PESTICIDE REGULATION DIFFERENCES OF THE U.S., CHILE, AND MEXICO ON IMPORTED BERRIES

Presented to the

Faculty of the Agribusiness Department

California Polytechnic State University

In Partial Fulfillment

of the Requirements for the Degree

Bachelor of Science

by

Kayla Felicia Gardener

June 2013

APPROVAL PAGE

TITLE: PESTICIDE REGULATION DIFFERENCES OF THE U.S., CHILE, AND MEXICO ON IMPORTED BERRIES

AUTHOR: Kayla Gardener

DATE SUBMITTED: June 2013

Marcia Tilley ______________ __________________________

Senior Project Advisor Signature

Abstract

Growing consumer demand for knowledge in the area of food safety and producer accountability on what is applied to fresh produce is resulting in a greater need for transparency in the industry. Additionally, the demand for safe, fresh produce year round has led to extensive international trade and consumers to wonder if imported produce is of the same quality of that in produced in the U.S. The study analyzes the differences and similarities between pesticide application tolerance standards, and labels for applied use on berries produced in the U.S., Mexico, and Chile. This is done by reviewing tolerance information and criteria from governmental agencies that regulate pesticide use levels and individual pesticide labels from each country to determine the comparative level of standards. The results indicate equal regulations for Mexico-produced and exported tolerance levels on berries compared with U.S. numbers in and even longer wait periods following pesticide application before harvest. Meanwhile, Chilean pesticide regulations showed even higher standards on pesticide residue levels for berries, but still shorter harvest wait periods compared with the U.S. The study provides an interesting looking into international standards for fresh berries and how the industry is evolving to meet consumer demand for quality assurance and safety.

TABLE OF CONTENTS

LIST OF TABLES

Chapter 1

INTRODUCTION

Food safety is becoming more and more important, as demonstrated by the newly passed Food Safety Modernization Act of 2011. U.S. food producers and processors will be more heavily regulated by the federal government as to how they meet these newly established standards. While many producers have been implementing industry-based standards for years, specifically top California berry producers like Red Blossom, Driscoll's, Nature Ripe, and California Giant (Aliotti, 2010), the issue of food safety is growing in importance. These standards in turn specify limitations and guidelines for crop inputs and their application, for example berry pesticide application of active ingredients.

The dangers of using pesticides are not only environmental and potentially adverse health effects on the laborer and consumer, but also inconsistent application between countries. Required pesticides are not always available in the same form in each country and may be applied differently during production, depending on recommended use labels and local requirements (Lichtenberg, Spear and Zilberman, 1993). The ratio of active ingredients can differ in foreign countries on produce and lead to infractions with U.S. laws on imported crops. Additionally, the standard inspection systems required in Mexico or Chile may vary with those applied in the U.S. as shown by Nganje et al, (2009) which makes it harder to find consistent standards.

Problem Statement

Are imported berries from Chile and Mexico required to the U.S. meet local pesticide regulations mandated for domestic producers, in terms of field re-entry periods and percentage of an active ingredient applied? Are the regulations from these countries more lenient than U.S. food safety standards?

Hypothesis

Imported berries with pesticides applied in Mexico will have 10% shorter harvest wait periods and 15% higher active ingredient use allowances than U.S. domestic food safety requirements on the same product. Chilean berries will have 5% shorter harvest wait periods and 10% higher use allowances for the same active ingredients compared to U.S. domestic food safety requirements.

Objectives

1) To determine if country the crop is grown in, or the importing country's standards need to be met first in pesticide application and use for Chilean and Mexican grown berries.

2) To identify key differences between Chilean and Mexican pesticide limits from those enforced in the U.S. on domestic product.

3) To assess if there is a strong adverse affect in terms of food safety, resulting from differences found between U.S., Chilean, and Mexican grown berries.

Justification

The growing emphasis on food safety following the successfully passed Food Safety Modernization Act (2011) places additional motivation on U.S. berry producers to meet industry standards on the national level. On a local level, the Santa Maria Valley and the Central Coast produce about two-thirds of the California strawberry production, which makes up over 80% of U.S. consumption and about 20% of total world consumption, per the National Science Foundation Center for Integrated Pest Management "Crop Profile on California Strawberries" (1999). In 2011, California alone produced 2.3 billion pounds of harvested strawberries for a value of $2.4 billion, according to researchers with the Nonfumigant Strawberry Production Working Group (2013). According to the USDA National Agricultural Service (NASS) in 2012 alone the U.S. produced $44,520,000 in blackberries and $239,820,000 in raspberries. However, the USDA Economic Research service also reports that in the year 2011 alone, the U.S. imported 394,180,000 lbs of Strawberries from Mexico. While in 2011 Chile's exported $11,350,000 in berries to the U.S., its third largest importer after China and the European Union according the USDA Foreign Agricultural Service (2013).

The increasing national standard in the U.S. and its growing export market in turn calls into question whether or not key berry exporters, like Mexico and Chile, will have to meet these standards for pesticide application. Differences in domestic standards as well as overall product availability can affect what is applied and accepted in various countries. This can lead to either superior or inferior produce being imported and produced in the U.S. A comparative analysis of U.S. Chilean and Mexican pesticide regulation may offer a clearer view into the overall food safety equality between countries and it how it can negatively impact U.S. consumers and producers.

Chapter 2

REVIEW OF THE LITERATURE

Associated Food Safety Risk

Conventional agriculture, particularly crops like berries with short production times, relies on pesticides for efficient and effective elimination of crop-destroying pests. Lichtenberg, Spear, and Zilberman (1993) point out the alternative can be damaged, unsalable crop, which lowers in production and revenues. However, this widespread pesticide use in agriculture faces three major drawbacks: environmental effects, employee health, and product safety for consumers. For the purposes of this study, the focus will remain on current pesticide use and regulation and how it relates back to these key factors. Specifically, post-pesticide re-entry periods are important for harvest worker health, to minimize illness and hospitalizations as well as maximize producer revenue with optimal harvests per Lichtenberg, Spear and Zilberman (1993).

In terms of consumer safety, the U.N.'s Food and Agriculture Organization with the World Trade Organization (2003) emphasize the dietary risks of pesticide consumption in an analysis from an annual meeting. The study assesses a variety of commonly used pesticides' short-term effects on international consumption in the U.S., Japan, and several European countries. The chemical compound, Bifenthrin shows the highest percentages of Acute Reference Doses (ARfD) and is used mostly commonly on berries. While the meeting had little information on actual toxicity levels, it is clear that berries make up part of the highest levels of consumer exposure and consumption of pesticides. The researchers emphasize the study provides a good economic starting point for future policy, but forms only a portion of what needs to be considered. Meanwhile, Suhre (2000) clarifies the amount of residues found in foods are determined by additional variables including: application rate, frequency of application, interval from last treatment to harvest, percentage of crop treated, weather conditions, and post-harvest processing of the treated crop.

U.S. Requirements

Suhre's (2000) analysis, reacts to the 1996 Food Quality Protection Act (FQPA), however, he provides some strong feedback for the pesticide tolerance level changes that will come about following the recently passed Food Safety Modernization Act (2011). Specifically, he notes the Delaney Clause as part of the early legislation (an amendment to the 1954 Federal Food Drug and Cosmetic Act) which recognizes both the benefits and risks associated with pesticides should be taken into account in setting tolerance levels for raw commodities. Suhre (2000) isolates the most effective ways to determine and set pesticide tolerance levels by following both probabilistic and worst-case-scenario assessments. Probabilistic includes normal supply chain treatment and processing for the product and worst-case-scenario assessments highlight possible risks for the consumer outside of Good Agricultural Practices (GAP) and Best Management Practices (BMP). These methods of testing are still used today by both industry people and federal governments to set Maximum Residue Levels (MRLs).

The Food, Conservation, and Energy Act (2008) set forth requirements for the enforcement of pesticide application (and other FDA food safety recommendations) through of third party auditors to inspect and certify; this includes both private sector as well as foreign import certification. The Food Safety Modernization Act (2011) under Title III, Section 301 imports will be required to meet U.S. compliance requirements no later than 18 months after the date of enactment. While this may seem a little delayed in its requirements, it is important to note that the requirements enforced by the act are actually legislating what has become, or will become industry-standards. This includes food safety elements like supplier verification of inputs including pesticides in the form of letters of guarantee so there is a clear supply chain and proof the producer will follow GAPs. Once this is implemented, specific pesticides use, application, and post-harvest intervals will be easier to track and build more accountability between each level of production.

In terms of U.S. production, NSF (1999) put together an informative "Crop Profile on California Strawberries," which includes everything from top producing regions to production methods and main chemicals used. The overview mentions top chemicals used for soil fumigation including methyl bromide and chloropicrin which are applied two weeks prior to planting. A 4-year phase out of methyl bromide is also mentioned due to environmental concerns by the year 2005, but the phase out could lead to increased prices in the following decade. Unfortunately, the crop profile was not updated with current replacements, but seems to be something the industry is still working to effectively replace.

On a local level, the California Department of Pesticide Regulation has recently developed the "Nonfumigant Strawberry Production Working Group Action Plan" in order to develop alternative pest regulation for the industry. The plan describes how methyl bromide is actually still allowed under certain "critical-use" exemptions in California, although it may expire in 2015. Following this ban, however most current alternative pesticide measures have been relatively unsuccessful due to limited sample sizes and funding. This in turn has led the researchers to focus on breeding for disease resistance in strawberries as well as developing soil management techniques to better protect against soil borne pathogens. The action plan also describes methods for promoting and educating California strawberry growers with new Nonfumigant techniques and practices as they become available. The group advises both on-farm training and online resources through the coordination of groups like the California Strawberry Commission, UC Cooperative Extension, and UC Integrated Pest Management. Following the plans for implementation the group also presented its findings based on the preliminary test areas of: anaerobic soil disinfestation, biopesticides, biofumigants, plant breeding, soilless substrate, steam (for disinfestation), and solar energy (trapped to kill soil borne organisms). While there is still extensive research needed to follow up on each of these areas to determine overall feasibility for strawberry growers, the action plan provides the industry with some much needed direction and foundation for that research and adoption of pesticide alternatives. With this in mind, this study will focus on the impact of the more traditional pesticides still in active use in the local industry and abroad for a clearer understanding on the present state of the strawberry industry, in the U.S., Chile, and Mexico.

International Implementation and Trade:

Burnquist, Shutes, Rau, Pinto de Souza, and Nunes de Faria (2011) analyzed pesticide MRLs for several different commodities including: apples, bell peppers, pears, and tomatoes, produced in select countries around the world and compared to the European Union. This shows how trade effects national regulations compared with imports, specifically how MRLs can vary from country to country along with chemical availability and application guidelines. Further cross-country analysis is done in Thorbek and Hyder's (2006) which compares food safety standards set by the USA, European Union and Codex using a statistical algorithm of "threelayer perceptrons" to analyze the relationships between residue limits and properties of active ingredients. The authors also bring up a key point of pest and disease prevalence in regions affect MRLs, as the level of impact a pest has on region's crop helps determine the strictness of local regulation. This explains why U.S. tolerances were so much higher than those of the E.U. Therefore, this same principle can be applied when comparing U.S. berry production to that of Chile and Mexico, where threatening pests and diseases could be more prevalent. The study lacks some key variables such as application rate, number of applications, and pre-harvest intervals (re-entry/wait periods after last pesticide application before harvest).

On a more isolated level, Williams and Shumway (2000) analyze "Trade Liberalization and Agricultural Chemical Use: U.S. and Mexico" through econometric estimation and simulation to determine the effects of NAFTA, economic growth, research investment, and farm policy on pesticide use. The study isolates input use on several agricultural sectors: vegetables, fruits, food grains, livestock feeds, and other field crops, as well as meat animals and other livestock for potential changes in real farm income and estimated total fertilizer and pesticide use. By focusing on the results from fruit production and the analysis of pesticide use, the study shows a pesticide price negative elasticity of -0.039 of U.S. fruit and a pesticide use elasticity of fruit price of 0.071 in the U.S. Meanwhile, Mexico's quantity of fruit showed a positive response to pesticide prices and a negative responsiveness between pesticide quantity and fruit prices. While the study does not include commodity-specific data, it provides a good starting point to analyze the current trends in expanded trade between the U.S. and Mexico, which show increased trend of chemical pesticide usage. Nganje et al. (2009) discusses the effectiveness of FDA border inspections to find hazards associated with produce imported from Mexico. The use of Threat, Vulnerability and Consequence Prevention (TVCP) isolates key areas of risk in the supply chain. The study determines the most effective means of monitoring risk and traceability is real-time intelligent technologies. These technologies use GPS and video cameras throughout the supply chain to track product's location and process stage. This conclusion is supported by surveys and comparison, followed testing six different areas of food protection, and includes the use of three risk detection tools utilized and developed by the USDA, FDA, and Department of Homeland Security. Overall, Nganje et al (2009) determine that transportation constitutes the greatest area of food safety risk, in produce from Mexico, as opposed to actual pesticide residues. This is good for the U.S. in terms of safety for pesticide comparison, however it still does not highlight whether or not the same standards of U.S. producers are being enforced.

The most in depth analysis of international compliance is seen in a recent study by Neff et al (2012) titled references increased fruit consumption in the U.S. with nearly half of the supply coming from imported crops and fairly low levels of testing to validate U.S. MRLs are met, in relation to domestically grown produce. Their research is quite extensive, analyzing differences in MLRs from key export markets including: apples and grapes from Chile, oranges from Spain and Italy, and melons from Guatemala, Honduras, and Costa Rica, among others. The chemicals with the highest potential to exceed U.S. MLRs and still be imported and consumed are then analyzed in terms of their potential health effects to the consumer, as well as a side-by-side comparison of produce of concern from various health-based studies. The study compares the information with those from groups including the FDA and EPA, for imported commodities. Across the board grapes and apples were listed as out of scope with the MRLs most often, while blackberries and strawberries were noted as well. They recommend limiting this import risk by improving FDA assessment execution and improved cross-country analysis, and increased inspections. The study focuses on a broad U.S. consumption impact and potential sources of the big issues, however they do not consider the trends of food safety and MRLs of these countries or how to go about minimizing this risk in the short-run, as this study will.

In conclusion, the present state of the California strawberry industry and that of Mexico and Chile have the potential for vital differences in locally enforced standards. This study is meant to expose these key differences and how they affect consumers and producers, both foreign and domestic.

Chapter 3

METHODOLOGY

Procedures for Data Collection

This study isolates five active chemical ingredients of berry pesticides in the U.S. which when used under the label recommendations keep the crop within EPA issued tolerance levels for maximum residue levels (MRLs). The chemical ingredients include: Bifenthrin, Carbaryl, Chlorpyrifos, Malathion, and Methomyl. These pesticides are all used in the berry industry to kill insects, and will be hereafter referred to as insecticides. The specific commodities covered will include strawberries, raspberries, and blackberries, which each of these insecticides are used on. The time period of the study covers insecticide labels from the U.S., Chile, and Mexico from the past five years (2008-2013), in order to show any trends relating the international MRLs. A side-by-side comparison of insecticide regulations then utilizes Codex Alimentarius (the World Health Organization and the U.N.'s Food and Agriculture Organization standards for GAPs), E.P.A., and Mexican and Chilean national standards from the Foreign Agricultural Service (FAS) database for requirements and MRLs of these chemicals. This in turn isolates the leader in these insecticide requirements and helps to determine that the same standards are being applied across the international berry market.

With the chemical residue figures isolated, the use instructions provided on the insecticide labels are then compared using the following key variables, as listed on the use labels:

information stating suggested application rates, frequency of application (total amount applied per season), percentage of active ingredient in insecticide, and harvest wait period for the treated crop (also known as re-entry period). These use labels are provided by the EPA's Pesticide Product Label System (PPLS) as well as product manufacturer websites for Mexico and Chile. To compare insecticide usage in Chilean and Mexican berries to those in the U.S., the study identifies comparable chemicals with the same active ingredients used (at identical or near identical percentages) in those countries with what is available in the U.S. This is be done by analyzing international brands of chemicals as well as comparing the country of origin for the different brands.

Procedures for Data Analysis

The analysis of this data begins with analyzing MRLs provided by FAS to determine which chemicals meet the most standards. This is done by using a comparative table to present each of the variables and total the areas where the U.S., Chilean, and Mexican insecticides are in line with one another. For example, sample Table A, shown below, isolates the U.S. required MRLs for each commodity from the FAS for Bifenthrin and compares them to those set out by the Codex Alimentarius, and national standards from Chile and Mexico. The lowest MRL required will be presented in bold to show the industry leader in terms of acceptable levels.

Sample Table A. Bifenthrin MRL Regulations in Parts per Million (ppm) Prototype:

Crop	**EPA (U.S.)**	**Codex Alimentarius**	**Chilean Law**	**Mexican Law**

Blackberry	ppm
Raspberry	
Strawberry	

Source: Will be FAS MRL Database

With the use tolerances in mind, pesticides key variables are compared to show label-recommended use trends, these variables include: suggested application rates, maximum frequency of application, percentage of active ingredient used, and harvest wait period of the treated crop. The insecticide names, country(s) sold in, and year approved by the EPA will allow for further specification and analysis for each pesticide. Sample Table B, below shows how Bifenthrin's suggested use labels will compare between countries.

Sample Table B. Bifenthrin Labels Prototype:

Insecticide name	**Country(s) sold in**	**Year Approved**	**Application Rate**	**Frequency of Use**	**% Active Ingredient**	**Harvest Wait Period**

Source: Will be the EPA's PPLS

The tolerance data results will highlight regulatory standards enforced within these areas and help determine the strictest and most relaxed country for these approved berry chemicals. Meanwhile, the label information will show the actual pesticides in use as well as their country of origin and prove or disprove the related hypotheses.

Assumptions

This study assumes that pesticides, when applied according to use labels to 100% of the crop, and will result in residue levels within MRLs of the commodity's country of origin. As many of the chemicals are widely used, this study aims to isolate international differences in standards rather than the use of illegal amounts of pesticides applied.

Limitations

This study is limited by the number of key active ingredients it will analyze and compare due to the wide variety of pesticide on the market, both foreign and domestic. The methodology is developed to focus on use according to pesticide labels, as out of scope use cannot be effectively measured at this time on an international level.

Chapter 4

DEVELOPMENT OF THE STUDY

Data Collection Problems

During the data search, tolerances for the chemical Methomyl could only be found for use on strawberries in the U.S. EPA requirements (with an MRL of 2 ppms as of 12/12/12) and the Codex standards (up to 0.07 ppm as of 7/9/11). However no requirements for the insecticide were listed under the FAS database as from April- June 1st 2013. Due to these limited and out-dated results, the chemical is left out of further analysis as it is no longer approved for use on berries according to updated Codex records and inconclusive EPA regulations.

Analysis

MRL Tolerance Comparison

The data for the tolerance portion of the study is first collected for the actual active ingredient MRLs from databases including the FAS for the required for each country (as well as the Codex Alimentarius). The MRLs provide some reassuring results for U.S. exporters and consumers, which partially contradict hypothesis in terms of where the U.S. ranks in pesticide limitations between the three countries. The active chemical ingredients selected are available and used in each of the countries for use on berries in fumigation for pest control. The FAS database does disclaim that it does provide any indication of banned or non-existent MRLs, so for the purposes of this study, the (-) indicates that no requirements are available and further analysis will follow. Additionally, each chemical is compared in terms of its MRL for the three commodities, with tolerances lower than what is required in the U.S. shown in bold. It is important to note, that the FAS database stated that all Mexican MRLs provided, for these chemicals follow and enforce U.S. tolerances (under CRF 40 Part 180 Tolerances and Exemptions) as they are what are accepted in practice for imports and exports with the U.S. Similarly, when Chilean MRLs are not established they default to Codex tolerances, as shown in italics below.

The chemical Bifenthrin is one of the few cases in the study where the U.S. did not have the lowest MRLs in the case of strawberries. This gives Chile and the Codex a 33% stricter tolerance than the U.S. for this commodity and chemical combination and a 40% lower average for this chemical overall. Otherwise the results are uniform for this chemical and demonstrate consistency between the countries.

Table 1. Bifenthrin MRL Regulations in Parts per Million (ppm)

Crop	**EPA (U.S.)**	**Codex Alimentarius**	**Chilean Law**	**Mexican Law**
Blackberry	1	1	*1*	1
Raspberry	1	1	1	1
Strawberry	3	**1**	**1**	3

Source: USDA Foreign Agricultural Service (FAS). 2013. Pesticide MRL Database. Accessed May 29, 2013.

Due to relatively high MRLs for Carbaryl, Codex does not have any set tolerance levels for this chemical, and neither does Chile for blackberries here. The tolerances are otherwise equivalent and lack of ppms in this case prevents there from being a quantitative leader, therefore it can be assumed that the U.S. standards are the strictest here since Chile and Codex do not appear to restrict or outlaw the use of the chemical where tolerances are not present.

Table 2. Carbaryl MRL Regulations in Parts per Million (ppm)

Crop	EPA (U.S.)	Codex Alimentarius	Chilean Law	Mexican Law
Blackberry	12	(-)	(-)	12
Raspberry	12	(-)	12	12
Strawberry	4	(-)	4	4

Source: USDA Foreign Agricultural Service (FAS). 2013. Pesticide MRL Database. Accessed May 29, 2013.

The chemical Chlorpyrifos provides interesting results for blackberries and raspberries; according to the tolerances reported by FAS for the U.S. blackberry and raspberry ppms are based on “Food commodities” use for sanitation in food service establishments as they are the lowest tolerance levels allowed for the insecticide on these berries, and no further tolerances were included under CFR 40 . Further research of EPA requirements did not produce any additional tolerances for either blackberries or raspberries which keeps the tolerance levels in line with Codex. Therefore the U.S. and Mexico as well remain the leaders for the insecticide Chlorpyrifos with the lowest raspberry and strawberry tolerances compared with Chile.

Table 3. Chlorpyrifos MRL Regulations in Parts per Million (ppm)

Crop	EPA (U.S.)	Codex Alimentarius	Chilean Law	Mexican Law
Blackberry	0.1	(-)	(-)	0.1
Raspberry	0.1	(-)	0.5	0.1
Strawberry	0.2	0.3	0.3	0.2

Source: USDA Foreign Agricultural Service (FAS). 2013. Pesticide MRL Database. Accessed May 29, 2013.

Finally, Malathion show the second instance where Chile and Codex tolerances are lower than those accepted with U.S. strawberries, giving them an 87.5% lower tolerance for the commodity chemical combination. However, the lack of Codex standards for the other two commodities, and Chile for blackberries somewhat offsets this lead.

Table 4. Malathion MRL Regulations in Parts per Million (ppm)

Crop	EPA (U.S.)	Codex Alimentarius	Chilean Law	Mexican Law
Blackberry	8	(-)	(-)	8
Raspberry	8	(-)	8	8
Strawberry	8	**1**	**1**	8

Source: USDA Foreign Agricultural Service (FAS). 2013. Pesticide MRL Database. Accessed May 29, 2013.

As previously stated, since Mexico had identical standards with the U.S. according their published numbers by the FAS, this disproves the first part of the hypothesis which predicted that Mexico would have 15% higher active ingredient use than the U.S., in terms of tolerances. The lowest comparative tolerances between the U.S. (with Mexico) and Chile then are determined by taking the total available tolerances for Chile, taking the average, and then comparing it for those same commodities and chemicals in the U.S. Between the two, the U.S. has a total of 37.3 ppms divided by Chile's 9 tolerances gives them an average of 4.14 ppms, while Chile has a total of 28.8 ppms for the same 9 tolerances resulting in a 3.2 ppm average and 22.8% lower tolerances. Therefore, the hypothesis for Chile's comparative MRLs was off by 12.8%.

Insecticide Label Comparison

The insecticide labels were first chosen, according to the MRLs in the previous section, to represent accepted use on all three commodities, blackberries, raspberries, and strawberries. Data for this section is sourced from the EPA's PPLS and pesticide manufacturer websites and cross referenced on individual company sites for labels in Mexico, and those for Chile were double checked against the latest approved pesticides, released May 20th, 2013 by Chile's Ministry of Agriculture. Unfortunately, label recommendations for all of the commodities were not available on each individual insecticide; therefore the study is limited on crop comparison and more focused on differences between countries. This is particularly evident with the number of approved labels found for the insecticide Chlorpyrifos, which has significantly smaller tolerance levels as seen on Table 3 of the previous section which has resulted in more limited insecticide use.

In terms of application rates and frequencies, this refers to the maximum recommended use, while 'ai' amount of active ingredient which should be applied. A column has also been added to each of the tables differentiate use instructions on an applicable crop basis, which was done by shortening the Year Approved column to simply "Yr." Additionally, the commodity acronyms below are as follows: BB stands for blackberries, RB for raspberries, and SB for strawberries. Several of the insecticides were first sourced from a list "Pesticide Guide for Northwest Berries" complied with the help of Oregon State University on the industry website Berries Northwest (2013) as a starting point, as well as Tattersall Agroinsumos (2013), a Chilean pesticide distributor that allows the user to search products on their website by active ingredient. The * on the tables below indicates that something is no longer included under the latest Chilean pesticide approval list (as of May 20th, 2013), whether it is for a chemical or crop under the approved use list.

The insecticides for Bifenthrin for U.S. and Mexico are both produced by FMC Corporation, Agricultural Products group, as Brigadier is the Spanish translation for Brigade. This helps to explain the identical maximum use requirements between the two on strawberries. Capture 10EC from Chile is a liquid-based insecticide and follows cc/ha on the label's dosage which was then converted into gal/acre for better comparison. While this difference in physical make up of the chemicals still limits some of the comparison, it is clear based on the percentages of active ingredient and applicable crops that it is used on the same level as Brigade WSB. Overall, the insecticides below appear range in accordance with their MRL regulations; however Chile had the shortest wait period for the percentage of Bifenthrin applied. This is interesting since Chile was the leader with MRL tolerances for the ingredient. That said, due to the irrigated application of the insecticide it is more likely to reach the insects faster. Nevertheless, Chile has a 33% shorter wait period for raspberries and a 60% wait period for Capture 10CE than the U.S. Surprisingly, Mexico had the strictest application rules in this case and clearly disproved the hypothesis in regards to harvest wait periods with a 7 day period before harvest. While this is partially due to a 1.3% higher concentration of Bifenthrin which does follow the theory in the first part of the hypothesis for Mexico's allowed active ingredient use. However it is still a 28% longer wait period compared to next longest period for U.S. strawberries.

Table 5. Bifenthrin Approved Labels:

Insecticide Name	**Country(s) sold in**	**Yr**	**Crop**	**Application Rate (ai/acre)**	**Frequency of Use (per acre/season)**	**% Active Ingredient**	**Harvest Wait Period**
Brigade WSB	U.S.	2009	SB	0.2 lb	0.5 lb ai	10%	5 days*
Brigade WSB	U.S.	2009	BB RB	0.1 lb	0.2 lb ai	10%	3 days
Brigadier	Mexico	2011	SB	0.048 lb	0.5 lb ai	11.3%	7 days
Capture 10EC	Chile	2010	RB SB	0.003 gal	4.28 gal ai	10%	2 days

Sources: EPA. Pesticide Product Label System (PPLS). Accessed June 3, 2013.
Servico Agricola y Ganadero, SAG. 2013 "Lista de Plaguicidas con Autorizacion Vigente." Inocuidad y biotecnologia: Plaguicidas y fertilizantes (Serie 1000).

Carbaryl proved to be the most uniform ingredient analyzed, as it is applied up to the same dose requirements for all of the crops under each insecticide. The label requirements for the U.S. and Mexico are dramatically stricter in terms of individual application rate, percentage of active ingredient, harvest wait period. Unlike the MRL comparison there is a clear divide between how much more exposure the crop is getting with Carbaryl 85 in Chile just before it is picked and packaged for consumption. As the * indicates, indicates that Carbaryl is no longer going to be approved for use on berries in Chile. Additionally, the list of canceled pesticides put out by Chilean authorities at the same time as included a powder application of Carbaryl, effective December 28th, 2013. According to the publication, that insecticide will continue to be available for the next two years, however it indicates a strong trend in limiting and preventing it's use altogether in the coming years, which should put Chile at the top for berry pesticide regulation in this case, despite the disproportional numbers shown below. Once again the harvest wait period hypotheses have been negated in this case due to equal requirements with Mexico and the 85.7% shorter period in Chile will soon no longer be effective.

Table 6. Carbaryl Labels:

Insecticide name	**Country(s) sold in**	**Yr**	**Crop**	**Application Rate (ai/acre)**	**Frequency of Use (per acre/season)**	**% Active Ingredient**	**Harvest Wait Period**
Carbaryl 4L	U.S. & Mexico	2011	All 3	0.217 gal	1.085 gal	43.4%	7 days
Carbaryl 85*	Chile	2009	All 3	0.016 gal	0.033 gal	85%	1 day

Source: EPA. Pesticide Product Label System (PPLS). Accessed June 3, 2013.

Servico Agricola y Ganadero, SAG. 2013 "Lista de Plaguicidas con Autorizacion Vigente." Inocuidad y biotecnologia: Plaguicidas y fertilizantes (Serie 1000).

Chlorpyrifos, which is produced by DOW Agrosciences was the most universally available with its Lorsban line of insecticides between the U.S. and Chile. Lorsban 4E is also approved by the EPA under the same specifications as Chlorpyrifos 4E-AG, for use on strawberries, the only key differences between it and the Chilean version is a 3.1% higher concentration and the method for applying it to raspberries instead of strawberries. These differences are further supported with Chile's higher MRL tolerances for Chlorpyrifos on these crops shown on Table 3. Meanwhile, Lorsban 75WG is one of the few Chilean insecticides which is labeled in terms of mass for its dosage and was then converted to pounds for clearer comparison. Although it, like Lorsban 4E is only approved for raspberries, the main difference between it and its Mexican and U.S. approved counter-parts is the 60% higher concentration of the active ingredient. This difference is made up in the actual application standards of the labels, but still leaves Chile with higher residue levels like their tolerances for the insecticide. The hypothesis for the Mexican wait period is once again proven false. Meanwhile, despite the period for Lorsban 4E coming in equal to the U.S.label, Lorsban 75WG is 5% shorter, the Chilean numbers are also impacted by the higher use of Chlorpyrifos.

Table 7. Chlorpyrifos Labels:

Insecticide name	**Country(s) sold in**	**Yr**	**Crop**	**Application Rate (ai/acre)**	**Frequency of Use (per acre/year)**	**% Active Ingredient**	**Harvest Wait Period**
Chlorpyrifos	U.S.,	2012	SB	2 lbs	4 lbs	44.9%	21 days

4E-AG	Mexico						
Lorsban 4E	Chile	2012	RB	0.006 gal	2.05 gal	48%	21 days
Lorsban 75WG	Chile	2012	RB	1 lb	2 lbs	75%	20 days

Source: EPA. Pesticide Product Label System (PPLS). Accessed June 3, 2013.
Servico Agricola y Ganadero, SAG. 2013 "Lista de Plaguicidas con Autorizacion Vigente." Inocuidad y biotecnologia: Plaguicidas y fertilizantes (Serie 1000).

Malathion shows the best example of globalization of all the insecticide analyzed between the three countries. The labels are identical for the U.S. with both Chile and Mexico, on nearly every level, with the exception of blackberries, which are no longer listed as approved for application of Malathion 57EC, per the recent Chilean approved chemical list (2013). Given these similarities, it is interesting that the U.S. has approved the use of two chemicals with such different harvest wait periods, only a 1% difference in concentration, and identical dosages of Malathion. The year these insecticides were approved does help to explains this as the wait period is longer on the 2012 approved chemicals. Due to these similarities, both hypotheses for Chile and Mexico wait periods are disproved.

Table 8. Malathion Labels:

Insecticide name	Country(s) sold in	Yr	Crop	Application Rate (ai/acre)	Frequency of Use (per year)	% Active Ingredient	Harvest Wait Period
Malathion 5 EC	U.S. & Mexico	2012	SB	2 lbs	8 lbs	56%	7days
Malathion	U.S. &	2012	BB,	2 lbs	6 lbs	56%	7 days

5 EC	Mexico		RB				
Malathion 57 EC	U.S. & Chile	2011	SB	2 lbs	8 lbs	57%	3 days
Malathion 57 EC	U.S. & Chile	2011	BB*, RB	2 lbs	6 lbs	57%	1 day

Source: EPA. Pesticide Product Label System (PPLS). Accessed June 3, 2013.
Servico Agricola y Ganadero, SAG. 2013 "Lista de Plaguicidas con Autorizacion Vigente." Inocuidad y biotecnologia: Plaguicidas y fertilizantes (Serie 1000).

Given the differences in harvest wait periods identified in for each insecticide above, Mexico had one label with 28% longer requirements 3 equal to the U.S. which averaged out to 7% longer harvest wait periods overall. This clearly disproves the hypothesis stating that Mexico would have 10% shorter wait periods, and gives the U.S. something to work towards with meeting its own tolerances for the insecticides. Chile on the other hand, was projected to have 5% shorter harvest wait periods after insecticide applications, had an average of 32% shorter periods, excluding the no longer relevant 85.7% shorter period from the Carbaryl comparison. This proves very interesting following the increasingly strict requirement for Chilean MRLs and limits on pesticide use compared to the U.S.

Chapter 5

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

Summary

Following the analysis it is clear that food safety, in terms of insecticide regulations and labeling between countries is more globally integrated than one might assume. The analysis of this study shows some variance in the level of pesticide standards between countries, specifically with the differences in MRL tolerances for the berry insecticides compared. These tolerances for individual countries are set by local authorities or based off of leading industry standards. This is seen clearly with the relationship between the U.S. and Mexico as well as Chile and the Codex Alimentarius suggested standards. Meanwhile pesticide labels were compared to find comparable, internationally accepted insecticides to compare for application and use differences.

Mexico matched each of the U.S. tolerances by following U.S. standards on pesticides for exported product, which disproved the first hypothesis that Mexico would allow higher active ingredient use than the U.S. The second portion of the study found longer harvest wait periods in Mexico by an average of 7%, and with the exception of the insecticide Bifenthrin had identical percentages of active ingredients with the U.S., therefore disproving both hypotheses for Mexico.

Due to limited application on blackberries and therefore fewer tolerances (9) to compare, however Chile ended up with 28% lower tolerances than the U.S. and disproved the hypothesis by about 13% for use allowances. For harvest wait periods on the other hand, Chile ended up with less strict tolerances than compared to U.S. berries by an average of 32%, which is 27% higher than was originally projected in the hypothesis. Additionally, the percentage of active ingredient use was equal to or higher than what was provided in the U.S. insecticides for each chemical. This also counters the assumption that many Americans have about less stringent regulations on Mexican and other foreign-grown produce from South America.

Conclusions

Pesticide tolerances in produce, particularly berries, are constantly evolving around the world as new research is completed and new chemicals and solutions are created within the industry and by governmental agencies. Additionally, the international demand for fresh produce year-round is met by the export markets for these countries with the productive growers using these insecticides, with synergy and standardized regulations in order to ensure uniform, safe produce. This study exemplifies the challenges that global producers and importing countries face in producing and selecting quality product, as well as how the need for global supply chains to meet the requirements of importing countries. Finally, the study really shows that U.S. consumers do not have much to worry about as one might assume with pesticides on their imported berries from Mexico and Chile after all.

Recommendations

While private companies and berry producers are unlikely to share industry secrets or specific insecticide use information, it would be interest to include the opinion of a certified Pest Control Advisor in each of these countries. This would help to determine which pesticides are most commonly used on berries in each particular area without having to dig through government databases, which might not even collect such information. Due to the difficulty and hours spent researching specific active ingredients is recommended to instead start with a specific pesticide company or brand of products, which are available globally, and then compare them and the tolerances for each country. It would also be helpful to identify which specific crops to study and compare later, as chemical use varies by country and then by specific crop, and it is not always guaranteed that commodities from the same crop group will all be approved with a specific pesticide.

Works Cited

Aliotti, Giovanni Gaspare. 2010. “An Analysis of the Producer Benefits of Traceability Systems with the California Fresh Strawberry Industry.” Unpublished Senior Project. California Polytechnic State University, San Luis Obispo. Project#48. pp. 20-22.

Bayer CropScience Chile. 2013. Productos: Insecticides. Accessed June 5, 2013.

Burnquist, H. L. ,Karl Shutes, Mary-Louise Rau, Maurício J. Pinto de Souza, and Rosane Nunes de Faria. 2011. “Heterogeneity Index of Trade and Actual Heterogeneity Index – the Case of Maximum Residue levels (MRLs) for Pesticides.” Paper Presented at the Agricultural and Applied Economics Association AAEA & NAREA Joint Annual Meeting, Pittsburgh. July 24-25.

DeFrancesco, Joe. 2013."Pesticide Guide for Northwest Berries: Insecticides/Miticides." Berries Northwest. Accessed June 3, 2013.

EPA. Pesticide Product Label System (PPLS). Accessed June 3, 2013.

FMC Agroquimica. 2011 Productos: Insecticides (Brigadier 0.3% G). Accessed June 3, 2013.

Food and Agriculture Organization (FAO) of the United Nations. 2003. “Dietary Risk Assessment for Pesticide Residues in Food.” Report of the Joint Meeting of the FAO Panel of Experts on Pesticide Residues in Food and the Environment and the WHO Core Assessment Group on Pesticide Residues, Geneva. FAO Plant Production and Protection Paper 176. September 15–24.

Lichtenberg, Eric, Robert C. Spear, and David Zilberman. 1993. “The Economics of Reentry Regulation of Pesticides” *American Journal of Agricultural Economics* (75: 4). Nov. pp. 946-958.

National Science Foundation (NSF). 1999. "Crop Profile for Strawberries in California." NSF Center for Integrated Pest Management: North Carolina State University. Raleigh.Oct. pp. 1-6.

Neff, Roni A., Jennifer C. Hartel, Linnea I. Laestadius, Kathleen Dolan, Anne C. Rosenthal, and Keeve E. Nachman. 2012. "A Comparative Study of Allowable Pesticide Residue Levels on Produce in the United States." *Globalization and Health* (8:2). Jan. pp. 1-14.

Nonfumigant Strawberry Production Working Group. 2013. "Nonfumigant Strawberry Production Working Group Action Plan." California Department of Pesticide Regulation (CDPR). Sacramento. Apr. pp. 1-18.

Nganje, William, Timothy Richards, Jesus Bravo, Na Hu, Albert Kagan, Ram Acharya, and Mark Edwards. 2009. "Food Safety and Defense Risks in U.S. –Mexico Produce Trade." *Choices*. (24:2).Apr. pp.16-20.

Servico Agricola y Ganadero, SAG. 2013 "Lista de Plaguicidas con Autorizacion Vigente." Inocuidad y biotecnologia: Plaguicidas y fertilizantes (Serie 1000).

Servico Agricola y Ganadero, SAG. 2013. "Listado de Plaguicidas Cancelados." Inocuidad y biotecnologia: Plaguicidas y fertilizantes. pp. 2.

Suhre, Francis. B. 2000. "Variability in Pesticides Residues - The US Experience." *Food Additives and Contaminants* (17:7). July. pp. 497-501.

Tattersall Agroinsumos. 2013. Catálogo de Productos: Agroquimicos/Insecticida. Accessed June 5, 2013.

Thorbek, P. and K. Hyder. 2006. "Relationship between Physicochemical Properties and Maximum Residue Levels and Tolerances of Crop-Protection Products for Crops Set by the USA, European Union and Codex." *Food Additives and Contaminants* (23:8). Feb. pp. 764–776.

Williams, Shon P. and C. Richard Shumway. 2000. "Trade Liberalization and Agricultural Chemical Use: U.S. and Mexico." *American Journal of Agricultural Economics* (80:1). Feb. pp. 183-199.

U.S. Food and Drug Administration. 2011. *Food Safety Modernization Act*. Washington, D.C. pp. 3953-3966.

U.S. Congress. 2008. "H.R. 2419: Food, Conservation, and Energy Act of 2008 (Farm Bill)." Washington, D.C. pp. 1823-7.

USDA. 2012. "Monthly U.S. imports of fresh and frozen strawberries from Mexico, 1980-2011." Economic Research Service (ERS) (Table 16).

USDA Foreign Agricultural Service (FAS). 2013. Pesticide MRL Database. Accessed May 29, 2013.

USDA Foreign Agricultural Service (FAS). Global Agricultural Trade System: Standard Query (Annual General Commodities Imported From Chile). Accessed June 2, 2013.

USDA. 2012 "National Statistics for Blackberries." National Agricultural Statistics Service (NASS).

USDA. 2012 "National Statistics for Raspberries." National Agricultural Statistics Service (NASS).