultural policies focused on the poor rural population may bring excellent results in the long and short term of food insecurity and poverty reduction.

Some limitations in this research should be mentioned. Firstly, the size of the sample is relatively small and is not necessarily representative of all the Mexican rural areas, although the socioeconomic structure is fairly similar. It would be of great interest to carry out a similar research with a larger number of participants and in different regions to consolidate our preliminary findings, and also, to include in the research the determination of the availability of calories per capita of the household. This is because this research only allowed to measure the access to foods and analyse the dietary diversity levels of the families. Secondly, the statistical analysis applied only provides an assessment of the effect -positive or negative- of the diversity of the diet and it does not provide a monetary evaluation. Despite these limitations, the main results of this research constitute an initial baseline by providing a greater understanding of the dietary diversity of the indigenous communities of Sierra Tarahumara. These findings would help the decision makers to develop effective strategies to fight against food insecurity. Future researches should focus on the conduct of researches on food security, especially, in the rural areas and paying particular attention to the communities at risk and indigenous populations.

Statement of Competing Interests

The authors declare no conflict of interest related to this study.

List of Abbreviations

CONEVAL: National Council to Evaluate Development Policy
DA: Discriminant analysis
FAO: Food and Agriculture Organization of the United Nations
HDDS: Household Dietary Diversity Score
INEGI: Mexican Institute of Statistics and Geography
SHCP: Secretariat of Finance and Public Credit
WHO: World Health Organization

Acknowledgements

The fieldwork was carried out with the aid of a grant from the Mexican Ministry of Agriculture, (in Spanish: Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación, SAGARPA), within agreement with the Autonomous University of Chihuahua, (in Spanish: Universidad Autónoma de Chihuahua, UACH) (grant number CONV/UACH/SAGARPA2014). We would like to express our sincere gratitude to all the surveyed of the communities, their great kindness contributed decisively to the completion of the field work. Also, we are grateful to local leaders of San Ignacio de Arareco, CEIGRAM-UPM, CEIR-UACH and REINU-UACH for their logistic support into this research. O. Vanessa Cordero-Ahiman acknowledges a scholarship for PhD studies from the Secretary of Higher Education, Science, Technology and Innovation of Ecuador (SENESCYT).

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