

## Consumption Data for the Main Cheeses (Mexican-Style Fresh and Oaxaca) for Dietary Exposure Assessment among the Population of Veracruz City, Mexico

Hernández Camarillo E<sup>1</sup>, Ramírez-Martínez A<sup>2,3</sup>, Vargas-Ortiz M<sup>1</sup>, Wesolek N<sup>2</sup>, Rodríguez-Jimenes GC<sup>1</sup>, Salgado-Cervantes MA<sup>1</sup>, Roudot A-C<sup>2</sup>, Carvajal-Moreno M<sup>4</sup>, and Robles-Olvera V<sup>1\*</sup>

<sup>1</sup>Unidad de Investigación y Desarrollo de Alimentos, Instituto Tecnológico de Veracruz. Miguel Ángel de Quevedo 2779, Col. Formando Hogar, 91897 Veracruz Ver, Mexico

<sup>2</sup>Laboratoire d'évaluation du risque chimique pour le consommateur, Université de Bretagne Occidentale. 3 rue des Archives - CS 93837 - F29238 Brest cedex 3, France

<sup>3</sup>Colegio de Posgraduados (COLPOS), Campus Veracruz. Cerrada Las Orquídeas, Mza. 20, Lote 20, 91675 Tolome, Ver, Mexico

<sup>4</sup>Instituto de Biología, Universidad Nacional Autónoma de México. Ciudad Universitaria, Coyoacán, 04510 Ciudad de México, Mexico

\*Corresponding author: Robles-Olvera Víctor, Unidad de Investigación y Desarrollo de Alimentos, Instituto Tecnológico de Veracruz. Miguel Ángel de Quevedo 2779, Col. Formando Hogar, 91897 Veracruz Ver, Mexico, Tel: + (52)229-9341500; Fax: 9345701 ext 201; E-mail: vrobles@itver.edu.mx

Received date: Sep 06, 2016; Accepted date: Oct 010, 2016; Published date: Oct 20, 2016.

Copyright: © 2016 Estela HC, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

### Abstract

In tropical areas of Mexico and the world mycotoxin-producing fungi grow in some cereals such as corn. These fungi can contaminate corn with Aflatoxin B1 and subsequently be consumed by dairy cows, which metabolize it into Aflatoxin M<sub>1</sub>. This toxin is potentially carcinogenic for humans and it can be excreted by dairy cows into milk. Much of this milk is converted into cheese. It is therefore essential to assess the exposure of the population to this toxin through the consumption of cheese. Food intake data is the first step to assess exposure of contaminants through food consumption. Therefore, the objective of this study was to design and implement questionnaires to determine the most consumed cheeses among Veracruz City population, consumption rates of these cheeses, as well as to determine the main factors influencing consumption patterns. The two methods used for data collection of the intake of cheeses were a Purchase Frequency Questionnaire and a 7-day food diary. The city of Veracruz is a good representation of the urban population of Mexico (552,156 inhabitants; 232.3 km<sup>2</sup> of surface area). The questionnaires show that the average consumption rate was 50.9 g/person/day and 47.8 g/person/day for fresh and Oaxaca cheeses, respectively. The results of the Purchase Frequency Questionnaire and food diary were confirmed. The methodology used can be applied in other countries requiring not only the assessment risk of exposure to aflatoxin M<sub>1</sub> but also other pollutants through cheese consumption.

**Keywords:** Consumption; Fresh and Oaxaca cheeses; Diet; Food-frequency questionnaire; Veracruz

### Introduction

The Mexican consumers prefer to buy cheese from local stores. The quality of the milk used to produce fresh and Oaxaca cheeses are not monitored by any local authority because they are handmade by producers [1]. Oaxaca type cheese is produced in the same way all over the country; the acidification of milk is more accentuated. The obtained curd is subjected to mixing with hot water (65°C a 70°C), and then it is stretched until the formation of strands [2]; fresh cheese is an unripen cheese and its production varies according to the state of Mexico in which it is made [3,4], in this process milk first coagulates by the addition of rennet, the curd is cut, the whey is drained, salt is added to the curd and finally the curd is moulded [5].

Veracruz State is the sixth largest producer of milk in Mexico [6]. The 53% of the total milk production is used to produce handmade cheeses [7] and a large share of this raw milk is sent to big cities such as Veracruz City (the largest city in Veracruz state) [8]. It has been shown that raw milk products can have high concentrations of pathogenic bacteria, dioxins, heavy metals, hormones, antibiotics and mycotoxins [9-14]. Mycotoxins, such as aflatoxins have carcinogenic properties [15,16]. Aflatoxins can be transferred from milk to cheese [17]. The aflatoxin M<sub>1</sub> (AFM<sub>1</sub>) is frequently found in cheese when dairy cattle have been fed with aflatoxin B<sub>1</sub>-contaminated feeds [18]; however,

there exist few studies that measure the consumption of this contaminated cheese by the population.

The exposure assessment is defined [19] as the qualitative and/or quantitative evaluation of the likely intake of biological, chemical or physical agents via food. The method used depends on the available information, the level of accuracy required, the funding and the available time [20]. In the case of cheese intake this assessment requires accurate knowledge of patterns and rates of cheese consumption among the population. The collection of valid data on the food consumption habits of a population is the most difficult problem to overcome before any assessment can be made of dietary exposure to a contaminant because the pattern of food consumption vary widely between persons and groups of persons. The causes of pattern of food consumption variability may be ethnic, age, cultural, economic, dietetic and social aspects, age and health status [21].

There are two methods for obtaining information on dietary patterns: (i) indirect measurement based on surveys of collective consumption in a region or home, (ii) direct measurement which involves the survey of individual consumption that incorporates the collection of personal data on the effective quantities of food consumed by a person or a family [22]. Direct measurements serve to collect data when there is no previously available data, which is the case of Mexico and in particular, Veracruz City. Direct measurements can be divided into two categories: recall and record methods. The record method evaluates the intake through a food diary in which food

consumption can be recorded by weighing or estimating the quantity of food consumed over one or several days. Recall methods are based on the intake over the previous day (24-hour recall) or on the usual food intake (food frequency) [20,21]. Consumption data obtained by these methods can be combined to improve accuracy and validate the survey. The aim of this study is to obtain data for subsequently assessing the risk to which the population of Veracruz City is exposed for aflatoxin M<sub>1</sub>. Consumption data may also be used in other areas such as Health Care and Nutrition.

## Materials and Methods

### Survey design

The population of interest was the population of Veracruz City. This city covers 232.3 km<sup>2</sup> and is located on the Gulf of Mexico. In order to study the frequency of purchase of both cheeses as well as the variability of the consumption patterns of Oaxaca and fresh cheeses (social class, age and gender), the map of Veracruz City was used. The map dimensions of Veracruz City were fed into the MATLAB software to generate 150 and 400 random geographical coordinates for the Frequency Purchase Questionnaire and the food diary, respectively. These coordinates were located on the map. In the case of the Purchase Frequency Questionnaire, one hundred points were enough to cover all kinds of people in the city in proportions similar to the total population. In the case of the food diary, 309 from the 400 random sample points allowed to cover all kinds of people in the city.

Once the geographic coordinates were located, the interviewer went to the located place and invited to one member of the household to fill the survey. If the member of the household did not agree to participate, the interviewer would select another house in the area until he found a member of a household that accepted to fill the survey. The same methodology for the Purchase Food Frequency and the food diary was followed.

In Mexico, some health and nutrition surveys had been already conducted [23,24]. However, most of these surveys were conducted in Mexico City and few studies have characterized the food consumption of populations in other urban communities. Thus, preliminary surveys were carried out to evaluate the clarity of the instructions and the format of the questionnaires to assess consumption.

### Data collection

**Purchase frequency questionnaire:** The food frequency questionnaire was applied through face-to-face interviews at the sampling points obtained previously (100 sample points). Surveys were conducted from September 2014 to November 2015. The interviews were carried out in 5-10 minutes with the inhabitant who usually made purchases in the home. Surveyed people were asked to indicate their educational background, profession, economic situation, the meal and time of year at which they consumed cheese and the place of storage of consumed cheese.

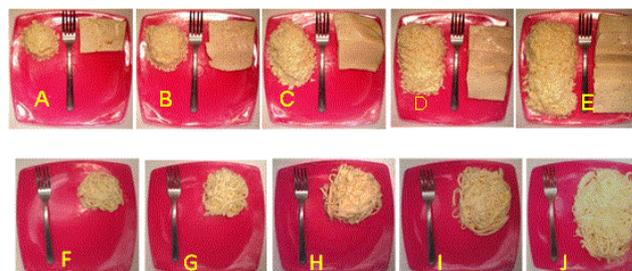
The survey included eight photos with common cheeses consumed in Mexico (Manchego, American, Parmesan, Mozzarella, Cottage, fresh, Oaxaca and curd). Below each photo, respondents indicated the amount, frequency of purchase and the place of purchase of the cheese or cheeses they usually consume. In this investigation the Food Frequency Questionnaire is called a Purchase Frequency Questionnaire because the questionnaire was used to assess the

frequency of purchase of cheeses instead of the frequency of consumption.

### Food diary

The Food Diary questionnaire was applied for the two types of cheese that were the most purchased according to the results obtained from the Purchase Frequency Questionnaire (Oaxaca and fresh cheeses). Similarly to the Purchase Frequency Questionnaire, random sampling points (309) were obtained in order to define the locations of the inhabitants selected to answer the food diary questionnaire.

The questionnaire was applied by face-to-face interviews at the sampling points. First, a 5-10 minute explanation was given to the inhabitant who usually prepared the meals within the home. Then, the questionnaire was left for seven days in order to be filled in by the interviewee, who was also asked to indicate the age, gender, weight and social class of each member of his/her household as well as their consumption at each meal (breakfast, lunch and dinner). In order to help participants to estimate their own consumption and that of their family the questionnaire included five photos showing different servings. Each photo represented different portions varying from a small to a large portion. A different letter was assigned to each photo to help the interviewee to fill in the questionnaire (A, F: 36 g; B, G: 60 g; C, H: 92 g; D, I: 122 g and E, J: 184 g). These portions were determined from preliminary surveys (n=30). The Oaxaca cheese was shown in shredded form, because this is how it is commonly consumed in Mexico. The fresh cheese was presented in the two forms in which it is consumed: sliced and shredded. All the photos included a plate and a fork. The fork helped people to identify the portion size (Figure 1).



**Figure 1:** Portions for fresh (A to E) and Oaxaca (F to J) cheese assigned with different letters A, F (36 g), B, G (60 g), C, H (92 g), D, I (122 g) and E, J (184 g).

The questionnaires were carried out from November 2014 to October 2015, in order to take into account any possible seasonal variability.

### Statistical analyses

Consumption rates were calculated for each type of cheese. Consumption rates were also calculated individually (as the sum for each individual), for a household (as the sum for each individual of the same family), and for different categories (age, gender, social class and meal schedule). The consumption results will be represented in the form of a Probability Distribution Function (PDF).

Descriptive statistics were generated to summarize the percentage of families who do not eat fresh cheese but eat Oaxaca cheese, the

percentage of families who do not eat Oaxaca cheese but consume fresh cheese and the percentage of families consuming both cheese types.

Data from the Purchase Frequency Questionnaire and the food diary were entered into the statistical software (@Risk). The mean consumption rate and the 95<sup>th</sup> percentile were calculated for each type of cheese and for each category.

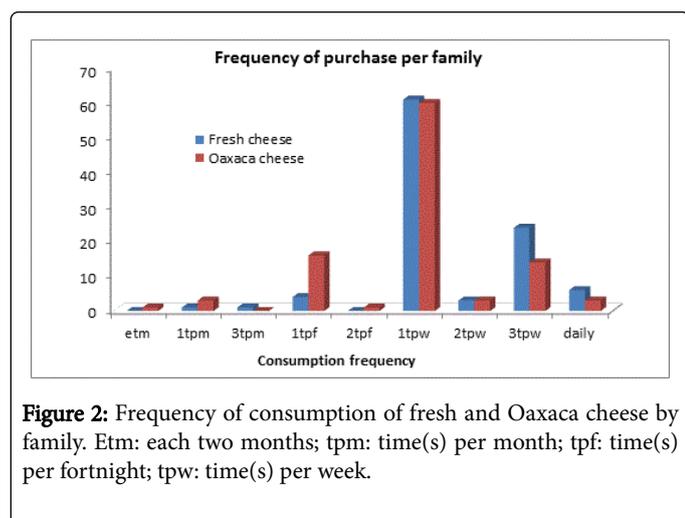
Comparisons were performed among data from the two research methods, i.e. the Purchase Frequency Questionnaire and the food diary. In order to detect significant differences between the mean, median and distributions, the Mann-Whitney and Kruskal-Wallis tests were used. In order to obtain a robust statistical analysis, when the number of samples was very different between groups, resampling was performed to equilibrate their size. This was conducted with @Risk software using a bootstrap procedure.

## Results

### Characteristics of the consumers

**Purchase frequency questionnaire:** All residents invited to participate in the purchase frequency questionnaire, agreed to complete the survey. Of the 100 households interviewed, 98 consumed fresh and Oaxaca cheese. As stated above, this survey was filled out by the inhabitant who usually prepared meals at home. Among the surveyed inhabitants who stated that the family consumed cheese 7 were men and 91 were women.

The results of this questionnaire also showed the purchase preferences of different types of cheeses (Table 1). Oaxaca (75% purchase) and fresh cheese (90% purchase) were the most consumed cheeses among the population of Veracruz City. Moreover, of the 98 surveyed families, 24 consumed only fresh cheese, 6 consumed only Oaxaca cheese and 68 consumed both type of cheeses. Figure 2 shows the frequency of purchase of the surveyed families.



**Figure 2:** Frequency of consumption of fresh and Oaxaca cheese by family. Etm: each two months; tpm: time(s) per month; tpf: time(s) per fortnight; tpw: time(s) per week.

Table 1 shows the education level, occupation, and preferential season for the consumption of cheese. Purchase frequency questionnaire allowed to know that more than 30% of the surveyed families had members with educational level of high school or preparatory, the occupation of most of them (42%) was on the house, in about 50% of households consume cheese for lunch and 85%

consume it all year, the supermarket (41%) and the market (31%) are the preferred purchase places and in 96% of households, the cheese is kept in the refrigerator.

Cheese preference and consumer characteristics			
Cheese types	% Purchase	Cheese types	% Purchase
Fresh	90	Curd	10
Oaxaca	75	Parmesan	7
Manchego	35	Mozzarella	3
American	12	Cottage	1
Educational level family	Proportion of households (%)	Occupation family	Proportion of households (%)
Degree	5.1	House	42
Preparatory	33.7	Employee	34
High school	38.8	Own business	20
Primary	7.1	Unemployed	2
Technical	14.3	Student	2
Uneducated	1.0		
Time and season of cheese consumption			
Meal schedule	Proportion of households (%)	Time of year	Proportion of households (%)
Breakfast	24.5	Spring	9
Lunch	48.9	Summer	2
Dinner	7.1	Autumn	0
All days	19.4	Winter	4
		All year	85
Place of purchase and cheese storage			
Place of purchase	Proportion of households (%)	Place of storage	Proportion of households (%)
Grocery	27	Refrigerator	96
Market	31	Showcase	3
Supermarket	41	Cooler	1
Retailers	1		

**Table 1:** Characteristics and consumption preference of Veracruz citizens (Purchase Frequency Questionnaire, n=98 households).

Information relating to the social class and the meal schedule together with information on the consumption of fresh and Oaxaca cheeses obtained from the food diary questionnaire enabled both surveys to be validated.

**Food diary questionnaire:** Seven hundred food diary questionnaires were delivered to the population, of these, 309 surveys (representing 1100 people) were properly filled. Of this population, 87% consumed cheese, of which 92% consumed fresh cheese and 83% consumed Oaxaca cheese. Table 2a shows the statistics of the total consumption

per family for fresh and Oaxaca cheeses obtained from the food diary questionnaires. Fresh cheese was more consumed (167.5 g) than Oaxaca cheese (152), the difference was statistically significant ( $p < 0.05$ ); these data include persons who eat a type of cheese but they also eat from the other. People who only eat one of the cheeses, eaten more Oaxaca cheese (196 g) than fresh cheese (143 g). Detailed

information about the mean body weight (kg) and the gender of the consumers is given in Table 2b. Body weight (74 kg men and 66 kg women) of persons who consumed cheese was independent of the type of cheese they eat. These results confirm what was observed in the Purchase Frequency Questionnaire, i.e. that 90 and 75 of the families buy fresh cheese and Oaxaca cheese, respectively (Table 1).

2a. Amount (g) of cheese consumed by household per day				
	Fresh cheese*	Oaxaca cheese*	Only fresh cheese*	Only Oaxaca cheese*
n	299	279	28	9
Mean (g)	167.5 <sup>a</sup>	152.1 <sup>b</sup>	143.4 <sup>a</sup>	196.1 <sup>b</sup>
Median (g)	112	93.7	111	133.7
Standard deviation	197.6	198.3	109.8	214.9
P95 (g)	532.3	494	365.1	672.3
2b. Body weight (kg) of cheese consumers greater than 14 year-old in the City of Veracruz				
	Fresh cheese		Oaxaca cheese	
	Gender		Gender	
	Men	Women	Men	Women
Mean (kg)	73.8	65.5	73.9	65.7
Median (kg)	75	65	75	65
Standard deviation	13.7	11.8	14.1	11.7
P95 (g)	96	85	97	85

\*Mann Whitney test is applied to determine if there are significant differences between the columns (1 and 2) and (3 and 4). The different superscript letters represent significant difference; there is no statistical difference for the consumers of one only cheese type. P95: Percentile 95.

**Table 2:** Consumption of cheese per day by household (2a) and body weight of the survey respondents (2b).

### Cheese consumption patterns by population

The daily average consumption of fresh cheese for children aged 0-8, 9-13 and teenagers between 14 and 17 year-old are 39.9 g, 49.7 g and 63.9 g, respectively. The average consumption of Oaxaca cheese for the same age groups is 40.1 g, 42.9 g and 62.4 g, respectively (Table 3a).

The consumption rate for the same types of cheese among surveyed children and adolescents showed no significant difference in the consumption of fresh cheese ( $p > 0.05$ ). However, there is a significant difference between the consumption of fresh cheese among children (0 to 8 year-old and 9 to 13 year-old) and that of adolescents (14 to 17 year-old) ( $p < 0.05$ ). The same behavior was observed for the consumption of Oaxaca cheese (Table 3a).

The results for the average consumption of fresh cheese for adult men between 18 and 40 year-old, 41 and 59 year-old and over 60 year-old were 51.9 g, 57.2 g and 38.7 g, respectively. Surveyed women within the same age ranges reported consumed rates of 48.8 g, 44.8 g and 46.4 g, respectively. There is a significant difference ( $p < 0.05$ ) between the consumption reported by the men aged 18-40 year-old and that of the other two groups (41-59 and >60 year-old). There is no significant difference between the consumption reported by men aged 41-59 and

over 60 year-old ( $p > 0.05$ ). For women's consumption of fresh cheese, there is no significant difference ( $p > 0.05$ ) between the different age groups (Table 3b).

The mean consumption of Oaxaca cheese for men aged 18-40, 41-59 and over 60 year-old is 49.9 g, 51.7 g and 34.9 g, respectively. The mean consumption of Oaxaca cheese for women in the same age ranges is 45.8 g, 40.4 g and 42.7 g, respectively.

According to the results observed for Oaxaca cheese, there is a significant difference ( $p < 0.05$ ) between the >60 year-old men consumption with regard to the 18 to 40 year-old and 41 to 59 year-old consumption (Table 3b). With regard to women, there is no significant difference between the different age groups ( $p > 0.05$ ).

The amount of cheese consumed per day for the population over 14 year-old is shown in Table 4a. The mean consumption per day for fresh cheese is 50.90 g/day ( $n = 872$ ) and the mean consumption of Oaxaca cheese is 47.8 g/day ( $n = 781$ ). It can be observed that only 5% of the population consumes over 170.6 g/day for both types of cheeses. There is a significant difference between the consumption of fresh cheese and Oaxaca cheese among consumers only in the population over 14 year-old.

3a. Amount of cheese (g) consumed by children and adolescents.						
	Fresh Cheese <sup>§1</sup>			Oaxaca cheese <sup>§2</sup>		
Age (year-old)	0-8	9-13	14-17	0-8	9-13	14-17
n	69	66	81	65	62	76
Mean (g)	39.9 <sup>a</sup>	49.7 <sup>a</sup>	63.9 <sup>b</sup>	40.1 <sup>a</sup>	42.9 <sup>a</sup>	62.4 <sup>b</sup>
Median (g)	24	30.9	40	27.4	27.4	37.1
Standard deviation	37.8	58.8	62	42.9	54.6	55.8
P95 (g)	130.6	205.4	190	135.4	107.4	182
3b. Consumption of fresh and Oaxaca cheese by gender and age range.						
Fresh cheese						
	Men <sup>*1</sup>			Women <sup>*2</sup>		
n	221	122	44	223	144	37
Age (years)	18-40	41-59	>60	18-40	41-59	>60
Mean (g)	51.9 <sup>a</sup>	57.2 <sup>b</sup>	38.7 <sup>b</sup>	48.8 <sup>a</sup>	44.8 <sup>a</sup>	46.4 <sup>a</sup>
Median (g)	34.9	36	30.9	30.3	29.1	27.4
Standard deviation	58.4	63.9	34.8	55.8	39.9	45.1
P95 (g)	184.3	243.7	122	179.4	121.7	164
Oaxaca Cheese						
	Men			Women		
n	197	110	33	205	130	30
Age	18-40	41-59	>60	18-40	41-59	>60
Mean (g)	49.9 <sup>a</sup>	51.7 <sup>a</sup>	34.9 <sup>b</sup>	45.8 <sup>a</sup>	40.4 <sup>a</sup>	42.7 <sup>a</sup>
Median (g)	32	32	18.9	29.1	27.4	27.4
Standard deviation	56.1	62.3	43.2	58.2	41.7	42.9
P95 (g)	142	204.6	186.9	152.6	130.3	137.4

Kruskal Wallis test is applied to determine if there are significant differences between consumer ages and <sup>§1</sup> the columns of Fresh cheese (0-8, 9-13 and 14-17 years) and <sup>§2</sup> Oaxaca cheese (0-8, 9-13 and 14-17 years); and between <sup>\*1</sup> the columns of Men (18-40, 41-59 and >60) and <sup>\*2</sup> the columns of Women (18-40, 41-59 and >60). The different superscript letters represent significant difference P95: Percentile 95.

**Table 3:** Fresh and Oaxaca cheese daily consumption by age range. Kruskal Wallis test is applied to determine if there are significant differences between consumer ages and <sup>§1</sup> the columns of Fresh cheese (0-8, 9-13 and 14-17 years) and <sup>§2</sup> Oaxaca cheese (0-8, 9-13 and 14-17 years); and between <sup>\*1</sup> the columns of Men (18-40, 41-59 and >60) and <sup>\*2</sup> the columns of Women (18-40, 41-59 and >60). The different superscript letters represent significant difference P95: Percentile 95.

The average consumption of fresh cheese for men and women is 53 g and 48.9 g, respectively while the average consumption of Oaxaca cheese for men and women is 50.6 g and 45.2 g, respectively (Table 4b).

Only 5% of the male population consumes more than 164.5 g of cheese/day of either type of cheese, and only 5% of surveyed women consume more than 152.6 g/day of either type of cheese. There is a significant difference between the average consumption of fresh cheese

in men (53 g) and women (49 g,  $p < 0.05$ ), whereas no significant difference between the average consumption of Oaxaca cheese in men and women was observed ( $p > 0.05$ ).

Of the 309 families surveyed, 86% indicated to which social class they belonged. Of this number, 12% reported belonging to the high class, 76% to the middle class and 12% to the lower class (Table 5a).

4a. Cheese consumed (per day) by people over 14 year-old.				
Type of cheese	Fresh cheese <sup>*1</sup>	Oaxaca cheese <sup>*1</sup>	Only fresh cheese <sup>*2</sup>	Only Oaxaca cheese <sup>*2</sup>
n	872	781	140	49
Mean (g)	50.9 <sup>a</sup>	47.8 <sup>b</sup>	41.1 <sup>a</sup>	60.7 <sup>b</sup>
Median (g)	34.3	30.6	29.1	44.6
Standard deviation	55.4	54.7	34.5	73.9
P95 (g)	170.6	162.6	102	135.7
4b. Cheese consumed (per day) by gender.				
	Fresh Cheese		Oaxaca Cheese	
	Men <sup>§1</sup>	Women <sup>§1</sup>	Men <sup>§2</sup>	Women <sup>§2</sup>
	430	442	381	400
Mean (g)	53.01 <sup>a</sup>	48.9 <sup>b</sup>	50.6 <sup>a</sup>	45.2 <sup>a</sup>
Median (g)	36.8	30.3	32	28.6
Standard deviation	54.1	52.1	57.4	52
P95 (g)	164.5	157.1	186	152.6

Mann Whitney test is applied to determine if there are significant differences between the columns (4a); and between the <sup>§1</sup>columns of the fresh cheese (men and women) and <sup>§2</sup> the columns of Oaxaca cheese (men and women) (4b). The different superscript letters represent significant difference; there is statistical difference for the consumers of one only cheese type (\*<sup>2</sup>).

**Table 4:** Cheese consumed per day, by person of 14 year-old or more and by gender.

5a. Cheese consumption by social class						
	Fresh cheese			Oaxaca cheese		
	High class	Middle class	Low class	High class	Middle class	Low class
n	30	199	33	29	181	31
Mean (g)	48.7	49	28.6	56.8	42.4	35
Median (g)	35.7 <sup>b</sup>	31.8 <sup>b</sup>	24.1 <sup>a</sup>	38.7 <sup>b</sup>	28.2 <sup>a</sup>	25.9 <sup>a</sup>
Standard deviation	51.5	50.1	17.2	50.7	44.2	28.8
P95 (g)	107.2	179.4	60.4	165.4	131.9	88.4
5b. Consumer fresh and Oaxaca cheese in each meal						
	Fresh cheese <sup>*1</sup>			Oaxaca cheese <sup>*2</sup>		
	Breakfast	Lunch	Dinner	Breakfast	Lunch	Dinner
n	783	742	572	649	563	578
Mean (g)	163.3 <sup>ab</sup>	175.0 <sup>b</sup>	160.4 <sup>a</sup>	155.1 <sup>a</sup>	183.3 <sup>b</sup>	158.8 <sup>a</sup>
Median (g)	128	131.3	116.5	108	131.2	113.5
Standard deviation	146.9	164.2	149.1	145.6	171.3	147.4
P95 (g)	420	454.9	436.1	458	475.5	442.7
n	783	742	572	649	563	578

Kruskal Wallis test is applied to determine if there are significant differences between <sup>\*1</sup> the columns of the fresh cheese by social class and meal and <sup>\*2</sup> the columns of Oaxaca cheese by social class and meal. The different superscript letters represent significant difference.

**Table 5:** Cheese consumption by social class (5a) and meal (5b).

Fresh cheese is consumed more among the high and middle classes. The median for these social classes is 35.7 g and 31.8 g, respectively, whereas the median consumption of the lower class is 24.1 g. Moreover, there is no significant difference ( $p > 0.05$ ) in the median consumption rate between the high and the middle classes, but there is a significant difference between the median consumption of the high and middle classes and that of the lower class ( $p < 0.05$ ).

Oaxaca cheese is preferentially consumed by the high class. There is a significant difference ( $p < 0.05$ ) between the median consumption of the high class with regard to the middle and lower classes (Table 5a).

The results for the consumption of Oaxaca and fresh cheese according to the meal schedule are presented in Table 5b. Fresh cheese was similarly consumed at breakfast (163 g) and dinner (160), while consumption at lunch was statistically significant (175 g). The same pattern of consumption is observed with Oaxaca cheese.

## Discussion

As both questionnaires (Purchase Frequency and Food Diary Questionnaires) were applied we found that both agree in their results. Most of the families consume both fresh and Oaxaca cheeses, a portion of cheese at least once a week or more (Table 1). The problem is that the amount of milk intended for the production of handmade cheeses is raw and not ultra-pasteurized, that is a risk for human health [7,25].

The proportion for fresh cheese is higher compared to Oaxaca cheese (93.48% vs. 78.37%, respectively). The Purchase Frequency Questionnaire determines that the main time of consumption for both cheeses is during lunch throughout the year. The surveyed interviewers declared that 58% of fresh and Oaxaca cheeses were purchased at the market and in grocery stores and only 41% were bought from the supermarket.

Both questionnaires found a large percentage of the population consume both cheeses. Moreover, the results obtained on the total amount purchased per week per family (Purchase Frequency Questionnaire) and the total amounts consumed per week (Food Diary) were corroborated. Table 2 gives data related to purchase, consumption and weight of consumers that are useful as national statistics.

Table 2a is the comparison of consumption of fresh and Oaxaca cheese by household per day that had different significance between both cheeses. Table 2b shows the weight (kg) for the consumer population of cheese greater than 14 year-old in the City of Veracruz.

The cheese consumption in 0-8 year-old is significantly lower than that measured for the group of 14 to 17 year-old, while no significant difference between children aged 0-8 year-old and 9 to 13 year-old was observed (Table 3a). The cheese consumption increases with the age, the opposite situation happens with milk where small infants consume more than teenagers [26].

Fresh and Oaxaca cheese consumption in adults is also influenced by age group. Fresh cheese is consumed more by men in the 18-40 year-old group, but there is a significant difference in men from 41 to

over 60 year-old category (Table 3b). However, in the case of women, there is no significant difference in consumption of cheese in the three groups, this may be because women are more susceptible to the loss of calcium and osteoporosis and therefore tend to consume more cheese. As for Oaxaca cheese, no significant difference between men aged 18 to 59 year-old was observed, but they consume less cheese in the group of more than 60 year-old. This could be because young and mature men engage in more physical activity therefore they require a greater food intake compare to men over 60 year-old. These results suggest that the consumption of both types of cheese may be influenced by physical activity in men and nutritional requirements in women for each group of individuals, purchasing power of individuals, and the possibility of damage from cholesterol and heart attacks (Table 3b) [27,28].

Table 4 gives data about cheese consumed per day, per person of 14 year-old or more, and gender. The consumed fresh cheese has different significance between men (53.01 g) and women (48.9 g) but there is no difference on respect the Oaxaca cheese. The adult population's consumption rate of fresh and Oaxaca cheeses correspond to 50.9 g/person/day and 47.8 g/person/day, respectively (Table 4a). These values are higher than published surveys in Mexico (2002, 2007) [29-31] but they coincide with the consumption of Oaxaca cheese reported [32].

With respect to the consumption of fresh cheese by social class, the upper class and the middle class have an average consumption of 48.7 g and 49 g, respectively (Table 5a) while the lower class consumes less fresh cheese, due to the lower income. Regarding Oaxaca cheese, statistically the higher class shows greater consumption (56.8 g), which may be because Oaxaca cheese is double the price of fresh cheese, and the middle and lower classes have more limited revenue with which to buy it.

Because of this it can be argued that socioeconomic status influences the consumption of cheese. Similar behavior was observed [33], who evaluated the consumption of dairy products (including cheese) with respect to indicators such as socioeconomic status and age. Moreover, Kubicova et al. [34] reported that the price of dairy products such as cheese directly influences the frequency of consumption of these products.

Table 5b show that during lunch time similar amounts of both cheeses are consumed because lunch is the main meal for the population of Veracruz [35].

Data for per capita cheese consumption nationwide are obtained by adding imports to domestic production and subtracting exports, and dividing the result by the total population. We note that the total population also includes non-cheese consumers. The value of cheese consumption per person per day in this study is higher than that reported for per capita consumption in 2013 (Table 6). This may be due to the inclusion of non-consumers in the national per capita calculation, which greatly reduces the resulting ratio. Moreover, the per capita calculation only includes information on the production and sale of cheeses subject to sanitary, commercial and fiscal controls but does not include the marketing of artisanal cheese (representing 53% of total milk production) to be marketed directly, therefore the amount

of cheese used in the official per capita calculation is lower than real. A similar phenomenon was reported by Rossini et al. [36] who evaluated the cheese consumption in Argentina through household interviews and reviewed the calculation of monthly cheese consumption with and without the non-consumer population. In the first case per capita consumption was 1.3 kg/person/month and in the second case it was 2.4 kg/person/month.

Regions	Global Consumption 2013 (kg per capita)	Cheese Consumption (g/person/day)
Argentina	12.4	33.9
Brazil	3.7	10.1
Chile	8.8	24.1
Colombia	0.9	2.5
Uruguay	8.5	23.5
Mexico [5]	3.6	9.9
Canada	12.2	33.4
United States	15.4	42.2
France	25.9	70.9
Mexico city		41 (Oaxaca cheese) [29]
		51 (American cheese) [29]
Mexico city	---	15.6 [27]
Mexico city	---	19.9 [28]
Veracruz city (This study)	---	50.9 (Fresh cheese)
Veracruz city (This study)	---	47.8 (Oaxaca cheese)

**Table 6:** Comparison of cheese consumption in the world [26].

The ENURBAL [30,31] survey is carried among the population of Mexico City (2002, 2007). Data is also obtained from 24-hour recall surveys. These surveys revealed that cheese is one of the most consumed foods among the population of Mexico City with a consumption of 15.6 and 19.9 g/person/day in 2002 and 2007, respectively. However, these data were lower than those obtained in this investigation, which could be due to the fact that the survey conducted was based on a 24-hour recall method while our work used a food diary for 7 days, therefore covering a longer period of time, recording cheese intake in a greater proportion.

Rosado et al. [32] reported the values obtained by the ENSANUT [37] survey (1974) for Oaxaca cheese consumption. This survey was carried out throughout the country and it studies urban consumption and rural consumption separately. Even though the consumption of fresh cheese was not reported, the consumption of fresh cheese obtained in the present study is similar to that of American cheese (Table 6) [32]. This suggests that the Oaxaca consumption rate has not varied among adults since 1974, which supports the idea of chronic consumption.

## Conclusion

In Veracruz City, the main cheese consumed is fresh cheese, followed by Oaxaca cheese and consumption is higher than the average national value for all cheeses. The high class and middle class are major consumers of fresh cheese, while Oaxaca cheese is consumed mainly by the higher class. Men in productive age groups consume more fresh and Oaxaca cheeses, whereas among women the consumption of cheese is similar for all ages. The consumption of fresh cheese and Oaxaca cheese takes place principally during lunch. This research aims to generate anthropomorphic data; consumption statistics and it may also serve to study health issues related to the consumption of both cheeses in the State of Veracruz and in the country. The average daily consumption of cheese is around 100 g (fresh + Oaxaca cheeses) in adults; consequently the consumption of contaminated cheese may represent a risk to health. With the results published in this article and with those obtained from the quantification of Aflatoxin M<sub>1</sub> in fresh and Oaxaca cheeses (currently in course), it will be possible to do calculations for risk assessment.

## Acknowledgments

Authors would like to thank to Mexican CONACyT and M12-A02 SEP-CONACYT-ANUIES-ECOS project for the financial support given through the doctoral research subvention of E. Hernández-Camarillo.

## Ethical Approval

The authors obtained ethical approval by the ethical committee of the University of Brest.

## References

- Galán C, de JJ (2014) Identificación de serotipos patógenos del género *Salmonella* A partir de queso fresco expedido en la zona conurbada Veracruz - Boca del Río. Tesis de Maestría. Universidad Veracruzana.
- De Oca-Flores EM, Castelán-Ortega OA, Estrada-Flores JG, Espinoza-Ortega A (2009) Oaxaca cheese: manufacture process and physicochemical characteristics. *Int J Dairy Technol* 62: 535-540.
- Hernández-Raya JC, Martínez-Soto G, López-Orozco M, Mercado-Flores J, Alcántara-González ML (2005) Evaluación de Rendimientos y costos de fabricación en: Queso Asadero, Oaxaca y Yoghurt a nivel Industrial. VII Congreso nacional de ciencia de alimentos y III Foro Nacional de Ciencia y Tecnología de Alimentos. Guanajuato, Gto. México.
- Moore PL, Richter RL, Dill CW (1986) Composition, yield, texture, and sensory characteristics of Mexican white cheese. *J Dairy Sci* 69: 855-862.
- Torres-Llaneza MJ, Vallejo-Córdoba B, Díaz-Cinco ME, Mazorra-Manzano MA, González-Córdova AF (2006) Characterization of the natural microflora of artisanal Mexican Fresco cheese. *Food Control* 17: 683-690.
- SIAP (Servicio de Información Agroalimentaria y Pesquera) (2015) Boletín de Leche. enero-marzo de 2015.
- FUNPROVER (Fundación produce Veracruz) (2010) Colegio de Postgraduados Veracruz. Reporte Técnico de Proyecto. Estudio y análisis del mercado de los productos del sistema bovinos de doble propósito en el Estado de Veracruz [Project Technical Report. Study and Analysis of the product market of bovine system of double purpose in the State of Veracruz]. Xalapa, México.
- Secretaría de economía (2012) Análisis del sector lácteo en México. Dirección general de industrias básicas.
- Shahani KM, Whalen PJ (1986) Significance of antibiotics in food and feeds. In WA Moats (ed.), *Agricultural uses of antibiotics*. 190th Meeting of the American Chemical Society, Washington DC. pp: 88-99.

10. Meironyté D, Norén K, Bergman A (1999) Analysis of polybrominated diphenyl ethers in Swedish human milk. A time-related trend study, 1972-1997. *J Toxicol Environ Health A* 58: 329-341.
11. Khaniki GR (2007) Chemical contaminants in milk and public health concerns: a review. *Int J Dairy Sci* 2: 104-115.
12. Ahmed MMM, Hafez EE, Mona AM, Abdelrassoul HA, Mabrouk YM (2014) Detection of Baby Milk Powder Contamination by Microorganisms. *World Appl Sci J* 30: 93-98.
13. Signorini ML, Gaggiotti M, Molineri A, Chiericatti CA, Zapata de Basílico ML, et al. (2012) Exposure assessment of mycotoxins in cow's milk in Argentina. *Food Chem Toxicol* 50: 250-257.
14. Torres-Vitela MR, Mendoza-Bernardo M, Castro-Rosas J, Gómez-Aldapa CA, Garay-Martínez LE, et al. (2012) Incidence of Salmonella, Listeria monocytogenes, Escherichia coli O157: H7, and staphylococcal enterotoxin in two types of Mexican fresh cheeses. *J Food Protect* 75: 79-84.
15. Binder EM, Tan LM, Chin LJ, Handl J, Richard J (2007) Worldwide occurrence of mycotoxins in commodities feeds and feed ingredients. *Anim Feed Sci Tech* 137:265-282.
16. Pereyra CM, Alonso VA, Rosa CAR, Chiacchiera SM, Dalcerro AM, et al. (2008). Glitoxin natural incidence and toxigenicity of *Aspergillus fumigatus* isolated from corn silage and ready dairy cattle feed. *World Mycot J* 1: 463-467.
17. Seglar WJ (2003) Fermentation analysis and silage quality testing. In: Proceedings of the Minnesota Dairy Health Conference. May, Minneapolis MN. College of Veterinary Medicine, University of Minnesota, USA.
18. Peitri A, Bertuzzi T, Bertuzzi P, Piva G (1997) Aflatoxin M1 occurrence in samples of Grana Padano cheese. *Food Addit Contam* 14: 341-344.
19. WHO (World Health Organization) (1997) Guidelines for predicting dietary intake of pesticide residues. GEMS/Food in collaboration with the codex committee on pesticide residues.
20. Kroes R, Müller D, Lambe J, Löwik MR, van Klaveren J, et al. (2002) Assessment of intake from the diet. *Food Chem Toxicol* 40: 327-385.
21. WHO (World Health Organization) (1985) Guidelines for the study of dietary intakes of chemical contaminants. WHO Offset Publ : 1-102.
22. CCA (Comisión del Codex Alimentarius) (1989) Guidelines for simple evaluation of food additive intake. Orientaciones para una evaluación sencilla de la ingesta de aditivos alimentarios.
23. Sánchez-García R, Reyes-Morales H, González-Unzaga MA (2014) Food preferences and nutritional status in school-age children living in Mexico. *Bol Med Hosp Infant Mex* 71: 358-366.
24. Vargas TM, Peláez JJ, Sánchez CS (2014) Overweight, obesity and socio-cultural conditions in school children between seven and eleven years old in the city of Orizaba, Veracruz. *An Inst Nac Antropol Hist* 48: 273-299.
25. Martínez CJ, Cotera J, Kido MT (2013) Marketing and margins in channels of dairy products in Dobladero, Veracruz, Mexico. *Rev Mex Agroneg* 17: 283-286.
26. Aranceta J, Perez-Rodrigo C, Ribas L, Serra-Majem LL (2003) Sociodemographic and lifestyle determinants of food patterns in Spanish children and adolescents: the enKid study. *European Eur J Clin Nutr* 57: S40-S44.
27. Rose G, Shipley M (1986) Plasma cholesterol concentration and death from coronary heart disease: 10 year results of the Whitehall study. *Br Med J (Clin Res Ed)* 293: 306-307.
28. Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, et al. (2015) Heart disease and stroke statistics--2015 update: a report from the American Heart Association. *Circulation* 131: e29-322.
29. CDIC (2015) Global cheese consumption (kg per capita). Canadian Dairy Information Centre.
30. Ávila CA, Shamah LT, Chávez VA, Galindo GC (2003) Encuesta Urbana de Alimentación y Nutrición en la Zona Metropolitana de la Ciudad de México, ENURBAL-2002. *Inst Nac Ciencias Médicas y Nutrición Salvador Zubirán. México*.1-115.
31. Ávila CA, Galindo GC, Hernández RA, Chávez VA (2007) Encuesta Urbana de Alimentación y Nutrición en la Zona Metropolitana del Estado de México, ENURBAL 2007. *Inst Nac Ciencias Médicas y Nutrición Salvador Zubirán. México* pp: 1-77.
32. Rosado JL, López P, Morales M, Munoz E, Allen LH (1992) Bioavailability of energy, nitrogen, fat, zinc, iron and calcium from rural and urban Mexican diets. *Br J Nutr* 68: 45-58.
33. Bashir KA (2011) Consumption of dairy products in the UAE: A comparison of nationals and expatriates. *J Saudi Soc Agric Sci* 10: 121-125.
34. Kubicová LU, Kadekova K, Dobák D (2014) Trends in consumption of milk and dairy products in Slovakia after EU accession. *Eur Policies, Financ Market* 12: 90-97.
35. Smith KL (2010) Cultural diversity: Eating in American-Mexican-American. Ohio State University Extension. Fact sheet: HYG-5255-95.
36. Rossini G, Vicentin J, Depetris E (2015) Household Cheese Consumption in Argentina: A Double-Hurdle Model Estimation. In 143rd Joint EAAE/AAEA Seminar, March 25-27, 2015, Naples, Italy (No. 202739). European Assoc Agric Economists. Italy.
37. Chávez A (1974) Encuestas nutricionales en México. Estudios de 1958 a 1962. México DF. Editorial División de Nutrición del Instituto Nacional de la Nutrición 1: 1-342.