FACTORS AFFECTING THE SUPPLY AND DEMAND FOR LIMES AND LIME OIL IN THE U.S.: DEVELOPMENT IMPLICATIONS FOR VERACRUZ STATE, MEXICO

by

SAUL JULIAN ABARCA OROZCO

(Under the Direction of Jack E. Houston)

ABSTRACT

The fresh lime industry is an important economic activity in Veracruz, Mexico. In this thesis, the economic potential of the fresh lime and lime oil industries are investigated. The aim is to determine what effect prices and consumption have on the quantity supplied. Also factors such as regional economic impacts, the feasibility of expanding production, and quality of inputs are examined with respect to how they affect efficiency of production. Results show that optimal quantities of these products are not shipped to the U.S. Recommendations for increasing efficiency in this Mexican industry include increasing economies of scale of by products and taking advantage of trade agreements which widen market access.

INDEX WORDS: Limes, Import Demand, Lime Oil, Productivity, Price Flexibility, Income and Cross Price Elasticities, Veracruz, Mexico

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DEDICATION

I would like to dedicate my work to my family, who always gave me the love, courage and understanding that helped me to continue through my studies. To my mother and my father, Maria Teresa and Saul; my siblings, Daimon and Anaid and my uncle, Jose Antonio. They gave me the inspiration and strength I have always needed in tough times. I also want to thank and dedicate my work to Victoria my best friend and partner for all her caring love, her patience, suggestions, corrections, great humor and faith that made everything easier while I was in Athens.

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CHAPTER 1

INTRODUCTION

1.1 Overview of World Lime Markets

Since the 1980's, world citrus production and consumption has been steadily increasing. Citrus fruits that have experienced rapid expansion include: oranges, lemons, limes and tangerines. Consequently, per capita consumption has risen in countries such as the United States (U.S.), and regions like the European Union and Asia. Lemons and limes are usually consumed fresh, processed in juice or processed for oil (Spreen, 2001). Fresh limes are typically consumed in association with other foods. Limes are grown in tropical climates, and they are highly sensitive to cold weather. Latin America participates in a major way, contributing with 38% of total world production. The major producers are Mexico, Brazil, and Argentina (accounting for 32% of total world production). Mexico and Brazil are the main producers of limes and Argentina is the leader in the production of lemons (UTEPI, 2006).

Thomas Spreen forecasts world lemon and lime production will be approximately 10.6 million metric tons in 2010; this amount represents an increase of 15% over 1996-1998 annual levels. Mexico, Argentina and Spain will continue providing the highest share of fresh lemons and limes. The Florida lime industry shifted toward other citrus crops after the multiple year freezes in the early 1980's that obliterated the orange groves that previously grew in Central Florida as far north as Gainesville. Virtually the entire Florida lime industry ceased with the devastation of Hurricane Andrew a decade later. These natural disasters, plus the implementation of NAFTA, provided impetus to the Mexican lime industry, as well as other Latin and South

American countries, such as Brazil, to expand production and the market of fresh limes, lime oil and lime juice. Actually the U.S. is considered the main importer of fresh limes, and by 2010 the U.S. alone will account for 20% of the World's imports (Spreen, 2001). The U.S is also forecast to be the worlds top importer of lime oil.

1.2 Mexican Participation in World Markets: Competitors and Market Niches

Due to the great demand coming from the United States, countries such as Brazil, Argentina, Chile, Ecuador, Guatemala, Venezuela and the Bahamas have started to increase production for future participation in international markets. The countries who are currently selling their production in international markets, however, are Spain, Argentina and Mexico. Brazil in particular, has great potential for future participation at the international level. Indeed, Brazil is already exporting low levels of limes and it has an additional 100,000 hectares under production.

Even though the United States represents a large market niche for this fruit, in general terms, the World market consumption trend has been experiencing a deceleration, mostly due to an increase in other varieties of limes and citrus fruits that final consumers are including in their daily diets. Key limes and Persian limes are economically very significant to Mexico. In 2006, Mexico produced approximately 1.9 million metric tons (MT) of lemons and limes, and exported 412,000 MT; the main growing states of this citrus fruit are Colima, Michoacán, Oaxaca, Veracruz and Guerrero (USDA, FAS 2006).

Among citrus, lime is the second most economically important, not only because of its high consumption value as fresh produce, but also for the industrial uses. Mexico is considered the principal producer of the Persian and Mexican (Key) varieties of lime. For Persian limes, the Mexican regions where the production is most significant are around the Mexican Gulf Coast:

Veracruz, Tabasco and Yucatan. Those three states contribute more than 40 % of the total citrus production. Conversely Mexican (Key) lime is cultivated on the Pacific Coast, with Colima, Michoacán, Jalisco, Guerrero and Oaxaca contributing 60% of the total citrus production (SAGARPA, 2005).

Every year, Mexico produces an average of 0.5 million MT of Persian lime, and 80% of this production is exported, with a commercial value of US $6 million. Most of this production is obtained in Martinez de la Torre, a municipality in Veracruz State (SAGARPA, 2005). In recent years, the area planted for both Persian and Key limes have increased in Mexico, mostly because of higher prices on the international market and few phytosanitary concerns. Almost every year, the citrus associations and the Ministry of Agriculture have focused their attention on a strategy that allows producers to develop good sanitary practices and avoid rejection or blocking of the entrance of their product to developed countries (USDA, FAS 2006).

Mexican Persian limes and Key limes compete for the same domestic market. When both are present at the domestic market during peak season, prices are relatively low. The peak marketing season for Persian limes is during the months of June to September, and it is very close to the peak season for key limes. Thus, prices for both lime varietals tend to fall. However, when Persian lime producers begin to export, two or three months later, domestic prices for Persian limes increase and remain high until April or May (USDA, FAS 2006).

The Mexico Citrus Annual Report 2006, published by the Foreign Agricultural Services of USDA, provides some relevant data about production costs, yields, and transportation costs for the analysis in this research. For Persian limes, the average production costs fluctuate from US $909.10 to $1,090.9/ha. Most of these costs are related to prices of basic imported inputs, such as fertilizers, pesticides and agrochemical products. Transportation costs from Veracruz to

Mexico City are usually US $327.25 to $381.80/truck and the estimated delivery time is about 8 hours. In comparison, the production cost for key limes vary according to the technology used and cultural practices in each state. For example, in Colima, Oaxaca and Michoacán, production costs can vary from US $663.63 to $1,509/ha (USDA, FAS 2006).

The yields for Persian limes in Veracruz range from 8 to 16 MT/ha, but sometimes are high as 25 MT/ha, while Key lime yields average between 7 to 12 MT/ha, with a few producers able to reach 30 MT/ha. Grower prices for Persian limes range from US $36 to $72.70/MT for the domestic market and US $54.50 to 272.70/MT for the export market (January to April). Key lime grower prices range from US $72 to 272.70/MT (USDA, FAS 2006).

1.3 Objectives

This study aims to contribute to the understanding of the lime and lime oil industries in Mexico (Mexican and Persian lime varieties), with a special emphasis in Veracruz State. These industries are analyzed using production and price data.

Specifically, the research objectives to be investigated are:

1) To investigate how economic and noneconomic factors of the U.S. import demand for fresh limes, impact the Mexican economy, using as substitutes the prices for other competitors in the market.

2) To identify the economic potential for the lime oil industry in Mexico. That is, whether the expansion of this industry is feasible and the effects that would have on the local economy.

3) To determine whether the establishment of an essential lime oil processing factory (medium size) in Southeastern Mexico is feasible and analyze some of the impacts on the local economy of Martinez de la Torre, Veracruz.

1.4 Procedures

There are no current studies that address this issue and this study proposes an analysis of monthly and annual import prices and quantities for fresh limes from 1989 to 2007. Autocorrelation can often be present in economic functions based on time series data. In Chapters 3 and 4, Ordinary Least Square (OLS), was used to estimate regression equations. In each case, tests for autocorrelation were implemented to avoid this problem.

1.5 Organization

This thesis consists of six chapters. Chapter 2 provides a literature review of the lime industry in general, including relevant publications for this topic. In this chapter, the contributions from previous studies are summarized, some limitations are pointed out and, also, the possible contributions of this research to the literature are described. Chapters 3, 4 and 5 are the main body of this thesis. Each of these chapters focus on a subject as outlined in the research objectives. Chapter 3 analyzes the economic and noneconomic factors affecting the U.S. import demand for limes and estimates the impact of these factors. The purpose of Chapter 4 is to determine the economic feasibility of expanding lime oil production in Mexico. Lime oil, as a by-product of lime processing, has a variety of food and industrial uses. Mexico is currently the world's leading producer of lime oil, which gives rise to interest in possible expansion of the industry. In chapter 5, the feasibility of establishing a citrus processing factory for limes in southeastern Mexico is investigated. This chapter will show an example of the potential economic impacts derived from one medium size citrus processing facility in the region of Martinez de la Torre, Veracruz. Finally, chapter 6 presents general conclusions, policy implications, limitations of this study and further research that can be done when more data becomes available.

Table 1.1. Important Lime Producing Countries, Production in tons per Year

Country	2000	2001	2002	2003	2004	2005
Mexico	1,661,220	1,594,020	1,725,090	1,824,890	1,927,540	1,806,780
India	1,400,000	1,320,000	1,370,000	1,370,000	1,420,000	1,420,000
Argentina	1,171,498	1,180,000	1,200,000	1,200,000	1,300,000	1,300,000
Spain	915,049	1,024,105	919,700	1,065,700	810,260	896,500
Iran	1,032,479	1,038,833	1,040,000	1,040,000	1,100,000	1,100,000
Others	4,944,046	5,461,078	5,791,053	4,989,890	5,112,043	4,999,800
TOTAL	**11,124,292**	**11,618,036**	**12,045,843**	**11,490,480**	**11,649,843**	**11,523,080**

Source: (FAOSTAT, 2007)

CHAPTER 2

LITERATURE REVIEW

2.1 Lime Industry Studies

Various studies have been conducted which analyze the lime industry. Ronald W. Ward and Vo Huu De in September 1978, were working at the University of Florida when they published a paper entitled "The Demand for Fresh Limes: Implications for Prorating", analyzing lime demand and the potential benefits from prorating. First they estimated the demand for limes and used the results to analyze the effects from prorating (assess proportionately this demand on a weekly basis). Their second step utilized the demand estimates in a forecast procedure. Their idea was to help the local industry improve its marketing of fresh limes. Both researchers expected that prices of limes were related to lime shipments, lemon supplies and to changes in the level of income. They incorporated into their model a growth trend variable, which captures the effect of income in addition to positive stimulants of growth.

Ward and De (1978) include tests for lime seasonality, demand growth, lemon and carryover effects. They also used price flexibility coefficients to measure how sensitive prices were to changes in demand. They concluded that changes in supply and seasonality were the major factors causing instability in lime prices. Prices were unstable and depressed when huge shipments came into the market after the peak demand weeks. Despite all of those changes, the prices in the fresh lime market remained elastic. Included in this paper was a policy simulation procedure which explored select prorating policies. A few examples were shown, and the results demonstrated that prorates alone could not be expected to be a major factor in stabilizing prices.

In conclusion, prorated shipments could improve returns, if some coordination efforts were made to reduce the effects of lime supplies in the peak season (summer months).

The Foreign Agricultural Service (FAS) of the United States Department of Agriculture (1981) published a report entitled "Lime Production in Florida: Projections and Economic Implications for 1981-82". In the early 1970's, Florida accounted for about 90% of domestic acreage and California the remaining 10%. Degner and Rooks (1980) undertook a price analysis using Free On Board (F.O.B) prices. Their results provided the lime industry with information for production and marketing decisions. Supply projections for California, Florida, Mexico and Cuba were included in the study. They concluded that F.O.B. prices for fresh Florida limes would increase between the periods 1978-79 to 1981-82. They also noticed that higher levels of imports would reduce season average F.O.B. prices by several dollars per bushel. Degner and Rooks also reported that Mexico was one of the exporters that sent their shipments of limes to the U.S. regardless of whether or not the price was high or low. This process affects both the local industry, and producers in Florida and California.

In the 1981-82 period, another study entitled; "Grower Prices for Limes: Projections through 1981-82" was published by Degner and Shonkwiller (1980). In this study the researchers evaluated the behavior of prices in a season of good news for producers. Prices received by Florida lime growers increased to record levels during that period. Consequently, growers decided to plant more trees and increase production due to the good revenues in the industry. From an economic point of view, however, if there are more fruit in the market, prices tend to decrease. The researchers focused on Florida production, because it was by far the most important in the U.S. in that period. They evaluated Florida lime acreage; lime yields, production and on-tree lime prices with the intention of providing long-run projections for the U.S. lime

industry. In their article, acreage and production data from Mexico and Cuba were also examined, but with some reservations due to data limitations and trade uncertainties. Estimates were made for 1979-80 through 1981-1982 using ordinary least squares regression analysis to examine historical price quantity relationships for Florida limes in conjunction with other variables. Their model, created to explain on-tree price variability, stipulates that lime prices depend on the quantity produced, consumer's incomes, and the prices of competing goods and services. The result was that an increase in per capita production results in lower prices.

In 1986, Graham Webster presented a thesis to the University of Florida entitled: "Persian Lime Exports from Veracruz, Mexico, and the Effects of Internationalization." The objective of this study was to analyze the shift in cropping patterns from a perspective of global inequality using a case study of Mexican agriculture, namely the Persian Lime Agroindustry in the Martinez de la Torre region of Veracruz State. Webster mentioned in his thesis that the region of Martinez de la Torre is a rich agricultural area, despite uneven land distribution and the lack of modernization. Although the packing plants in Martinez de la Torre were not as modernized as the ones in Homestead, Florida, they were able to produce an international grade product, meeting the standards of the U.S. and some other developed countries. The model of international agricultural integration that was primarily examined in this thesis consisted of utilizing Mexico's various advantages of production in order to export luxury agricultural products to developed countries. The other major consideration was about the increase in poverty that Mexico was experiencing. The analysis of causes, such as traditional displacement, U.S. production cost advantage, markups and vulnerability, were included and the results indicated that there were some negative effects in association with the internationalization of agriculture in the region. Webster also established that there are some people who benefit from these process

including large landowners, bankers, extension agents, technicians, U.S. consumers and U.S. bankers. On the other hand, there are some people who loose, smallholders and *jornaleros*. Ironically, the people who produce the fruit are the biggest losers, despite the fact that they are the ones who sustain the chain of packers, shippers, distributors and retailers that make the link with the U.S. consumer. Unfortunately, not much has changed; the small farmers and *jornaleros* continue to receive low wages and just a small portion of the retail price (Schwentesius, 2005).

Another qualitative analysis is: "An Analysis of Weekly F.O.B. Prices for Fresh Limes", conducted by Shonkwiller and Degner in 1980. The objective of this study was to provide a systematic means for testing causal relationships and for specifying distributed lag formulations within the context of a model for weekly lime prices. With their model, they tried to integrate simultaneously two concerns; to focus on the effect of Mexican lime exports to the U.S. and to study the corresponding effect on Florida fresh lime prices and future production. As the authors mentioned in their research, no one else had attempted to integrate these two concerns in a single model before. The two researchers discovered that, during the peak harvested season (May to August), prices were significantly and inversely related to Florida fresh lime shipments. Also, with the lagged Mexican lime shipments, Florida lime producers were against a strong competitor. Thus, the authors recommended that monitoring the Mexican lime shipments would be a good idea for producers in Florida. This study was an extension of the Ward and De report with the incorporation of Mexican Data.

Another interesting publication to review is the book "Persian Limes in North America, an Economic Analysis of Production and Marketing Channels". This book, published in 1996, was written by Michel Roy, a M.S. student in Food and Resource Economics from the University of Florida, and co-authored by Chris O. Andrew and Thomas H. Spreen, professors from the

University of Florida. These researchers developed an interest in the production and marketing systems for Persian Limes in the U.S. (mainly in the region of Dade County) and Mexico (Martinez de la Torre, Veracruz). Therefore, they decided that it would be a good idea to study some of the problems faced by the Mexican producers, such as the lack of production data information and other marketing issues.

Some topics included in the text by the authors are:

1) Description of the U.S. domestic Persian Lime Industry, its evolution, its setbacks, and its future within the North American Free Trade Agreement (NAFTA);

2) An assessment of the Persian Lime Industry in Mexico; and

3) A description of the role of the brokers at the United States Mexico Border. (Roy, Andrew, Spreen, 1996, p. IX).

They identified important elements for the variables of production and trade. At the end, they realized that the suspicion expressed by Webster in 1986 and a report from the Florida Agricultural Market Center in 1980 about Mexico becoming one of the major suppliers of vegetables and tropical fruits for the U.S. was absolutely true. The fears of many producers in the U.S. were not unreal; slowly but sharply, Mexico was increasing its participation in the U.S. market. The researchers established many factors that contributed to the Mexican rapid growth, some of which are specific to Persian Limes:

- The increase in U.S. demand for a year-round supply of fresh produce;
- A limited growing area in the U.S. for the production of tropical fruits;
- An increase in private investment in Mexican Agriculture and emphasis by the Mexican government in expanding non-petroleum exports; and
- The widening gap between Mexican and U.S. labor and land costs. (Roy, Andrew, Spreen, 1996, p. 117)

One decade has passed since 1997, and the statistics confirm that the consumption of tropical fruit and vegetables in the U.S. has increased, as Roy, Spreen and Andrew affirmed on their book. In addition, the pattern established in their book about the main regions where these products are consumed is now a reality. Cities such as Los Angeles, San Francisco, New York, Chicago, where a large portion of the population is Latino, account for the major cities where increased consumption has been noticed.

Roy, Andrew and Spreen (1996) conclude in their study that there is no more space to grow tropical fruits in the U.S. As a result in Mexico, all levels of government have offered financial incentives for export-oriented crops. The book emphasized some marketing constraints and challenges that the Persian Lime Industry will face. In Mexico, there is a possibility of overproducing. This is a problem that has become real, and the Mexican government has not been able to overcome. Roy, Andrew and Spreen identified this problem and mentioned in their book the necessity of a census that would include most of the variables that are difficult to analyze in the Mexican agricultural economy, such as total acreage, number of growers, farm size, age of trees, tree density and rootstock use. This action is imperative for the government at all levels.

Fortunately, in recent years, the Mexican government has realized the importance of this action and the *Instituto Nacional de Estadistica Geografia e Informatica* (INEGI) will conduct the First Agricultural Census, from June to December 2007 (INEGI, 2007). The census will provide better and more accurate information of the actual agricultural situation. Moreover, some tools can be developed for producers, to educate them about what they can do to improve or add to their businesses.

The Persian Lime Industry in Mexico lacks organization and cooperation in all the levels of the industry including producing, packing and exporting. This is a primary reason why the prices of Persian Limes are established in McAllen, Texas, and is something that the interested parties in Mexico need to analyze and fix as soon as possible (Estudios estrategicos, 2002).

Finally, the book concludes that future research can be done on topics such as the investigation of marketing channels which lie beyond the shipping points. Also:

- The final destination – the U.S. consumer – has not yet been analyzed.
- Competitiveness could be approached if terminal market data (specifically prices and quantities) could be found. If this information were available, market share and prices changes could be measured and analyze for both Florida and Mexico.
- A study regarding the technical side of lime growing would be useful as Mexican low productivity could be due to the presence of small groves and a serious deficiency in economies of scale.
  (Roy, Andrew, Spreen, 1996, p. 121)

2.2 Theory Literature on Import Demand

Econometric and case study literature relevant to methods chosen for this research were consulted. Regional price analysis has often yielded useful market information as shown by Houston and Nieto (1988) who analyzed regional market relationships within the U.S. shrimp industry. In a paper entitled "The Regional Shrimp Market Responses to Domestic Landings and Imports" they presented an analysis of how imports and domestic landings from other regions affect regional markets, obtaining a significant higher impact on prices for some local regions and markets that for the rest of them. The purpose of this approach was to determine the effect a single large market can have on markets in other regions. Further objectives of the study included estimating distribution effects of fresh shrimp on market prices and evaluation price behavior in the shrimp market with respect to shrimp species and size characteristics. To

accomplish these objectives several price dependent functions were analyzed as a system using Seemingly Unrelated Regression. Three species of shrimp, brown, white, and pink were studied in four regions: Gulf of Mexico, South Atlantic, West Coast, and New England. Data on shrimp prices and landing from 1958 to 1984 were obtained from the National Marine Fisheries Services and two additional sources; Basic Economic indicators, Shrimp 1972 and Fishery Statistics. The statistics shown that for this period approximately 70 % of the shrimp consumed in the U.S. were imported.

A key aspect of the economic model was said to be the analysis of shrimp harvest in one region relative to harvest in other regions. More specifically, the interactions of landings and prices were considered to determine gains or losses from changes in industry landings in different regions. It is also noted in the article that differences in growth cycles and appearance of shrimp in their respective markets will affect price structure, leading to the hypothesis that significant price interactions would exists between the three species examined in the study.

Flexibility coefficients from the resultant analysis showed that as the dependence of the South Atlantic region on other sources of shrimp grew, the effect of its own landings on prices decreased. As imports increased, prices decreased; however, reduction of imports would only provide a temporary solution. In the long run prices to other sectors of the industry and to regional consumers would increase. Prices in the West Coast region were most significantly affected by quantity supplied within the region and within the rest of the U.S. Regional personal disposable income was also found to be significant in this region. Landings, quantity supplied, within the region were also found to have an impact in the Gulf Coast, but not in the New England region. Regarding differences in species and size of shrimp, brown shrimp landings were found to be a good forecast tool for prices of other species rather than its own prices. These

results exemplify the importance that regional price analysis can have within an industry yielding credibility to the goals of the present study.

Research on import demand was undertaken by Lordkipanidze, Epperson, and Ames (1996) with a specific focus on canola oil. The goal of this study was to analyze the impact of economic factors on U.S. import demand for canola oil. Using generalized least squares, quantity of canola oil imports to the U.S. were modeled as a function of several different factors. These factors included prices of canola, soybean and palm oils, real disposable income and the U.S.-Canadian exchange rate. The Canadian exchange rate was included because at the time of the study, Canada was the primary supplier of canola oil to the U.S. Additional factors taken into consideration include a trend factor, and a dummy variable to account for seasonality.

The results computed from the model were given in the form of elasticities. Due to the small proportion of total consumer expenditure spent on canola oil, own price and income effects were not significant. Cross price elasticities showed that import demand for canola oil is most sensitive to the price of soybean oil. The study concluded that rising demand for canola oil along with a favorable production environment would yield future benefits for the domestic canola oil market. The analysis of import demand for limes presented in this paper should provide similar, much needed information to the industry.

CHAPTER 3

FACTORS AFFECTING THE IMPORT DEMAND FOR MEXICAN LIMES IN THE UNITED STATES

3.1 Introduction

During the decade of the 1990's food consumption patterns in the United States have been changing, and these changes have impacted international trade between producers and consumers of agricultural commodities. While these factors include economic influences some are noneconomic in nature, such as changes in lifestyles that influence consumers' tastes and preferences. Data from several sources suggest that American tastes and preferences for imported beer and other alcoholic beverages from Mexico have stimulated a demand for these products and their complementary product, limes, as measured by U.S. per capita consumption and shipments from Mexico (USDA, ERS, 2005). There has also been observed an increase among U.S. consumers in the per capita consumption of Key lime pie and sales of fresh limes at retail (the suspected use is as a garnish or flavoring and for freshly squeezed limeade). The likelihood that Mexican limes will capture a larger share of the U.S. fresh limes market depends on a number of factors driving the demand for this and complimentary products. The objectives of this study are: to determine the factors affecting the U.S. import demand for Mexican fresh limes and to estimate their relative influence.

An import demand model for fresh limes will be developed and evaluated, including own price, prices of substitutes, prices of complements, population, consumer disposable income, and seasonality. Continuous monthly Mexican prices and export shipment data are available

spanning the last 15 years, as are U.S. data on consumption, income and prices. Of special interest, with respect to the import demand question, are the income and price elasticities of fresh limes and the cross-price elasticities for substitutes of lime.

3.2 Model Specification

Income and price are two of the most important factors in economic theory that can influence the demand for a good relative to its complement and substitute goods. The effect of income on food expenditures, the income elasticity of demand is measured by changes in demand with respect to changes in income. The income factor however, is not expected to be large, due to its small proportion of consumers' expenditures. As mentioned before, relative prices of substitute goods generally play a substantial role in consumers' choice of limes, but noneconomic factors are also taken into account; examples of this are dietary concerns and cooking fashion trends. The U.S. import demand for Mexican fresh limes was specified as a function of its own import price, prices of close substitutes (limes coming to the U.S. from Central and South America), disposable personal income, the Mexican peso-U.S. dollar exchange rate, lagged imports, and seasonality.

The general form of the equation follows:

3.1 $MXQ_t = f(PMX_{t-1}, PSA_{t-1}, PCA_{t-1}, EX_{t-1}. INC_{t-1}, MXQ_{t-1}, DSEASON2_t, DPEAK_{t,}, DPEAK2_t)$

where MXQ represents quantity of limes imported from Mexico (thousands of metric tons), PMX is real own price of limes coming from Mexico (in real 1982-1984 dollars/kg), PSA is real price of limes coming from South America (in real 1982-1984 dollars/kg), PCA is real price of limes coming from Central America (in real 1982-1984 dollars/kg), EX is the Mexican peso-U.S. dollar real exchange rate ($Mexican peso/U.S.), INC is real U.S. disposable personal income

(trilllions 1982-1984 dollars), the CPI base year for all real values is 1982-1984. Dummy variable accounting for seasonality of import demand include, DSEASON2 (1 for January-April, 0 otherwise). Two additional dummy variables were included in the model to account for variability in the original data in the years 1994 to 1997 and a couple of months in the particular year of 2001 (see figure 3.1). DPEAK is (1 for July 1994-May 1997, 0 otherwise) and DPEAK2 is (1 for October – December 2001, 0 otherwise).

During the period of July 1994 to May 1997 quantities exported to the U.S. from Mexico were almost zero, due primarily to the effects of the devaluation of the peso in 1994 and the post-devaluation monetary crisis. Although the NAFTA agreement was signed in the same period, the advantages of this agreement were not put into action until late 1997, when most of the producers and government strategies were stabilized after the crisis (Acosta Barradas, 2001). Thus, DPEAK was introduced into the model to account for this economic crisis period. The variability in quantities during October to December, 2001, can be attributed to a severe dry weather that affected the states of Veracruz, Oaxaca, Michoacan and Colima, some of the main producers of limes in Mexico (USDA, FAS, 2002). Thus, DPEAK2 was introduced into the model to account for this period. Due to those factors, modeling the behavior of the data is difficult without the introduction of dummy variables, and the inferences and interpretation of results are also confounded.

The variables for lime prices (PMX, PCA, PSA), exchange rate (EX), and income (INC) were lagged to account for the time needed for the delivery process of the imported commodity (Othman, Houston and Ames, 1995). Among the monthly data, missing observations for prices in South and Central America were observed during certain months, however average prices were calculated using statistical software, to fill those missing values and contribute to the

sequence in the time series data. The variable for lagged imports (MXQ) was included in the model to account for import adjustments to income and relative price changes over time (Miller and Frattiani, 1974). The database consulted contains data from 1989 to 2007, and the study is based on monthly data from January 1989 through June 2007 (USDA, FAS, 2007).

3.3 Data and Empirical Procedures

Different varieties of limes are cultivated in Mexico, Central America, South America and the rest of the world. However, the two most important varieties are the Persian (Tahitian) and Mexican (Key) limes (Spreen, 2001). In this study, three main producer regions were studied: Mexico, Central America, and South America. Monthly data on those regions from 1989 to 2007 were obtained from the Foreign Agricultural Service's U.S. Trade Internet System. These data include United States international trade statistics on Agricultural, Fish, Forest and Textile Products from the inception of the harmonized coding system in 1989 to the present. The Harmonized Trade System (HTS), which classifies products traded internationally, indicates that limes are in Chapter 8 "edible fruit and nuts; peel of citrus fruit or melons", with the codes 0805.50.30 and 0805.50.40 corresponding to the Tahitian limes, Mexican limes and other limes of the citrus *aurantifolia* and *latifolia* varieties (USITC, 2007).

The U.S. Consumer Price Index (CPI) is taken from the U.S. Department of Labor, Bureau of Labor Statistics. Data on the Foreign Exchange Rates (EX) from January 1989 to December 1993 are from the *Banco de Mexico (BANXICO),* and data from January 1994 to June 2007 are taken from the Federal Reserve Board. Disposable Personal Income nationally was obtained from annual issues of the Bureau of Economic Analysis. Lime prices and disposable personal income were adjusted to 1982- 84 constant dollars (BEA, 2007).

Following previous analysis of Miller and Frattiani (1974), Othman, Houston and Ames (1995), and Seleka and Henneberry (1993), a log-log functional form was used to estimate the U.S. import demand for limes, as specified in equation 3.2:

3.2 $LN(MXQ_t)= B_o + B_1 LN(PMX_{t-1}), + B_2 LN(PSA_{t-1}), + B_3 LN(PCA_{t-1}), + B_4 LN(EX_{t-1}), + B_5 LN(INC_{t-1}), + B_6 LN(MXQ_{t-1}), + B_7(DSEASON2_t), + B_8(DPEAK_t) B_9(DPEAK2_t) + U_t$

3.4 Results and Implications

Estimation results of the model are presented in Tables 3.1 and 3.2. The own price and income effects on import demand were larger than expected, perhaps due to increasing contributions of limes in consumers' expenditures. The coefficient for own price was significant and positive at the 0.001 level. Overall, the lime import demand model is consistent with economic theory. Since the log-log function was used in estimation, the coefficients of variables in log form also represent elasticities (Intriligator, 1996). Thus, the import demand elasticity of Mexican limes with respect to own price is estimated to be 0.2265, meaning that a 0.23% increase in quantity has accompanied a 1% increase in lagged prices over this period. The income coefficient is positive but it is not significant, demonstrating little or no influence on imported limes.

On the other hand, the cross-price coefficients for Central (PCA) and South America (PSA), are negative, but not significantly different from zero, again having little or no effect on the imports of Mexican limes (Browning, 2002).

The exchange rate coefficient has a positive sign in the analysis and it is significantly different from zero, indicating an increase in import demand with an increase in the price of Mexican peso and *vice versa*. Thus, a higher value for the Mexican peso real exchange rate means a lower price in U.S. dollars for imported limes and *vice versa*.

The coefficient for the lagged import quantity variable for limes coming from Mexico was positive and significant at the 0.001 level, contributing to the dynamics of growing import demand. Such relationships suggest considerable growth potential for lime exports to the U.S.

Seasonality appears to be important for this product. DSEASON2 coefficient is negative and significant at the 0.01 level. DPEAK and DPEAK2 coefficients are negative and significant at the 0.001 level. The negative sign in the dummy season variable suggests that from January to April (winter and spring seasons), imported quantity is significantly less than in summer and fall; Mexican limes however, are produced all year round, and importers have access to the product any season of the year. The reported R-squared was 0.9553, indicating that more than 95% of the variability in monthly imports of limes was explained by the model.

3.5 Conclusions

Given the information provided by the analysis, the demand for limes appears to have a tremendous potential for revenue growth for Mexico. The possibilities for the Mexican lime industry seem to be great and also for the rural development in the associated states of production. The consumer demand for limes in the U.S. indicates that this product will continue have great acceptance among the U.S. population, at least partially because of the expansion of Latino communities all around the country in big cities, such as Los Angeles, Chicago, San Francisco, Atlanta, Houston, and others. Increasing consumer demand can also be explained by the high degree of substitutability and seasonality of lemons. When lemon prices are highest, typically in winter, consumers are more likely to purchase limes (CONCITVER, 2006).

Based on the analysis of monthly data for January 1989 through June 2007, U.S. import demand for limes was influenced mostly by own price, the U.S.-Mexican peso real exchange rate, income, seasonality and by extraordinary macroeconomic events and drought.

This analysis was limited to a portion of the overall question regarding the factors affecting the U.S. import demand for Mexican limes. It is important to note that producing Mexican limes is a much more encompassing process than finding alternative crops for farm producers. One occurrence has come into play which should lead to the continued expansion of limes production in Mexico; this is the elimination of the Mexican export tariff imposed on this product (SE, 2007). The fact that the U.S. production of limes has been decimated by natural disasters and that most of the citrus industry is now concentrated in the production of oranges, grapefruit and other kinds of tropical fruits, this window has created a good opportunity for Mexican producers to sell their products in international markets and keep a significant piece of the market share in the U.S.

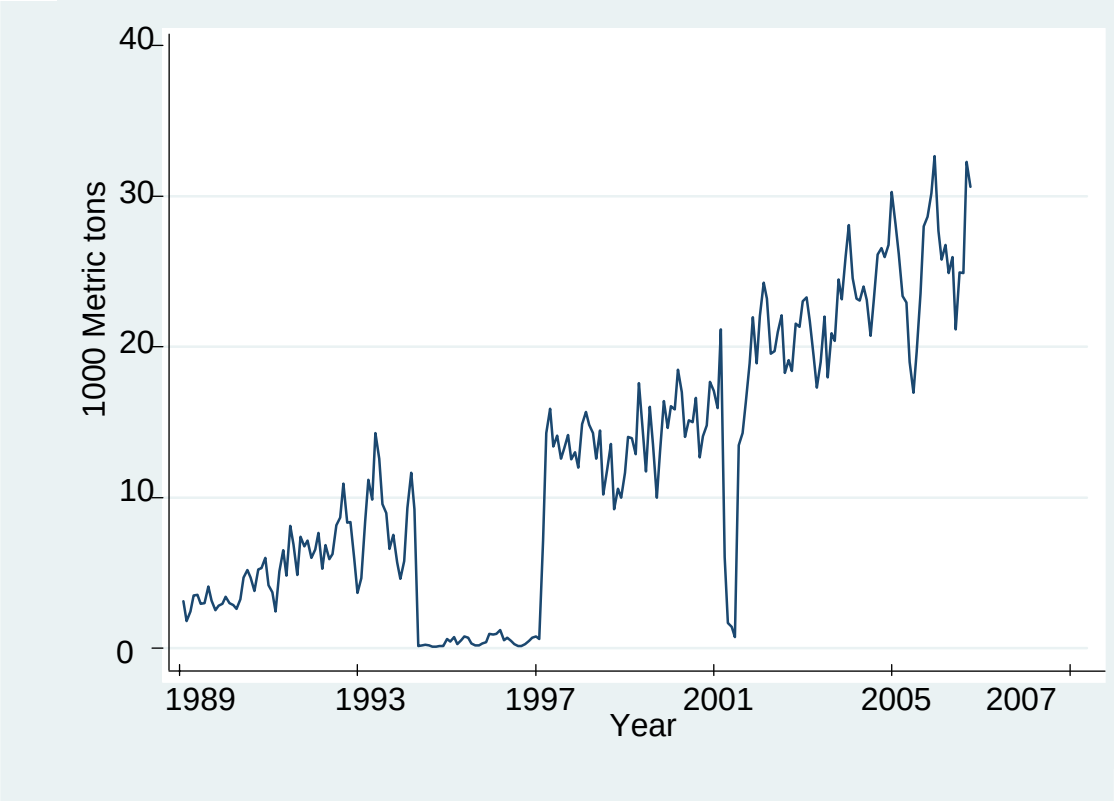

Figure 3.1 U.S. Monthly Imports of Mexican Limes, 1989-2007.

Table 3.1. Sample Statistics for Variables in the U.S. Lime Import Demand Model[a], 1989-2007

Variable[b]	Mean	Std Dev	Minimum	Maximum
MXQ	11.95693	8.951793	.0714	32.6667
LAGPMX	.1986851	.1007852	.082867	.614117
ILAGPCA	.3096747	.1480959	.066611	1.217029
ILAGPSA	.3714377	.154566	.095621	1.386964
LAGEX	7.35651	3.284405	2.2954	11.52
LAGINC	3.919143	.5262923	3.2189	4.9206
LAGMXQ	11.8725	8.883089	.0714	32.6667
DSEASON2	.3423423	.4755658	0	1
DPEAK	.1576577	.3652433	0	1
DPEAK2	.0135135	.1157204	0	1

[a] N=221

[b] Where MXQ represents U.S. imported quantity of limes from Mexico (thousands of metric tons), LAGPMX is real own price of limes coming from Mexico (in real 1982-1984 dollars/kg), ILAGPSA is real price of limes coming from South America (in real 1982-1984 dollars/kg), ILAGPCA is real price of limes coming from Central America (in real 1982-1984 dollars/kg), LAGEX is the Mexican peso-U.S. dollar real exchange rate ($Mexican peso/U.S.), LAGINC is real disposable personal income (trillions 1982-1984 dollars), LAGMXQ is the U.S. lagged imports coming from Mexico (thousand of metric tons), dummy variables accounting for seasonality are included in the model, DSEASON2 (1 for January-April, 0 otherwise) and also two dummy variables accounting for peaks or valleys among the data in specific years, DPEAK is (1 for July 1994-May 1997, 0 otherwise) and DPEAK2 is (1 for October 2001 – December 2001, 0 otherwise). The CPI base year for all real values is 1982-1984.

Table 3.2. Parameter Estimates of the Lime Import Demand Model,[a] 1989-2007.

Variable[b]	Parameter Estimate	Robust Standard Error	t Value	Pr > |t|
INTERCEPT	.0506398	.6755605	0.07	0.940
LNLAGPMX	.2265202	.0613746	3.69	0.000
ILNLAGPCA	-.0312382	.0503089	-0.62	0.535
ILNLAGPSA	-.0283886	.0745777	-0.38	0.704
LNLAGEX	.6102063	.14121	4.32	0.000
LNLAGINC	.2073481	.4622407	0.45	0.654
LNLAGMXQ	.3397594	.1016344	3.34	0.001
DSEASON2	-.0601947	.0230261	-2.61	0.010
DPEAK	-1.043668	.1681223	-6.21	0.000
DPEAK2	-.9133992	.1108468	-8.24	0.000

[a] N=221

[b] Where LNMXQ represents Log U.S imported quantity of limes from Mexico (thousands of metric tons), LNLAGPMX is real own price of limes coming from Mexico (in real 1982-1984 dollars/kg), ILNLAGPSA is real price of limes coming from South America (in real 1982-1984 dollars/kg), ILNLAGPCA is real price of limes coming from Central America (in real 1982-1984 dollars/kg), LNLAGEX is the Mexican peso-U.S. dollar real exchange rate ($Mexican peso/U.S.), LNLAGINC is real disposable personal income (trillions 1982-1984 dollars), LNLAGMXQ is the U.S. lagged imports coming from Mexico (thousand of metric tons), dummy variables accounting for seasonality are included in the model, DSEASON2 (1 for January-April, 0 otherwise) and also two dummy variables accounting for peaks or valleys among the data in specific years, DPEAK is (1 for July 1994-May 1997, 0 otherwise) and DPEAK2 is (1 for October 2001 – December 2001, 0 otherwise). The CPI base year for all real values is 1982-1984. R^2 = .9553 and D.W.= 1.39

CHAPTER 4

THE ECONOMIC POTENTIAL OF LIME OIL INDUSTRY IN MEXICO [1]

[1] Abarca Orozco, Saul and James E. Epperson.
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4.1 Abstract

Lime oil, as a by-product of lime processing, has a variety of food and industrial uses. Mexico is currently the world's leading producer of lime oil which gives rise to interest in possible expansion of the industry. The primary market is the U.S. with lesser potential in the EU based on past trends. Expansion of this industry, if feasible, would increase producer revenue and add jobs in lime processing and allied and secondary sectors of the economy spurring economic development in affected rural areas of Mexico. Juice for human consumption and pulp for animal feed are also products of lime processing but are fraught with commodity characteristics. Lime oil, on the other hand, is an ingredient in differentiated food and cosmetic products and appears to be associated with fairly stable prices over time even in the face of competition from Brazil and Peru. Thus, the purpose of this study is to determine the economic feasibility of expanding lime oil production in Mexico and to what extent.

4.2 Introduction

About 60 percent of citrus production in Mexico is on the west coast, largely including the states of Colima, Michoacán, Jalisco, Guerrero, and Oaxaca. The other 40 percent is produced on the gulf coast, including the states of Veracruz, Tabasco, and Yucatan (SAGARPA, 2005).

Mexico is the number one producer of limes, a major citrus crop, in the world, with a farm-gate value of $20 million. Limes are grown largely in tropical climates around the world (USDA, ERS, 2006). Among citrus crops, limes are second in economic importance to Mexico. This is not only because of high value in fresh form but also in processed forms (SAGARPA, 2007). In recent decades, the lime sector of Mexican agriculture, which involves exports mainly

to the U.S. and a few countries in the European Union, has experienced an increase in demand for limes and lime by-products (Consultores, 2002).

The main importers of lime oil are the U.S, the UK, Japan, Ireland, and Belgium (FAOSTAT, 2007). The food industry uses around 60 percent of essential oils production, and the cosmetics and fine fragrances industry uses the remaining 40 percent (Venkataraman, 2006). U.S. lime oil imports have been increasing on average about 4.9 percent per year since 1989 as the U.S. does not currently have a lime industry. In 2006, U.S. lime oil imports amounted to more than $ 25 million (USDA, FAS, 2007). As a result, the U.S. is a principal target market for lime oil producers. The main competitors for Mexico in the U.S. market are Peru and Brazil. However, Mexico is the principal exporting country to the U.S., with 1,078.1 metric tons in 2006. Second is Peru with 209.8 metric tons, followed by Brazil with 94.2 metric tons. Mexico accounts for 70 percent of all U.S. lime oil imports. The peak season for U.S. lime oil imports is from May through July (USDA, FAS, 2007).

There are three principal techniques for manufacturing lime oil (White Lotus Aromatics Newsletter, 2005). The first method is labor intensive, requiring extraction of the oil by pressing the limes by hand against a spike studded copper bowl. The benefit of this method is that it yields the highest quality oil, which is used primarily as candy flavoring. With the second technique, a machine is used to press the oil from the lime peels. The oil extracted via this process is generally used in beverages and perfumes. A process of distillation is used for the final method. Washed, crushed limes are stored in tanks for at least two weeks before the desired oil is extracted from the pulp at the top of the tank. Most lime oil is produced using this method for use in soft drinks, ice cream, and other lime-flavored food products (White Lotus Aromatics

Newsletter, 2005). Increased lime oil production in Mexico, with high availability of raw materials, technology, and quality, would seem to have great potential for the export market.

4.3 Model Specification

For competitive markets, the market clearing price is determined where demand and supply are equal. The U.S. quantity demanded is

4.1 Q_D = f (U.S. price, U.S. per capita income, CPI, U.S. population).

Quantity supplied (Q_S) in this case is predetermined. Because lime oil is a by-product from the production of limes, a highly perishable commodity with quantities that cannot be adjusted in the short run, lime oil quantities are treated as being predetermined with price adjusting to clear the market (Matsuda, 2004).

Thus, the market clearing price for $Q_D = Q_S$ is

4.2 U.S. price = f (Q_S, U.S. per capita income, CPI, U.S. population).

After specifying Q_S by source, combining per capita income and population, and adjusting price and income for inflation, the estimating equation becomes

4.3 real U.S. price = f (Q_i, real U.S. income),

where Q_i is quantity supplied from source *i*.

4.4 Data and Empirical Procedure

The primary suppliers of lime oil to the U.S. are Mexico, Brazil, and Peru. Thus, the data are grouped accordingly; i.e., Mexico, Brazil, Peru, and the rest of the world. Annual data for 1989 to 2006 were obtained from the US trade statistics database provided by the Foreign Agricultural Service (USDA, FAS, 2007). The Harmonized Trade System (HTS), which classifies products traded internationally, indicates that lime oil is in the category of "essential citrus fruit oils of lime" with code 330114 (USITC, 2007). The HTS data are given by quantity

and value. Thus, the U.S. price of lime oil is imputed. The price variable in the model is the real weighted average U.S. import price of lime oil. U.S. disposable personal income is from the U.S. Bureau of Economic Analysis. The price and income variables are deflated by the CPI in 1982-84 dollars (USDC, BEA, 2007). The definitions and sample statistics for the variables are given in table 4.1.

The linear regression model incorporating competition among source countries is specified:

4.4 USP = f (MXQ, PRQ, BRQ, RWQ, USDPI),

where the variables are defined in table 4.1.

4.5 Results and Implications

Estimation results of the price flexibility model are presented in table 4.2. The coefficients for Mexican lime oil quantity (MXQ) and rest of the world quantity (RWQ) demonstrate negative influence on prices as expected. The MXQ coefficient is weakly significant at the 0.20 level, while that for RWQ is significant at the 0.01 level. The coefficients for Peruvian (PRQ) and Brazilian (BRQ) quantities, however, are positive. The coefficient for PRQ is significant at the 0.20 level, while that for BRQ is not significantly different from zero. The positive coefficient for PRQ maybe is associated to a decline in Peru's market share of U.S. lime oil imports from 44 percent to 14 percent over the study period. Moreover, real U.S. lime oil prices (USP) were generally higher during the beginning of the study period. Generally higher real prices during the first part of the study period versus generally lower real prices later are also associated with rising real U.S. disposable personal income (USDPI); thus, a negative and significant (0.10 level) coefficient for USDPI, evidences declining expenditure proportions during this period.

Price flexibilities are computed from the significant (0.20 level) coefficients given in table 4.2 at mean values of the variables, (table 4.3). Flexibility coefficients are the percentage change in price for a one percent change in quantity or income (Houston and Nieto, 1988). The quantity and income impacts on price appear to be limited at mean levels. The greatest impact on price is shown to be with respect to income (USDPI) – a 10 percent increase in income is associated with a 6.9 percent decrease in price. Such limited relationships with price suggest considerable growth potential for lime oil exports to the U.S.

4.6 Optimum Mexican Lime Oil Exports to the U.S.

Using trend values for the variables and model coefficients from table 4.3, a price dependent demand curve for U.S. lime oil imports from Mexico is isolated for 2008. From this demand curve, the quantity that will maximize Mexican total revenue is computed. Using the inverse demand function in table 4.2 we substitute into trend values for all variables in the model 2008 except for MXQTY. We do the math and obtain a new equation with different intercept value. The resulting optimal quantity is 2.1 thousand metric tons which compares to a 2008 trend value of 1.2 thousand metric tons for Mexico. That is, the potential for Mexican lime oil exports to the U.S. for 2008 is nearly double the trend value.

4.7 Conclusions

Given the expected growth in demand for lime oil and tremendous potential for revenue growth for Mexico, as shown in this analysis, the future would seem to be bright for the Mexican limes industry and for rural development in affected states. However, recall that lime oil is a by-product. Other considerations are in order, namely, the economic feasibility of increasing the production of fresh limes, juice, and pulp uses such as animal feed.

This analysis was limited to a portion of the overall question regarding the feasibility of expanding the Mexican limes industry. Clearly, the lime oil segment shows great promise. Future research will address the remaining questions. It is important to note that producing Mexican lime oil is a much more encompassing process than finding alternative enterprises for farm producers. The means of developing and expanding this processing industry involve limes production, assembly, processing, marketing, distribution, and financing – all of which affect the rural economies of Mexico in complex ways. Of prime importance are the enhanced opportunities for producers and laborers at all skill levels.

Table 4.1. Sample Statistics for Variables in the U.S. Lime Oil Import Price Model, 1989-2006

Variable[a]	Mean	Std Dev	Min	Max
USP	10.13	1.87	7.88	14.54
MXQ	0.70	0.29	0.23	1.20
PRQ	0.19	0.06	0.10	0.28
BRQ	0.08	0.05	0.02	0.19
RWQ	0.12	0.05	0.05	0.25
USDPI	3.88	0.52	3.23	4.71

[a] USP is U.S. Import Price in thousand 1982-1984 dollars, MXQ is Mexican Quantity in thousand metric tons, PRQ is Peruvian Quantity in thousand metric tons, BRQ is Brazilian Quantity in thousand metric tons, RWQ is Rest of the World Quantity in thousand metric tons, and USDPI is U.S. disposable personal income in trillion 1982-1984 dollars.

Table 4.2. U.S. Lime Oil Import Price Model Parameter Estimates,[a] 1989-2006

Variable	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	19.28	3.83	5.03	0.00
MXQ	-2.50	1.74	-1.44	0.18
PRQ	7.07	5.19	1.36	0.20
BRQ	4.44	4.89	0.91	0.38
RWQ	-17.64	5.29	-3.34	0.00
USDPI	-1.81	0.98	-1.85	0.09

[a] N = 18.

Table 4.3. Estimated Lime Oil Price Flexibility Coefficients,[a] 1989-2006

Variable	Coefficient
MXQ	-0.17
PRQ	0.13
RWQ	-0.21
USDPI	-0.69

[a] Price flexibility coefficients, (dP/dQ)(Q/P) and (dP/dY)(Y/P), are calculated from estimated parameters at mean values (Houston and Nieto 1988).

CHAPTER 5

CASE STUDY: ESTABLISHMENT OF AN ESSENTIAL LIME OIL PROCESSING FACTORY IN SOUTHEASTERN MEXICO: FEASIBILITY AND IMPACTS.

5.1 Background

In 2006, Mexico produced approximately 1.9 million metric tons (MT) of lemons and limes, and exported 412,000 MT. The main growing states of this citrus fruit are Colima, Michoacán, Oaxaca, Veracruz and Guerrero.

Among citrus, lime is the second most economically important, not only because of its high consumption value as fresh produce, but also for the industrial uses. Mexico is considered the principal producer of the Persian and Mexican varieties of lime (USDA, FAS, 2006).

Every year Mexico produces an average of 0.5 million MT of Persian limes, and 80% of this production is exported, with a commercial value of US 6 million dollars (USDA, FAS, 2006). Most of this production originates from Martinez de la Torre, a municipality in Veracruz State, (see figure 5.1). The Martinez de la Torre region is one of the most fertile and productive areas in the state of Veracruz, around 815.13 km^2 (201,423.1 acres). Located on the bank of the Bobos river, it has the largest number of inhabitants in the region. Strategically located, Martinez de la Torre links up with Tlapacoyan, Atzalan and Perote to the West, the Nautla and Casitas Coastal zone to the east and Misantla, the Chiconquiaco mountain and chain and Xalapa to the South (INEGI, 2000). This valley is irrigated by several rivers which are tributaries of the Nautla river. The weather is warm-humid, with an average temperature of 23.7◦C (74.7◦ F) (INEGI, 2000).

Martinez de la Torre has been ranked as one of Mexico's biggest producers and exporters of citrus fruits, particularly Persian Limes, (see figure 5.2). Due to its industrial and commercial activity, this city boasts a good infrastructure in the area, hotels, restaurants and medical services (Webster, 1986).

5.2 Relevance of the Industry

Production of Persian Limes has increased in Mexico, due to a number of domestic and international influences. Florida's increase in orange production and a fall in orange trade prices are two significant influences. Other stimulants to planting Persian limes in Martinez de la Torre include a steady increase in U.S. demand for this product and unstable production of Mexican limes, (for which Persian limes are a close substitute) due to occurrences of extreme weather. (Roy, Andrew, Spreen 1996).

5.3 Consumer Demand

Within the food industry, Persian lime is only beginning to gain popularity mostly because the Mexican variety called "key lime" is the type typically used in the production of sodas, lemonades, and lemon flavor powders used to prepare jellies. Some of the latest consumer trends, which have affected the industry, revolve around specialty markets, such as beverages and cocktails. Other areas of increased demand lie within the cosmetics industry, as Persian limes have been found useful in the preparation of shampoo and the sector of household goods where Persian limes are used to make detergents (SAGARPA, 2006).

The Latino population, and specifically the Mexican portion, that live in the United States have shown a strong consumption preference for the Persian Lime. Thus, these potential customers will support part of the import demand for this product. Additional demand is likely to come from Europe and other countries. Exports to the European Union have been increased at an

average annual rate of 10% from 1995 to 2000 and now with the signature of Free Trade Agreements between Mexico and the EU, the consumption of citrus fruits including Persian Limes is likely to increase (Consultores M.G., 2002).

5.4 Beneficiaries in the Region

More than 40% of the Mexican citrus industry is in Veracruz State. In fact, on average, from every five citrus fruits that the country produces, two of them come from Veracruz. According to the Local Citrus Council in Veracruz, there exist more than 6000 citrus producers of Persian lime in the region of Martinez de la Torre. In this region (the municipalities of Misantla, Papantla, Tecolutla, Gutierrez Zamora, Nautla, San Jose Acateno, Atzalan and Tlapacoyan), they cultivated in the last 10 years more than 13,000 hectares of Persian lime. From this high level of lime production, it is also quite feasible to produce lime by-products, lime oil, pulp to feed cattle, pectins, etc. The average yield per hectare is around 20 tons and the estimated annual average total yield is around 260,000 tons. From this amount, 80% is used for the export-markets Asia, European Union, United States, Canada and the rest of the production, called by the citrus producers as "the thirds" is used in the local market (CONCITVER, 2006).

Citriculture practices in this region have generated 2,000,000 *direct jornales (the payment for one day of work at the Citrus plantations)* every year. This probably could be more, if we take into account the *indirect jornales* (*payment for one day of work outside of the Citrus plantations*) (Consultores M.G., 2002).

Exports of Persian lime have a great importance in the economy of Mexico, mainly because of their importance to many families' incomes. Based on estimations from the producers of the fruits, this export activity annually generates income of US $5,646,000 dollars. The citrus industry in Martinez de la Torre is of great local economic importance. When a new

company or processing packaging firm is established there, the social impact in the region is remarkable. Around 72,000 families are involved in the production and marketing part of this industry. Of the 6,000 citrus producers in Martinez 2,500 are dedicated to Persian lime farming, and the livelihoods of 18,000 families depend on this farming activity. Additionally, from some estimates in the region, between workers (some of them called *jornaleros, cortadores, cargadores, fleteros*) and people at the packing facilities, the number of families involved in the process could be raised to 72,000 families (Curti Diaz, INIFAP, 2003).

Unfortunately, due to instances of monopsony along the marketing chain, the farmers typically receive only a minimal portion of the retail value. Thus, the increased competition that a lime oil facility would bring to the industry could greatly benefit the families of Martinez de la Torre. Growth in this industry represents one of the options for diversification of the productive resources used by the agent chains that participate in the process (producers, packers, brokers, and the cardboard boxes producers). Previous instances of commercialization however, demonstrated a trend toward oligopolies. This happens because big importers from McAllen, Texas, buy large quantities of the imports from Mexico and distribute them later in groceries stores, supermarkets chains, restaurants, wholesale markets and small fruits business (Consultores M.G., 2002).

5.5 Feasibility Example of a Lime Oil Facility

The Citrus Association in Martinez, with 100 individuals and around 50 packing processors, is one of the pioneers in the lime business. They realize that a new facility producing lime oil and peel will help the partners of this Association increase their competitive advantage in the business. In general terms, this type of development will also contribute to regional development and prosperity. In 2002, the Citrus Association produced 6,309 tons of harvested Persian limes, but about 33% of this production (2,113 MT), can not be used for export due to small defects in the skin, color, weight, shape, ripeness, or other blemishes. The producers estimate that, in every harvest season, around 35% of the limes are not of exportable quality. Thus, in 2002, the remaining wasted production of limes was approximately 76,055.37 MT. The establishment of a new lime oil processing facility would allow the farmers to sell those limes to manufacturers, who will then use the limes to obtain lime oil and dehydrated lime peel (Agroindustrial G.I., 2002). In order to establish a medium size facility with the ability to process up to 100 MT of limes per day the plant requires a building of approximately 2500m^2 and a non urban site of approximately 40,000m^2 of land (Bartholomai, 1987). The citrus association already owns 26,250m^2 of land and a building space about 1,240 m^2 this infrastructure represents an investment of about 5.5 million 2002 pesos (US $548,902.20, in 2002 dollars), and will enable the citrus association to process up to 52 MT per day (Agroindustrial G.I., 2002).

5.5.1 Feasibility of Establishing a Lime Oil Processing Facility

The data used for analysis will be the estimates of production in the peak season of Persian limes for the period of the second week of March to first week of November (240 days) during the year 2002. The amount of ‘wasted’ fresh limes that could be obtained by the Citrus Association in Martinez de la Torre and remaining production is around 325.70 tons per day.

This quantity is calculated dividing the total production, 78,168.37 tons of limes between the 240 days of the peak season. These available limes are more than enough to cover the needs of the processing facility, table 5.1**.**

Table 5.1. Monthly Needs Estimates of Limes in Martinez de la Torre, 2002

Month	**Days**	**Metric tons per day that can be processed in the facility**	**MT[a]/month**
March	15	52	780
April	30	52	1,560
May	30	52	1,560
June	30	52	1,560
July	30	52	1,560
August	30	52	1,560
September	30	52	1,560
October	30	52	1,560
November	15	52	780
TOTAL	**240**		**12,480**

[a] MT= 1000 kilograms

5.5.2 By-products

As part of the lime oil industrial process, the peel of the lime and the waste pulp can be used as a base for cattle feed. Or with a good washing treatment and a dehydrate process, the dehydrated peel is useful to extract pectin.

Lime oil is a product not often purchased by the final consumer; most of the production is sold directly to intermediaries, who know the specific requirements of the industrial consumers or users. For the region of Martinez de la Torre, there are currently only a few local buyers. Opening the market to other players will not only allow for increase competition in the industry and better prices for the farmers and producers, but it will likely also lead to excess demand (Agroindustrial G.I., 2002).

5.5.3 Price of the Product

The prices that the intermediaries paid for this product in 2002 averaged between US $6.5 to US $7.5/lb (US $14.33 to US $16.53/kg) for essential oil. For the dehydrated peel, approximately US $ 620/MT was paid to producers on average.

Based on a market analysis made by "Grupo Interdisciplinario Agroindustrial" in Martinez de la Torre, tables 5.2 through 5.7 will illustrate the average production that a processing facility of lime oil and dehydrated peel of medium size will be able to produce and the profitability of the business. It is important to mention that 1 metric ton of fresh limes can yield approximately 4 kg of essential oil and 166.7 kgs of dehydrated peel. Thus, with a maximum total processing production of 12,480 MT/season of limes, the facility can obtain on average 49.92 MT/season of lime oil and 2080 MT/season of dehydrated peel. Table 5.2 will help to exemplify production and forecast total revenue per each product:

Table 5.2. Estimated Production of Lime Oil [a], Dehydrated Peel [b], and Total Revenue per Product (Base year, 2002).

Month	Lime oil (kg)	Price U.S.$/kg	Total Revenue	Dehydrated peel (MT)	Price U.S. $/MT	Total Revenue
March	3,120		44,709.6	130		80,600
April	6,240		89,419.2	260		161,200
May	6,240		89,419.2	260		161,200
June	6,240	**FCA[c]**	89,419.2	260	**FCA[c]**	161,200
July	6,240		89,419.2	260		161,200
August	6,240	**$ 14.33**	89,419.2	260	**$ 620**	161,200
September	6,240		89,419.2	260		161,200
October	6,240		89,419.2	260		161,200
November	3,120		44,709.6	130		80,600
TOTAL	**49,920**		**$ 715,353.6**	**2080**		**$ 1,289,600**

Source: Own calculations with established quantities and prices.
[a] Quantities for lime oil are measured in Kilograms
[b] Quantities for dehydrated peel is measured in metric tons
[c] **(FCA)** Free Carrier (named place): the seller hands over the goods, cleared for export, into the custody of the first carrier (named by the buyer) at the named place. This term is suitable for all modes of transport, including carriage by air, rail, road, and containerised / multi-modal transport.

With 49,920 kgs of lime oil at a price of $14.33 per kilo the total revenue that the lime oil processing facility can obtain is $715,353.6 from oil sales. On the other hand, with 2080 MT of dehydrated lime peel (DLP) at a price of $620/MT the total revenue that the lime peel processing facility can attain is $1,289,600 for DLP.

At this point of the study, it is necessary to know “How much is it going to cost to establish a lime oil facility in the region?” in order to compare the costs against the revenues and

analyze the feasibility of the project. To help with this matter, tables 5.3 to 5.5 show the operation and administrative cost associated with the establishment of the facility.

Table 5.3. Cost of Equipment (Base year, 2002).

Item	Name and Description	Price (U.S. $)
1	Filler, scale, conveyors	5,000
2	Pump, flow control and line filter	7,363.18
3	Reagent supply tank with pump	5,000
4	Washing centrifuges	55,000
5	Water receiving/settling tanks with pumps	12,786.07
6	Refined oil dryer with vacuum system	24,825.88
7	Dry oil discharge pump with cooler	12,885.57
8	Instrument and electrical control panel	14,875.62
9	Valves, piping, fittings, insulation	10,000
10	Electrical cable, conduit and starters	4,875.62
11	Main and distribution circuit breakers	10,000
12	2 Oil storage tanks	44,776.12
13	Quality control laboratory equipment	24,776.12
14	Steam boiler	69.651.74
15	Water and sewage treatment systems	25,000
	Total FOB point of manufacture	**$326,815.92**
	Transportation and insurance	$100,000
	Total CIF destination	**$426,815.92**

Source: Own calculations with established quantities and prices.

Table 5.4. Utilities Per Month (Base year, 2002).

Name	Water M^3/h 30^0C	Total Cost/month U.S. $ ($1.46/m^3$)	Electric power Kw/h	Days/ month	Total /month Kw	Total cost/month U.S. $ (.09c/Kw)
			5.96		143.04	12.8736
Cleaning and	(30*8)		11.92		286.08	25.7472
classification area	240	350.4	29.84		716.16	64.4544
			11.92		286.08	25.7472
	(7*8)		29.84		716.16	64.4544
Desludger area	56	81.76	11.92		286.08	25.7472
				24		
	(7*8)		17.84		428.16	38.5344
Drying area	56	81.76	29.84		716.16	64.4544
			29.84		716.16	64.4544
	(1*8)		5.96		143.04	12.8736
Polisher area	8	11.68	5.96		143.04	12.8736
			17.84		428.16	38.5344
	(1*8)		14.9		357.60	32.184
Finished oil area	8	11.68	11.92		286.08	25.7472
			1.49		35.76	3.2184
TOTAL	**368**	**537.28**	**236.99**		**5687.76**	**$511.8984**

Source: Own calculations with established quantities and prices.

Table 5.5. Operation and Administrative Costs per 240 days (8 months) of Processing Limes, (base year, 2002).

Operation Costs		**Administrative Cost**	
Input	**Cost ($)**	**Concept**	**Cost ($)**
Raw Material	230,897.32	Office supplies	2,220.16
Direct workforce	18,471.79	Fuels and lubricants	4,440.32
Electricity	4,095.19	Equipment maintenance and repairs	2,324.16
Diesel	424,850.32	Indirect workforce	11,367.25
Metal Containers	6,335.64		
Plastic Bags	3,206.91		
Water and sewer	4,298.24		
Equipment	426,815.92		
Subtotal	**$ 1,118,971.3**	**Subtotal**	**$ 20,351.89**
Total Cost of Operation: $ 1,139,323,19			

Source: Grupo Interdisciplinario Agroindustrial and own calculations with established quantities and prices.

5.5.4 Breakeven Point

In order to obtain the break-even point, it is necessary to classify costs into fixed and variable costs, as shown in table 5.6.

Table 5.6. Variable and Fixed Costs

Concept	Fixed Costs [a] ($)	Variable Costs [b] ($)
Raw Material		$230,897.32
Direct workforce	$18,471.79	
Indirect workforce	$11,367.25	
Electricity		$4,095.19
Diesel		$424,850.32
Metal Containers		$6,335.64
Plastic Bags		$3,206.91
Water and sewer		$4,298.24
Equipment	$426,815.92	
Depreciations and amortization	$122,807.74	
Office supplies		$2,220.16
Fuels and lubricants		$4,440.32
Equipment maintenance and repairs		$2,324.16
TOTAL	**$579,462.7**	**$682,668.26**

Source: Grupo Interdisciplinario Agroindustrial and own calculations.

[a] Costs that stay the same over a time period regardless of the level of output.
[b] Costs that vary directly with the level of output.

Table. 5.7. Contribution Margin and Break Even Point Calculations.

Variable	Per Unit	Quantity (kgs)	Combined (US$)	BEP Quantity	12, 480 MT/season
Selling price of Lime oil	14.33 $/kg	49,920	$715,353.6		
(+)Lime Peel	.62 ¢/kg	2,080,000	$1,289,600		
(=) Total Revenue			$2,004,953.6		
(-) Variable cost			$682,668.26		
(=) Contribution margin			**$1,322,285.34**	**.438228 (conversion)**	**$579,462.7**
(-) Fixed cost			$579,462.7		(-) $579,462.7
(=) Operating Income			**$742,822.64**		**$ 0**

Source: Own calculations with established quantities and prices.

As illustrated in table 5.7., the break-even points for quantities of limes and total revenue are more than satisfied by the new lime oil facility. Thus, we can conclude that producers have a good chance of succeeding in this business, obtaining profits from the sources that were previously considered production waste. Moreover, the results from the financial analysis indicate that introducing the dehydrated peel in the local market would also be very profitable.

Total revenue from both products (lime oil and lime peel) to break even must cover total costs (fixed plus variable), or $1,262,130.96. Since these final products are extracted from the raw product of fresh limes, the break even quantity of fresh limes to be processed, given the stated conversion factors, is 5,469.09 MT [.438228 x 12,480 MT].

5.6 Implications of Results

Lime oil is a by-product of lime processing which has a variety of industrial uses. Mexico is currently the world's leading producer of lime oil, and interest in expanding this segment of agri-business has arisen.

Some of the strategies that the industry needs to follow in order to gain a better position in international markets and to increase the potential of this sector are:

- Increase the product image in all the countries where there is an actual preference or could be a potential market niche.
- Establish a designation of origin, as most of the products in the European Union have, in order to protect the region of Martinez de la Torre and to obtain a better price in international Markets.

Mexico has optimal weather conditions in the producers' regions, in addition to the infrastructure necessary to increase the National supply and exports requirements of lime oil. It is necessary, however, that the industry receives good policy and financial support from the Mexican government and financial institutions. If those goals are attained, then the results will show improved incomes for producers and higher total revenues in the rural areas.

Besides the economic benefit to the region, this business can contribute to control the drastic decreasing in prices of fresh limes during the peak seasons. The overproduction could be used as raw material for the lime oil industry, which can transform the limes into a new, value added product. Complications in establishing lime oil processors arise because many of the farmers are not aware of the economic potential of differentiating between limes for export use and industrial uses. Thus, the prices of the Persian limes sink when the farmers are competing

against overproduction in the state as well as the production of "key limes" from other states in the country (SAGARPA, 2006).

If these obstacles can be overcome, not only will the farmers be better off, but others in the region will also benefit. This project will be able to add at least 20 jobs permanently to the regional economy and about 100 more indirectly, along the entire chain; farmers, producers, packers, brokers, professionals, retailers (Agroindustrial G.I., 2002).

5.7 Conclusions

This study has examined some of the opportunities associated with expanding lime oil production in Mexico, and has found that this venture is a good investment opportunity for producers. The benefits to Mexican farmers from intensifying the production and processing of lime oil include the use of a percentage of the yield per year that is not available to export. In the extracting oil process, there exists another benefit for producers; with the same machinery, it is possible to use the peel from the fruit. This by-product, dehydrated lime peel, can generate revenues in national markets, mainly as feed for cattle.

Finally, producers can specialize in the production and commercialization of this product, generating good revenues in the short run and positioning the product as competitive as some other producing countries; avoiding in the long run the complex and large chain of intermediaries that normally retain most of the profits like in the case of fresh fruit. It would therefore, be good for the region of Martinez de la Torre to invest in lime oil production.

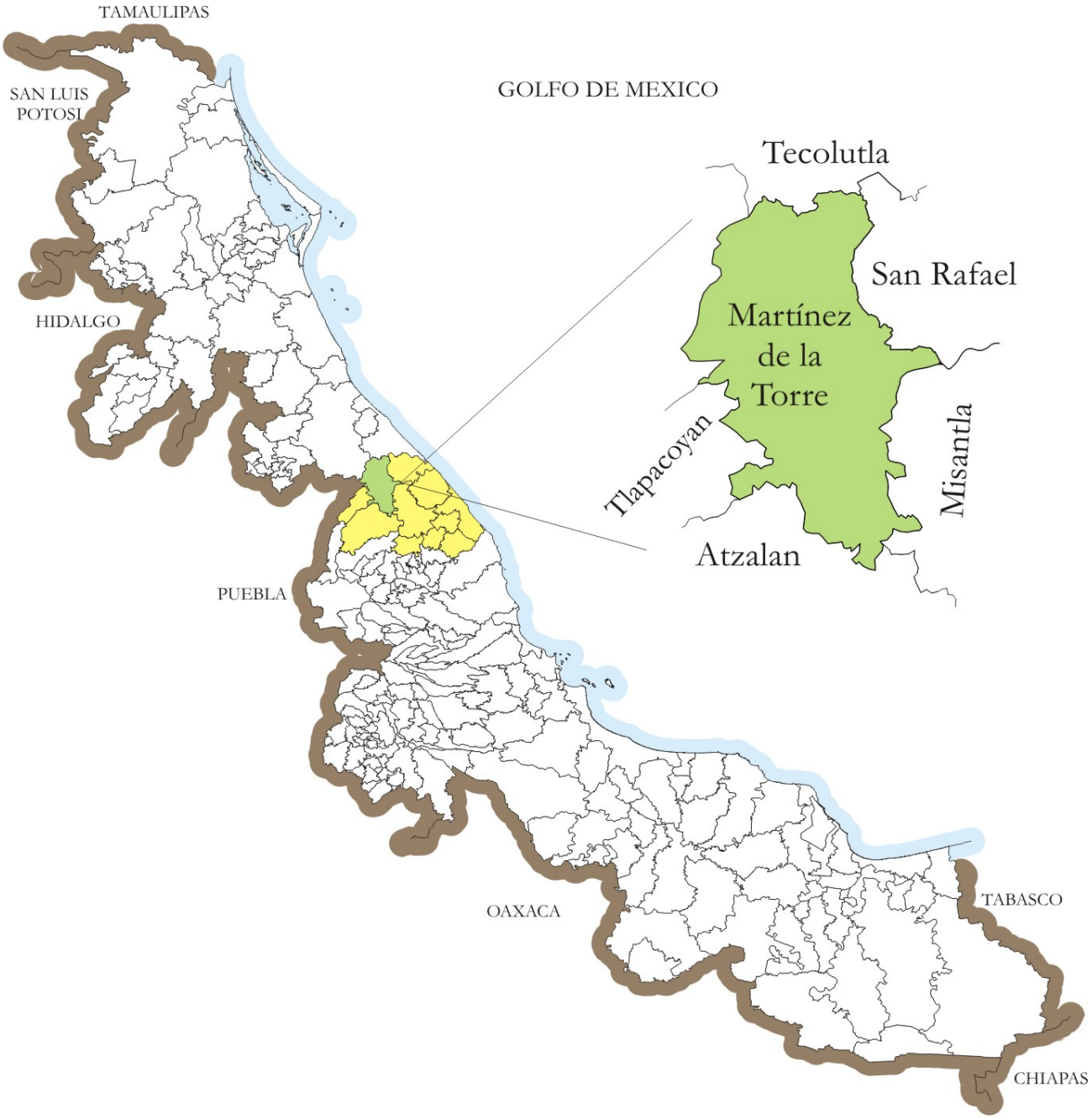
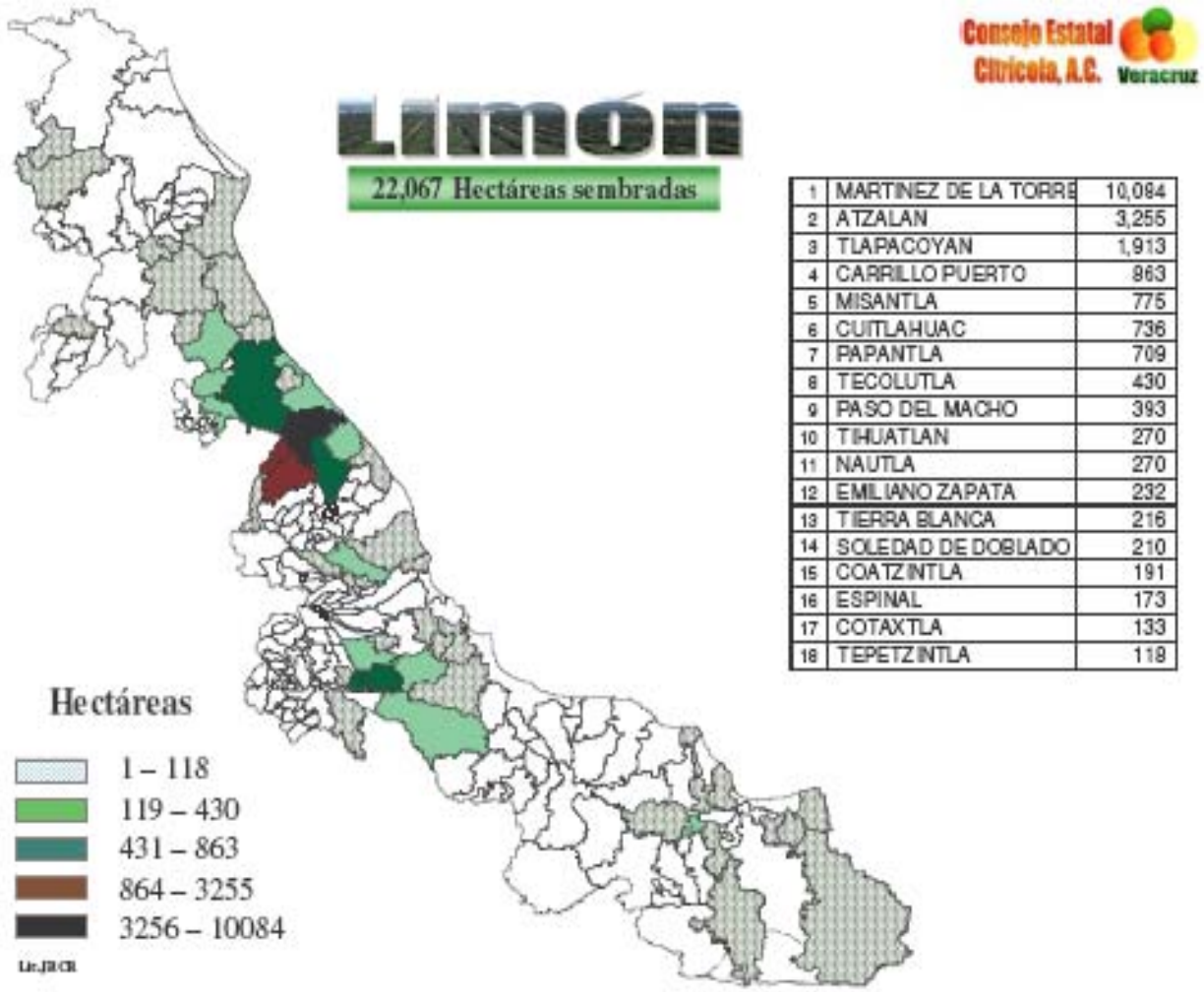


Figure 5.1. Martínez de la Torre Geographical Location



Source: Consejo Estatal Citrícola, Veracruz, México 2005.

Figure 5.2. Total Cultivated Hectares of Land in Veracruz, (22,067 Ha)

CHAPTER 6

SUMMARY, CONCLUSIONS AND IMPLICATIONS

6.1 Summary

This analysis of the factors affecting the supply and demand for limes and lime oil in the U.S. with implications for development in Veracruz State Mexico was undertaken due to problems had by local producers in Mexico. These problems primarily revolve around a lack of information in different areas like, production efficiency, seasonality, variability of prices, price control from external agents, weak industry chains and infrastructure. This paper aims to provide this type of information by analyzing many variables in three different aspects of the industry; first the lime industry as a whole, then one of the by-products obtained from limes and which has great potential in international markets, and finally a case study for one of the regions in Veracruz State where the production of one variety of lime is the main economic activity for producers.

The analysis performed in this thesis has shown that price, quality of the fruit and suboptimal production quantities are affecting supply and demand for limes and lime oil in the U.S. with correspondent effect for local producers in Veracruz State. Implications of this research suggest that in order for fresh limes production in Veracruz to yield increasing benefits to the local economy it is necessary for the region to make some efforts to increase production efficiency. Additionally, in order for lime producers in Veracruz to repeal competition from Central and South America, producers need to invest more money in infrastructure, to improve information transfer among them and to improve data analysis during each harvesting season.

Demand in the U.S., E.U., Japan and other developed nations is growing fast so if Mexico can revitalize the production networks, organize producers to avoid the problems associated with a lack of information, then the lime industry in Mexico could yield more benefits for the people leaving in the citrus regions.

6.2 Conclusions

Given the information provided, the demand for limes has a tremendous potential for revenue growth for Mexico. The possibilities for the Mexican lime industry seem to be great and also for the rural development in the associated states of production. The consumer demand for limes in the U.S. indicates that this product will continue have great acceptance among the U.S. population, at least partially because of the expansion of Latino communities all around the country in big cities, such as Los Angeles, Chicago, San Francisco, Atlanta, Houston, and others. Also, because of the substitution that most Americans consumers would do when prices for lemons are higher in the market, mostly in the winter time (CONCITVER, 2006).

As mentioned before the fact that the U.S. production of limes was destroyed by natural disasters and that most of the domestic citrus industry is now concentrated in the production of oranges, grapefruit and other kind of tropical fruits, has created a good opportunity for Mexican producers to sell their products in international markets and keep a significant piece of the market share in the U.S.

Moreover, the expected growth in demand for lime oil shows potential for Mexico. As shown in previous chapters, the future looks bright for the Mexican lime oil industry. However, recall that lime oil is a by-product. Other considerations are in order, namely, the economic feasibility of increasing the production of fresh limes, and where to divert other byproducts such juice and pulp.

The means of developing and expanding this processing industry involve lime production, assembly, processing, marketing, distribution, and financing, all of which affect the rural economies of Mexico in complicated ways. Of prime importance are the enhanced opportunities for producers and laborers at all skill levels.

This study has examined some of the opportunities associated with expanding lime oil production in Mexico, and has found that this venture is a good investment opportunity for producers. The benefits to Mexican farmers from intensifying the production and processing of lime oil include the use of a percentage of the yield per year that is not available to export. In the extracting oil process, there exists another benefit for producers; with the same machinery, it is possible to use the peel from the fruit. This by-product, dehydrated lime peel, can generate revenues in both national and international markets, mainly as feed for cattle.

This analysis was limited to a portion of the overall question regarding the feasibility of expanding the Mexican lime industry in general and lime oil in particular. The lime oil segment shows great promise. Future research needs to address the remaining questions. It is important to note that producing Mexican lime oil is a much more encompassing process than finding alternative enterprises for farm producers.

Finally, producers can specialize in the production and commercialization of this product, generating good revenues in the short run and positioning the product as competitive as some other producing countries are, in the long run, avoiding the complex and large chain of intermediaries that normally retain most of the profits like in the case of fresh fruit. Therefore, it would be good for the region of Martinez de la Torre, Veracruz to continue investing in limes and its by-products.

6.3 Implications

Citrus fruits are consumed more than any other fruit crop in the country, fresh fruits and juices combined. Average per capita consumption for 2004 was: 78.8 lbs of sweet oranges (86% as juice), 7.9 lbs of grapefruit (48% juice), 6.7 lbs of lemons (54% juice), 2.6 lbs of limes (28% juice), and 3.9 lbs of tangerines (28% juice). Unlike most other citrus fruits for which consumption remains constant, consumption of limes has increased (Rieger, 2007).

México has optimal weather conditions in the producers' regions, in addition to the infrastructure necessary to increase the National supply and exports requirements of limes and lime oil. It is necessary, however, that the industry receives good policy and financial support from the Mexican government and financial institutions. If those goals are attained, then the results will show improved incomes for producers and higher total revenues in the rural areas.

Lime oil is a by-product of lime processing which has a variety of industrial uses. Mexico is currently the world's leading producer of lemon-limes crops and lime oil, and interest in expanding this segment of agri-business has arisen.

Besides the economic benefit to the region, this business can contribute to control the drastic decreasing in prices of limes during the peak seasons. The overproduction could be used as raw material for the lime oil industry, which can transform the limes into a new, value added product. If the obstacles mentioned above can be overcome, not only will the farmers be better off, but others in the region will also benefit.

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