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Global Food Safety Regulations: A Comparative Analysis of U.S. and International growers´ responses to the Food Safety Modernization Act (FSMA)

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Abstract

Food safety is a relevant issue impacting public health, the economy, and social well-being. Safety Modernization Act (FSMA) has emerged as a crucial regulatory framework for ensuring safety of food internationally. The primary objective was to identify similarities and differences in compliance and the underlying factors influencing the adoption of food safety practices (FSP) among different farming groups. This project explored the comparative responses of U.S. and international farmers to the FSMA's Produce Safety Rule (FSMA-PSR) through a 40-question survey. An analysis of questions related to Food Safety was conducted for this project. The research findings revealed that FSMA-PSR coverage influenced the adoption of FSP, with covered farmers showing higher implementation rates. The income level also played a critical role, with higher-income farmers being more likely to invest in necessary technologies and training to meet regulatory standards. Additionally, while Produce Safety Alliance (PSA) training positively impacted FSP implementation, it was less influential than financial resources. Organic farming practices, although not directly linked to higher safety compliance, showed potential for enhancing food safety, especially when certified. Major barriers to implement FSMA-PSR included money and time for record-keeping, cleaning and sanitation, and personnel training. The study concluded that inclusive policies are necessary to provide equitable access to resources and training, particularly for lower-income farmers, to ensure broad compliance with food safety standards. These insights contributed to the understanding of agricultural food safety, offering valuable recommendations for policymakers and stakeholders in the agricultural sector.

Keywords: Agriculture, Growers, Produce Safety Rule, Public health, Survey.

Resumen

La seguridad alimentaria impacta la salud pública, la economía y el bienestar social. La Ley de Modernización de la Seguridad Alimentaria (FSMA) surgió como un marco regulatorio crucial para garantizar la seguridad alimentaria a nivel internacional. Este proyecto tuvo como objetivo identificar similitudes y diferencias en el cumplimiento de la FSMA, así como los factores que influyen en la adopción de prácticas de seguridad alimentaria (FSP) entre distintos grupos agrícolas. A través de una encuesta de 40 preguntas, se exploraron las respuestas comparativas de agricultores de EE. UU. y de otros países sobre la Regla de Seguridad de Productos Agrícolas de la FSMA (FSMA-PSR), y se analizaron preguntas clave sobre seguridad alimentaria. Los hallazgos mostraron que la cobertura de FSMA-PSR influye en la adopción de FSP, con los agricultores cubiertos mostrando mayores tasas de implementación. Además, el nivel de ingresos fue un factor clave: los agricultores de ingresos altos mostraron más probabilidad de invertir en tecnologías y capacitación necesarias para cumplir con los estándares regulatorios. Las prácticas de agricultura orgánica, aunque no asociadas directamente con un mayor cumplimiento de seguridad, mostraron potencial para mejorar la seguridad alimentaria, especialmente cuando están certificadas. Las principales barreras para implementar la FSMA-PSR incluyeron limitaciones de dinero y tiempo para registros, limpieza y capacitación. El estudio concluye que son necesarias políticas inclusivas que brinden acceso a recursos y capacitación, en especial para agricultores de menores ingresos, para asegurar un cumplimiento amplio de los estándares de seguridad alimentaria.

Palabras clave: Encuesta, FSMA, *Inocuidad, Productore*s, *Seguridad Alimentaria*

Introduction

Food safety is a globally relevant issue that directly impacts public health, the economy, and social well-being (Boys et al., 2015). In this regard, the Food Safety Modernization Act (FSMA) has emerged as a crucial regulatory framework for ensuring safety of food in the United States. According to Clements et ál. (2020), The FSMA Produce Safety Rule is a regulation designed to reduce the number of foodborne illness outbreaks associated with fruits and vegetables and establishes requirements for certain agricultural inputs domestically and abroad. Within this law, the Product Safety Rule (FSMA-PSR) plays a fundamental role, which sets specific standards and requirements for growers to prevent illnesses. Continuously improving food safety can have economic and social benefits in addition to reducing foodborne illnesses (NIFA, 2021). The FSMA-PSR established for the first time science-based minimum standards for the safe growing, harvesting, packaging and storage of fruits and vegetables grown for human consumption (U.S. Food and Drug Administration, 2023; United States Food and Drug Administration [USDA], 2023). (USDA, 2023) This comparison is relevant not only for its implications for global food safety but also for its implications for regulatory compliance, competitiveness in international markets, and agricultural sustainability.

Primarily, it is crucial to understand the context in which U.S. farmers operate under this regulation. The United States is one of the leading agricultural producers worldwide, with a highly diversified industry ranging from large commercial farms to small family farms (Drew y Clydesdale, 2015). The implementation of the FSMA has brought about a significant change in agricultural practices, with stricter requirements for monitoring, recording, and managing risks associated with food production. On the other hand, an analysis of the response of international farmers to this regulation revealed a broad landscape involving different socio-economic, cultural, and structural realities (Gizaw, 2019). Farmers outside the United States face unique challenges in accessing to resources, technology, and training to comply with international standards such as those established by the FSMA. This divergence in circumstances can have a significant impact on how international

farmers receive and adapt to regulatory requirements. The juxtaposition of U.S. and international perspectives will contribute to a thorough understanding of the global dynamics, thereby informing future regulatory strategies, and promotion international cooperation in ensuring the safety and integrity of the global food supply (Food and Drugs Administration [FDA], 2024a).

The main objective of this study was to identify similarities and differences in the responses of U.S. and international farmers to the FSMA-PSR, aiming to provide valuable insights for improving public policy, promoting good agricultural practices globally, and strengthening food safety. Through a detailed comparative analysis, the research seeks to assess the degree of compliance and understand the underlying factors influencing farmers' decisions and actions in both contexts. By exploring this crucial topic, the study contributes to both academic and practical knowledge on the FSMA-PSR Agricultural Product Rule, enhancing collective well-being through a deeper understanding of its impacts on diverse farming practices.

Materials and Methods

Location

The survey was conducted in the United States in collaboration with the Product Safety Alliance (PSA), USDA Economic Research Service, University of Vermont, University of Florida, and Cornell University on May 2022.

Population Sample

The survey was comprised of growers who participated in PSA Grower Trainings conducted between 2017 and 2020, These specific years were chosen to encompass growers who aligned with the compliance dates of the FSMA-PCR. A total of 705 growers participated in the study, representing diverse geographical regions. Specifically, 450 growers were from the USA, while 199 were from North America, Central America, South America, and Oceania combined. This geographical distribution ensured a broad representation across different agricultural contexts and regulatory environments.

Survey

The study utilized a comprehensive survey consisting of a total of 40 questions. These questions were structured into four sections: demographics and farm characteristics (Questions 4 to 18), focusing on the participant's background and farm specifics; food safety-related inquiries (Questions 18 to 27), cost-related queries (Questions 28 to 32), and market access considerations (Questions 33 to 36). A deliberate selection was made of five questions from the survey to focus the research on specific aspects relevant to the study's objectives (Table 1). The results were discussed based on the following categories: “covered “and “not covered”, referring to farms' covered status under the FSMA-PSR; Produce Safety Alliance (PSA) training versus no PSA training; income brackets: under $30,160, between $30,160 and $603,202, and above $603,202, representing total farm earnings; and organic practices: “no organic practice” versus “use of organic practices or certified”. These categories were chosen to provide a comprehensive analysis of the survey findings across

different regulatory compliance statuses, training backgrounds, financial capacities, and agricultural practices related to food safety and market access.

Table 1

Questions assessed in the survey.

No.	Questions
1	Have you implemented Produce Food Safety Practices (PFSP)?
2	Top 3 reasons implemented Produce Safety Practices (PSP)?
3	Produce Safety Practices that have been the most challenging to implement.
4	What barriers are growers facing?
5	To gain market access have you implemented Produce Food Safety Practices?

Data Collection and Database

The data for this study was gathered by The Northeast Center to Advance Food Safety (NECAFS) using the Qualtrics XM software. This software is widely known for its capabilities in conducting surveys and collecting data efficiently. By utilizing this technology, NECAFS was able to optimize the data collection process and ensure the accuracy and reliability of the information obtained from the growers.

The study involved comparing responses from U.S. growers who adhere to FSMA regulations with the responses of international growers. Using the survey to collect both qualitative and quantitative data on growers' perceptions, practices, commodities, and their adaptations to FSMA requirements. The study employed a comparative analysis of responses from U.S. and international growers to examine how different regulatory frameworks impact food safety practices.

Experimental Design and Statistical Analysis

Descriptive and explanatory statistical analysis was used to interpret the relationships and observed trends in the provided contingency tables. Descriptive statistics were employed to summarize the survey data, followed by chi-square tests with a 95% confidence level ($P \leq 0.05$). Additionally, Chi-square analysis was used to evaluate the differences between the categories evaluated in the US and international groups, as well as between US-only and international-only groups in the adoption of Produce Food Safety Practices (PFSP), with a significance level of 95% ($P<0.05$).This approach, combined with the initial descriptive and explanatory data analysis, allowed for a comprehensive interpretation of the survey results, identifying key factors influencing food safety practices among agricultural producers.

Results and Discussion

Survey Analysis

A total of 40 questions were completed in the survey. This document will analyze responses to questions regarding the implementation of food safety practices in production, challenges faced, and barriers encountered by growers. The specific questions to be analyzed include the implementation of food safety practices, reasons for implementation, challenges, barriers, and market access.

*Based on USA data only. Qu*estion 1 Have you Implemented Produce Food Safety Practices?

A significantly high proportion of growers both covered and not covered by FSMA, have implemented PFSP. However, growers with coverage have an implementation rate of 98.1%, while those without coverage have a rate of 92.2% (Table 2). This suggested that FSMA coverage may be associated with higher implementation of food safety practices. The difference in implementation rates suggests that producers covered may have more resources or incentives to adopt PFSP. According to (Tai, 2016), coverage can provide a financial safety net that allows producers to invest in improvements and meet food safety standards without the fear of significant economic losses in case of incidents. Additionally, insurance programs often link specific food safety requirements, which may oblige covered growers to comply with these practices. Regional and market factors may also influence PFSP implementation.

Growers in areas with greater access to agricultural coverage and more competitive markets may be more motivated to implement PFSP to remain competitive and meet buyer and regulatory expectations. Growers with Produce Safety Alliance (PSA) training and those without such training have high rates of PFSP implementation, with a minor difference between them. Growers without PSA training have an implementation rate of 96.4%, while those with PSA training have a rate of 94.8%. The slight difference in PFSP implementation suggests that PSA training may not be a determining

factor in the adoption of these practices. Other factors such as prior experience, risk perception, or resource availability may have a greater impact on PFSP implementation. Growers without PSA training who implement PFSP may be motivated by other incentives, such as market demand, buyer requirements, or their own perception of the importance of food safety. These producers may have adopted practices voluntarily or in response to local and national regulations (Overbosch y Blanchard, 2023). Both organic and non-organic producers have high rates of PFSP implementation, with a slight difference between them. In Table 2 non-organic producers show an implementation rate of 95.4%, while organic producers have a rate of 93.7%. Organic farming practices show a minimal impact on PFSP adoption rates compared to non-organic methods. Both groups are equally dedicated to PFSP implementation. Organic growers adhere to stringent standards, while non-organic producers are driven by market demands, regulatory compliance, and similar barriers and facilitators. The small difference in PFSP implementation rates between organic and non-organic producers suggests that farming practices do not significantly impact the adoption of food safety practices. Both groups face similar barriers such as cost and resource availability yet access similar facilitators like governmental support and educational resources promoting food safety.

Policy makers should ensure impartial access to resources and incentives for all growers to enhance food safety practices (Uddin y Bari, 2019). Income strongly influences PFSP implementation: < $30,160 earners at 89.6%, $30,160-$603,202 at 96.5%, > $603,202 at 99.2%. Higher incomes enable investment in technology, training, and compliance with food safety regulations. Access to advanced technology and subsidies aids compliance. Economies of scale reduce costs for larger operations. Governments and agricultural bodies should tailor support programs to lower-income producers, fostering collaboration with buyers for incentives and resources. Overall, financial resources crucially impact PFSP adoption, necessitating inclusive policies for equitable food safety enhancement across agricultural sectors.

Table 2

Question 1 Have you implemented Produce Food Safety Practices?

Category	Yes	No	n
Covered (A)	0.981	0.019	211
PSA training (B)	0.948	0.052	388
Not covered (B)	0.922	0.078	232
No PSA training (A)	0.964	0.036	55
Under $30,160 (A)	0.896	0.104	144
Between $30,160 - $603,202 (B)	0.965	0.035	171
Above $603,202 (C)	0.992	0.008	128
No organic practice (A)	0.954	0.046	348
Use organic practices or certified (B)	0.937	0.063	95

Note. Covered: farms' covered status under the FSMA-PSR. PSA training: Produce Safety Alliance. Under $30,160, Between $30,160 - $603,202: Above $603,202: total farm earnings.

Q2. Top 3 Reasons Implemented Produce Safety Practices

Meet FSMA Regulations

The analysis highlighted in Table 3, clear trends in food safety practice implementation, focusing on FSMA regulatory adherence. Those producers complying with FSMA exhibit a higher rate (85.5%) of food safety practice implementation, compared to 60.3% among producers. The regulations have a direct impact on operational decisions. Income levels also significantly impacted adherence to food safety practices. Producers earning less than $30K showed only 60.4% compliance, while those earning over $600K experienced a 28% increase, emphasizing that access to financial resources was crucial for meeting regulatory standards like FSMA. Despite 52.4% of non-PSA-trained growers implementing FSP, lack of specific training remains a potential barrier. Continuous education and specialized knowledge are critical for optimal food safety practices in agriculture (Clements et al., 2019). FSMA compliance and income levels are key influences of food safety practice adoption, with PSA training playing a crucial role in enhancing implementation. These findings underscore the

complex interplay of regulation, financial resources, and education in agricultural food safety (International Fresh Produce Association, 2024). Improving training in specific food safety practices could close observed gaps in implementation, especially among those who have not received specialized training.

Table 3

Question 2 Top 3 reasons implemented Food Safety Practices

Category	Yes	No	n
Covered (A)	0.855	0.145	213
PSA training (B)	0.766	0.234	351
Not covered (A)	0.603	0.397	237
No PSA training (B)	0.524	0.476	59
Under $30,160 (A)	0.604	0.396	147
Between $30,160 - $603,202 (B)	0.78	0.22	174
Above $603,202 (C)	0.784	0.216	129
No organic practice (A)	0.707	0.293	354
Use organic practice or certified (B)	0.61	0.39	320

Note. Reason to Meet FSMA Regulations. Covered: farms' covered status under the FSMA-PSR. PSA training: Produce Safety Alliance. Under $30,160, Between $30,160 -$603,202: Above $603,202: total farm earnings.

Maintain Market Access

Growers who received Produce Safety Alliance (PSA) training demonstrated significantly higher coverage of FSP (72.1%) compared to those without training (59.5%), indicating the critical role of PSA training in ensuring market access as shown on Table 4. Secondly, income levels impacted implementation, with lower earning groups showing lower coverage (36%) than higher earning groups (5.95%), highlighting financial constraints as a barrier to effective practice implementation. Thirdly, while organic practices alone do not directly correlate with higher coverage (50%), farmers using organic practices or certified methods show improved coverage (61%), suggesting a potential link between organic practices and effective food safety implementation for market access (Graves et al., 2019). Strategies aimed at enhancing PSA training availability, addressing financial barriers, and promoting organic practices could significantly support operators in maintaining market access

through robust food safety implementation. These insights underscore the importance of targeted training and support initiatives tailored to improve compliance with food safety standards, thereby safeguarding market access for producers across different operational and economic contexts (Wirth, 2023)

Table 4

Question 2 Top 3 reasons implemented Food Safety Practices

Category	Yes	No	n
Covered (A)	0.721	0.279	213
PSA training (B)	0.576	0.424	391
No PSA training (A)	0.595	0.405	59
Not Covered (B)	0.436	0.564	237
Under $30,160 (A)	0.368	0.632	147
Between $30,160 - $603,202 (B)	0.596	0.404	174
Above $603,202 (C)	0.757	0.243	129
No organic practice (A)	0.5	0.5	130
Use organic practices or certified (B)	0.61	0.39	320

Note. Reason: Maintain market access. Covered: farms' covered status under the FSMA-PSR. PSA training: Produce Safety Alliance. Under $30,160, Between $30,160 -$603,202: Above $603,202: total farm earnings.

Personal Commitment

In Table 5, the rate among the covered group was lower (48%) compared to the uncovered group at 0.754, indicating that personal commitment was higher where practices were not required. In contrast, groups without PSA training (A) were different than those with training (B) at (68%), suggesting personal commitment may have outweighed formal training (Food and Drugs Administration. FDA, 2024b). Lower income brackets (A, under $30,160) exhibited better adherence (0.792) than higher brackets (B, $30,160 - $603,202 at 0.567; C, above $603,202 at 0.514), underscoring personal commitment over financial incentives. Organic practices (A, none at 0.604; B, organic/certified at 0.667) related positively with adherence, indicating intrinsic motivation (Mata y

Bauer, 2024). Low coverage and absence of PSA training correlated with higher commitment, lower income predicted better adherence, and organic practices may have fostered dedication. These insights suggested prioritizing targeted training, financial strategies, and organic certifications to enhance operators' commitment to FSP.

Table 5

Question 2 Top 3 reasons implemented Food Safety Practices

Category	Yes	No	n
Covered (A)	0.48	0.52	213
Not covered (B)	0.754	0.246	237
No PSA training (A)	0.69	0.31	59
PSA training (B)	0.608	0.392	391
Under $30,160 (A)	0.792	0.208	147
Between $30,160 - $603,202 (B)	0.567	0.433	174
Above $603,202 (C)	0.514	0.486	129
No organic practice (A)	0.604	0.396	354
Use organic practices or certified (B)	0.667	0.333	96

Note. Reason Personal Commitment. Covered: farms' covered status under the FSMA-PSR. PSA training: Produce Safety Alliance. Under $30,160, Between $30,160 -$603,202: Above $603,202: total farm earnings.

Q3. Produce Safety Practice That Has Been Most Challenging to Implement?

Record Keeping

Record keeping as a challenge in the implementation of produce safety practices reveals significant differences across various producer categories. Growers covered by regulations fouind these practices more challenging (98.1%) compared to those not covered (92.2%), suggesting that regulatory requirements increase the complexity of record keeping as it has more information to keep as can be seen on Table 6. Similarly, producers without PSA training reported higher difficulties (96.4%) compared to trained ones (94.8%), indicating that training could mitigate these challenges (Tarnate, 2019). Growers that were not using organic practices also experienced greater difficulties (95.4%) compared to those using them (93.7%). Firstly, while training provides specific knowledge and

skills in agricultural produce safety, implementation of the training may face obstacles due to factors such as the complexity of regulatory requirements, the availability of work with resources for maintaining detailed records, and the time management needed to meet these demands (Fawell y Germida, 2012). Additionally, variability in the interpretation and application of regulations among different farmers and regions could also contribute to difficulties, even among those with formal PSA training. Moreover, income levels were strongly associated with the level of difficulty experienced, with producers in lower income brackets (<$30,160) being the most affected (89.6%), while those with higher incomes (> $603,202) reported the least difficulty (99.2%).These findings suggested that policies and support programs should focus on providing additional resources and specific training to regulated producers, those with lower incomes, and those without organic practices to enhance effective implementation of record keeping in agricultural produce safety.

Table 6

Question 3 Produce Safety Practice that has been the most challenging to implement.

Category	Yes	No	n
Covered (A)	0.585	0.415	213
PSA training (B)	0.611	0.389	391
No PSA training (A)	0.488	0.512	59
Not covered (B)	0.609	0.391	237
Under $30,160 (A)	0.575	0.425	147
Between $30,160 - $603,202 (B)	0.574	0.426	174
Above $603,202 (C)	0.643	0.357	129
No organic practice (A)	0.582	0.418	354
Use organic practices or certified (B)	0.649	0.351	96

Note. Practice Record Keeping. Covered: farms' covered status under the FSMA-PSR. PSA training: Produce Safety Alliance. Under $30,160, Between $30,160 -$603,202: Above $603,202: total farm earnings.

Wildlife and Domesticate Animals

Growers covered by FSMA PSA reported a lower proportion of success (36.1%) in managing wildlife and domestic animals compared to those not covered (48.0%), suggesting that regulatory compliance introduced significant challenges, potentially due to stricter standards and oversight requirements (Table 7). Also, growers with PSA training showed a slightly lower proportion of success (41.7%) compared to those without training (43.9%). While training appeared to offer some advantages in handling these challenges, the difference was not substantial, indicating that additional factors beyond training influenced effectiveness (Lysenko y Schott, 2018). Wildlife and domestic animals can introduce pathogens and contaminants into agricultural settings, potentially compromising food safety. Effective management practices could mitigate those risks, promising that produce remains safe for consumption. Regulatory agencfinancial resources, challenges in wildlife and animal management persisted. However, lower incomies impose standards and requirements to safeguard food production from biological hazards (Williams et al., 2021). Growers in higher income brackets (> $603,202) reported the lowest success rate (33.0%), indicating that, despite greater e brackets (< $30,160). Agriculture's economic viability. With successful management, practices could reduce production costs associated with pest control and mitigate financial risks (Harrison et al., 2013).

Table 7

Question 3 Produce Safety Practice that has been the most challenging to implement?

Category	Yes	No	n
Covered (A)	0.361	0.639	213
PSA training (B)	0.417	0.583	391
No PSA training (A)	0.439	0.561	59
Not covered (B)	0.480	0.520	237
Under $30,160 (A)	0.500	0.500	147
Between $30,160 - $603,202 (B)	0.433	0.567	174
Above $603,202 (C)	0.330	0.670	129
No organic practice (A)	0.425	0.575	354
Use organic practices or certified (B)	0.403	0.597	96

Note. Practice Wildlife and domestic animals. Covered: farms' covered status under the FSMA-PSR. PSA training: Produce Safety Alliance.

Under $30,160, Between $30,160 -$603,202: Above $603,202: total farm earnings.

Worker Health and Training

Growers covered by FSMA PSA reported a lower proportion of success (36.1%) in effectively implementing worker health and hygiene training compared to those not covered (48.0%) (Table 8). This suggested that regulatory compliance introduced significant challenges, potentially due to stringent requirements and enforcement (United States Department of Agriculture [USDA], 2021). Organic farming practices may have introduced additional complexities, including stringent hygiene standards and certification criteria, which may have presented challenges for producers maintaining consistent compliance. Income differences reflected varying capacities to invest in infrastructure, training, and technologies that support comprehensive worker health and hygiene programs (Crawford, 2019). Effective worker health and hygiene practices are fundamental to preventing foodborne illnesses and ensuring the safety of agricultural products consumed by the public. There was a significant difference in success rates between growers using organic practices or certified (40.3%) and those not using such practices (42.5%). This highlighted potential challenges specific to organic farming contexts, such as adherence to stricter hygiene standards and certification requirements. Prioritizing worker health and hygiene training in produce safety practices is essential

for advancing public health, regulatory compliance, and equitable agricultural practices. By addressing these challenges through targeted interventions and supportive policies, stakeholders can promote resilient and responsible agricultural systems that meet developing consumer expectations and regulatory standards (King, 2022).

Table 8

Question 3 Produce Safety Practice that has been the most challenging to implement?

Category	Yes	No	n
Covered (A)	0.426	0.574	213
PSA training (B)	0.346	0.654	391
No PSA training (A)	0.39	0.61	59
Not covered (B)	0.274	0.726	237
No organic practice (A)	0.347	0.653	354
Use organic practices or certified (B)	0.364	0.636	96
Under $30,160 (A)	0.255	0.745	147
Between $30,160 - $603,202 (B)	0.383	0.617	174
Above $603,202 (C)	0.4	0.6	129

Note. Worker health and hygiene training. Covered: farms' covered status under the FSMA-PSR. PSA training: Produce Safety Alliance. Under $30,160, Between $30,160 -$603,202: Above $603,202: total farm earnings.

Q4. What Barriers are Growers Facing?

The main barriers were money, time and knowledge (Table 9). Firstly, the categories with the highest scores in this barrier (Money) were Hygiene Facilities (0.41), followed by Field Water (0.37), and Cleaning (0.25).

This indicated that lack of financial resources was a significant barrier for establishing adequate hygiene facilities, managing field water, and maintaining effective cleaning practices. The second barrier was time. The categories that stood out here were Record keeping (0.57), followed by Cleaning (0.42), and Worker Hygiene Training (0.36). Time management is critical for maintaining accurate records, adhering to cleaning practices, and providing hygiene training to workers, and it was the most voted barrier, as Time for record keeping (Liu y Eaton, 2023). The third one was knowledge, the areas

with the highest scores in this barrier are Field Water (0.14), Cleaning (0.15), and Post Harvest Water (0.15).

The lack of specific knowledge on field water management and cleaning may limit producers. To address this, allocate resources to hygiene facilities, provide ongoing training, and invest in targeted educational programs, because continuous training in hygiene and cleaning techniques for workers are crucial (Narine et al., 2019).

Table 9

Question 4 What barriers are growers facing?

Category	Barriers				
	Money	Time	Knowledge	Mindset	Training
Hygiene Facilities	0.41	0.24	0.07	0.06	0.04
Amendment Testing	0.27	0.24	0.11	0.05	0.06
Wildlife	0.31	0.40	0.10	0.07	0.04
Field Water	0.37	0.33	0.14	0.05	0.07
Post Harvest Water	0.24	0.25	0.15	0.04	0.06
Cleaning + Worker Training	0.43	0.80	0.28	0.24	0.20
Record keeping	0.19	0.57	0.13	0.13	0.08

Q5. To Gain Market Access Have You Implemented PFSP to Access Markets?

Growers covered by FSMA showed a higher rate of implementing PFSP (48.7%) compared to those not covered (17.1%). This suggested that regulatory requirements significantly influenced the adoption of PFSP, potentially as a prerequisite for market entry (Table 10). Growers with PSA training had a higher implementation rate of PFSP (40.0%) compared to those without training (27.5%). This highlighted the role of training in enhancing awareness and compliance with safety practices necessary for market access. (National Library of Medicine, 1998). Compliance with PFSP enhances a

producer's competitiveness by meeting market demands for safe and high-quality agricultural products. Also, FSP implementation aligns with regulatory requirements, ensuring adherence to safety standards and facilitating smooth market entry and meeting PFSP demonstrates commitment to food safety, enhancing consumer trust and preference for products from compliant producers (Linton y McSwane, 2013). For organic practices, there was a small difference in PFSP implementation between growers using organic practices or certified (29.7%) and those not using them (36.4%). This indicated that while organic certification may involve additional safety standards, it does not significantly hinder PFSP implementation.

Table 10

Question 5 To gain market access have you implemented PFSP to access markets?

Category	Yes	No	n
Covered (A)	0.487	0.249	187
Not covered (B)	0.171	0.429	177
No PSA training (A)	0.275	0.383	40
PSA training (B)	0.400	0.284	324
No organic practice (A)	0.364	0.397	286
Use organic practices or certified (B)	0.297	0.295	78
Under $30,160 (A)	0.248	0.343	105
Between $30,160 - $603,202 (B)	0.486	0.321	140
Above $603,202 (C)	0.513	0.101	119

Note. Covered: farms' covered status under the FSMA-PSR. PSA training: Produce Safety Alliance. Under $30,160, Between $30,160 - $603,202: Above $603,202: total farm earnings.

International countries' results

Question 1: Have you implemented food safety practices?

The Covered group showed a high proportion of "yes" responses (98.3%) compared to the Not Covered group, which had 91.2%. The T-tests revealed significant differences, indicating that the Covered group tended to have a higher proportion of "yes" responses (Table 11). The letters A, B, and C in the table represent different categories using t-tests. "A" and "B" are different levels or groups

within each category, while "C" indicates a third group or level. The t-test results indicate the statistical significance of differences between groups. For instance, t-test (A) and t-test (B) assess the difference between categories, and t-test (C) compares the third group. A statistically significant difference between the groups is indicated by a significant result (designated as "A" or "B") from the t-tests. The higher proportion of "yes" responses in the Covered group may have been due to more effective or comprehensive implementation of the relevant practices. According to recent research, thorough implementation of safety standards led to increased compliance and better outcomes. On the other hand, the Not Covered group might have struggled with less effective practices or incomplete coverage, resulting in lower "yes" responses. The PSA Training (B) group had 94.9% "yes" responses, whereas the No PSA Training group had 92.6%. Although the difference was not substantial, the t-tests suggested that PSA training might have positively impacted the proportion of "yes" responses. The greater proportion of "yes" responses in the PSA Training group could have been attributed to the positive impact of training on understanding and adherence to practices (Food and Drugs Administration. FDA, 2020). Training programs had been shown to improve knowledge and compliance, leading to better outcomes. Although the difference was not substantial, training generally enhanced performance and adherence (Trinetta et al., 2021). In the category of organic practices, the group using organic or certified practices had 92.2% "yes" responses, while the group without organic practices showed 95.2%. The difference between these groups was smaller, and the t-tests indicated that the impact of organic practices on "yes" responses was less pronounced. The smaller difference between groups with and without organic practices suggested that while organic certification could have benefits, its impact on "yes" responses might have been less pronounced compared to other factors. This was supported by recent findings that indicated the effectiveness of organic practices varied depending on implementation and context (Etuk et al., 2024). The higher "yes" response rate in the non-organic group could have been due to other beneficial practices in place (Kheradia y Warriner, 2013). Income also affected "yes" responses: the group earning below

$30,160 (A) had 89.3% "yes" responses, the group earning between $30,160 and $603,202 (B) had 96.3%, and the group earning above $603,202 (C) had 99.2%. The t-tests showed significant differences between these groups, indicating that higher income correlated with a higher proportion of "yes" responses.

This analysis revealed how various factors impacted responses and suggested important implications for interpreting data within the study's context. Significant differences in "yes" responses across income ranges likely reflected varying resource availability. Higher income levels generally provided better access to resources and higher-quality practices, which could enhance compliance (Bovay y Sumner, 2018). Lower-income groups might have faced consequences that impacted their ability to fully implement the standards of FSMA.

Table 11

Question 1 Have you implemented food safety practices?

Category	Yes	No	n	t-test (A)	t-test (B)	t-test (C)
Covered (A)	0.983	0.017	238	B	A	
PSA training (B)	0.949	0.051	430			
No PSA training (A)	0.926	0.074	68			
Not covered (B)	0.912	0.088	260	B	A	
Use organic practices or certified (B)	0.922	0.078	103			
No organic practice (A)	0.952	0.048	395			
Under $30,160 (A)	0.893	0.107		BC	A	A
Between $30,160 - $603,202 (B)	0.963	0.037		BC	A	A
Above $603,202 (C)	0.992	0.008				

Note. Covered: farms' covered status under the FSMA-PSR. PSA training: Produce Safety Alliance. Under $30,160, Between $30,160 - $603,202: Above $603,202: total farm earnings. t-test (A): Significant difference between A, B, and C ($p<0.05$). t-test (B): Significant difference between B, A, and C ($p<0.05$).

Meet FSMA Regulations

Covered showed an 86.1% "yes" response rate, compared to 61.9% for the "Not Covered (B) group. This difference indicated that comprehensive coverage is associated with higher "yes" responses. The

letters A, B, and C in the table represent different categories using t-tests. "A" and "B" are different levels or groups within each category, while "C" indicates a third group or level. The t-test results indicate the statistical significance of differences between groups. For instance, t-test (A) and t-test (B) assess the difference between categories, and t-test (C) compares the third group. A statistically significant difference between the groups is indicated by a significant result (designated as "A" or "B") from the t-tests. For PSA training, the "PSA Training (B)" group has a 76.6% "yes" response rate, while the "No PSA Training (A)" group has 56.2% (Table 12). This is aligned with findings that targeted training programs significantly improve performance (Walters y Rodriguez Joel, 2017). The "Use Organic Practices or Certified" group has an 80.5% "yes" response rate, compared to 72.6% for the "No Organic Practices" group. The difference, though notable, is not extremely large, but it does suggest that organic practices are associated with higher "yes" responses. This supports recent research indicating that certified practices can lead to improved outcomes (Pacini et al., 2003). Income range analysis shows that the group earning below $30,160 (A) has a 65.4% "yes" response rate, whereas both the $30,160 to $603,202 (B) and above $603,202 (C) income groups have 78.6% "yes" responses. The T-tests (A: BC, B: A) indicate significant differences, suggesting that higher income is linked to a higher proportion of "yes" responses.

Table 12

Question 2 Top 3 reasons for implementing Food Safety Practices

Category	Yes	No	n	t-test (A)	t-test (B)	t-test (C)
Covered (A)	0.861	0.139	202	B	A	
PSA training (B)	0.766	0.234	351	B	A	
Not covered (B)	0.619	0.381	197	B	A	
No PSA training (A)	0.562	0.438	48	B	A	
Under $30,160 (A)	0.654	0.346	133	BC	A	A
Between $30,160 - $603,202 (B)	0.786	0.214	154	BC	A	A
Above $603,202 (C)	0.786	0.214	112			
No organic practices	0.726	0.274	317			

Category	Yes	No	n	t-test (A)	t-test (B)	t-test (C)
Use organic practices or certified	0.805	0.195	82			

Note. Reason to Meet FSMA regulations. Covered: farms' covered status under the FSMA-PSR. PSA training: Produce Safety Alliance. Under $30,160, Between $30,160 -$603,202: Above $603,202: total farm earnings. Significant difference between A, B, and C ($p<0.05$). t-test (B): Significant difference between B, A, and C ($p<0.05$).

Maintain Market Access

As shown in the Covered group, it reported a 71.8% "yes" response rate, while the Not Covered (B) group had a significantly lower rate at 46.2%. The letters A, B, and C in the table represent different categories using t-tests. "A" and "B" are different levels or groups within each category, while "C" indicates a third group or level. The t-test results indicate the statistical significance of differences between groups. For instance, t-test (A) and t-test (B) assess the difference between categories, and t-test (C) compares the third group. A statistically significant difference between the groups is indicated by a significant result (designated as "A" or "B") from the t-tests. (Table 13). This finding was consistent with recent studies that emphasized the importance of full coverage in achieving better performance metrics. (Food and Agriculture Organization of the United [FAO], 2021) Moreover, PSA Training (B) showed a 58.7% "yes" response rate, whereas the group with "No PSA Training (A)" had a higher rate at 62.5%. This slight difference, while not overwhelmingly large, indicated that the impact of PSA training might have varied depending on other factors such as prior knowledge or experience. In addition, the income range analysis revealed a change in "yes" responses, with the lowest income group (under $30,160) showing a 42.9% "yes" response rate, the middle-income group (between $30,160 and $603,202) at 61.0%, and the highest income group (above $603,202) at 75.9%. The t-tests (A: BC, AC, AB) demonstrated significant differences across these income categories, indicating that higher income levels were strongly associated with better compliance and positive outcomes. This supported existing literature that linked financial resources to improved access to tools and practices that enhanced performance (Duarte et al., 2011).

Table 13

Question 2 Top 3 reasons for implementing Food Safety Practices

Category	Yes	No	n	t-test (A)	t-test (B)	t-test (C)
Covered (A)	0.718	0.282	202	B	A	
PSA training (B)	0.587	0.413	351			
Not covered (B)	0.462	0.538	197	B	A	
No PSA training (A)	0.625	0.375	48			
Under $30,160 (A)	0.429	0.571	133	BC	AC	AB
Between $30,160 - $603,202 (B)	0.610	0.390	154	BC	AC	AB
Above $603,202 (C)	0.759	0.241	112			
No organic practice (A)	0.603	0.397	317	B	A	
Use organic practices or certified (B)	0.549	0.451	82	B	A	

Note. Reason to Maintain Market access. Covered: farms' covered status under the FSMA-PSR. PSA training: Produce Safety Alliance. Under $30,160, Between $30,160 -$603,202: Above $603,202: total farm earnings. Significant difference between A, B, and C ($p<0.05$). t-test (B): Significant difference between B, A, and C ($p<0.05$).

Personal Commitment

In this case, the group covered (A) showed a lower "yes" response rate (48.5%) compared to the "Not Covered (B)" group, which had a significantly higher rate at (73.6%). The letters A, B, and C in the table represent different categories using t-tests. "A" and "B" are different levels or groups within each category, while "C" indicates a third group or level. The t-test results indicate the statistical significance of differences between groups. For instance, t-test (A) and t-test (B) assess the difference between categories, and t-test (C) compares the third group. A statistically significant difference between the groups is indicated by a significant result (designated as "A" or "B") from the t-tests (Table 14). Not Covered (B) group might be taking extra steps or employing alternative strategies to meet market requirements despite not having the same coverage as the "Covered (A)" group. This unexpected result may have indicated alternative strategies or compensatory mechanisms being employed by those without coverage (Bailey, 2022). The "No PSA Training (A)" group had a 66.7% "yes" response rate, slightly higher than the 60.1% observed in the "PSA Training (B)" group. This

suggested that PSA training did not necessarily lead to higher "yes" responses, possibly due to variations in prior experience or the nature of the practices assessed (Versteeg, 1992). In the income range analysis, the group earning below $30,160 (A) exhibited the highest "yes" response rate at 76.7%, followed by the middle-income group (between $30,160 and $603,202) at 54.5%, and the highest-income group (above $603,202) at 50.9%. This challenged the typical assumption that higher income correlates with better outcomes, hinting that lower-income groups might have adopted different strategies or possessed different motivations (McBride, 2024). The "No Organic Practices (A)" group reported a 59.3% "yes" response rate, indicating a moderate level of compliance or positive outcomes. The absence of organic practices did not significantly impact the "yes" response rate, implying that non-organic practices may have been equally effective, or that organic certification was not the sole determinant of compliance (Gambelli et al., 2014).

Table 14

Question 2 Top 3 reasons for implementing Food Safety Practices

Category	Yes	No	n	t-test (A)	t-test (B)	t-test (C)
Covered (A)	0.485	0.515	202	B	A	
Not covered (B)	0.736	0.264	197	B	A	
No PSA training (A)	0.667	0.333	48			
PSA training (B)	0.601	0.399	351			
Under $30,160 (A)	0.767	0.233	133	BC	A	A
Between $30,160 - $603,202 (B)	0.545	0.455	154	BC	A	A
Above $603,202 (C)	0.509	0.491	112			
No organic practice (A)	0.593	0.407	317			
Use organic practices or certified (B)	0.671	0.329	82			

Note. Reason: Personal commitment. Covered: farms' covered status under the FSMA-PSR. PSA training: Produce Safety Alliance. Under $30,160, Between $30,160 -$603,202: Above $603,202: total farm earnings.

Question 3 Produce Safety Practice that has been the most challenging to implement

Record Keeping

In the "Covered (A)" group, only (39.5%) of participants were able to affirmatively respond to successful record-keeping practices, while (60.5%) found it challenging. This trend is even more pronounced in the "Not Covered (B)" group, where only (32.1%) were successful, and (67.9%) struggled with record keeping. These results suggest that coverage status might influence the ability to maintain proper records, potentially due to differences in resource availability or support systems. In Table 15, growers with PSA training (B) had a lower affirmative response rate of (35.2%) compared to (41.3%) in the "No PSA Training (A)" group. This indicates that even formal training does not entirely mitigate the challenges associated with record keeping. Training can raise awareness, it might also highlight the complexities of compliance, making some practices seem more daunting and leading to lower affirmative responses (Cavazza y Serpe, 2010). Among those not using organic practices (A), (37.2%) managed to implement record-keeping effectively, whereas only (30.9%) of those using organic practices or certified (B) were successful. This difference could imply that organic or certified operations may have more stringent record-keeping requirements, making it more difficult for these participants to maintain compliance. Organic certification often entails additional documentation, which can add to the challenge of record keeping (Vigar et al., 2019). The data show that participants with the lowest income (under $30,160) had the hardest time with record keeping, with only (31.1%) successfully managing it. In contrast, (37.3%) of those in the middle-income range and (39.7%) of those in the highest income bracket ($603,202 and above) were successful. This pattern suggests that higher-income groups may have better access to resources, such as software or personnel, that can assist with maintaining records. Financial resources often play a critical role in the ability to comply with detailed and labor-intensive practices like record keeping (Durham et al., 2014).

Table 15

Question 3 Produce Safety Practice that has been the most challenging to implement?

Category	Yes	No	n
Covered (A)	0.395	0.605	205
PSA training (B)	0.352	0.648	355
Not covered (B)	0.321	0.679	196
No PSA training (A)	0.413	0.587	46
No organic practice (A)	0.372	0.628	320
Use organic practices or certified (B)	0.309	0.691	81
Under $30,160 (A)	0.311	0.689	132
Between $30,160 - $603,202 (B)	0.373	0.627	153
Above $603,202 (C)	0.397	0.603	116

Note. Reason: Record Keeping. Covered: farms' covered status under the FSMA-PSR. PSA training: Produce Safety Alliance. Under $30,160, Between $30,160 -$603,202: Above $603,202: total farm earnings.

Wildlife and Domestic Animals

Identifying the most challenging Produce Safety Practices (PFSP) to implement concerning wildlife and domestic animals reveal several key insights. Growers with coveremain5.1%) and those with PSA training (41.1%) reported lower affirmative response rates, indicating that managing wildlife and domestic animals remains a significant challenge despite having access to resources and training (Table 16). This contrasts with growers without coverage (47.4%) and those without PSA training (41.3%), who also struggled but to a lesser extent.

The lower implementation rates in the "Covered" and "PSA Training" groups suggest that even with support and education, addressing issues related to wildlife and domestic animals remain complex. This complexity often arises from the unpredictable nature of wildlife and difficulties in managing domestic animals, which can hinder effective compliance with safety practices (Gupta et al., 2023).

The data show similar challenges between growers with no organic practices (41.2%) and those using organic practices or certified (40.7%). This indicates that managing wildlife and domestic

animals is a broad issue not significantly influenced by the type of practices being followed. Furthermore, lower-income growers (45.5%) faced more difficulties compared to those in the middle-income bracket (43.1%) and the highest-income group (33.6%). Financial constraints may limit resources and strategies for managing these challenges effectively (Jobbs, 2003) .

Overall, these findings highlight that managing wildlife and domestic animals remains a challenging aspect of PFSP, influenced by factors such as coverage, training, and income. Addressing these challenges may require more specialized strategies and resources.

Table 16

Question 3 Produce Safety Practice that has been the most challenging to implement

Category	Yes	No	n
Covered (A)	0.351	0.649	205
PSA training (B)	0.411	0.589	355
Not covered (B)	0.474	0.526	196
No PSA training (A)	0.413	0.587	46
No organic practice (A)	0.412	0.588	320
Use organic practices or certified (B)	0.407	0.593	81
Under $30,160 (A)	0.455	0.545	132
Between $30,160 - $603,202 (B)	0.431	0.569	153
Above $603,202 (C)	0.336	0.664	116

Note. Reason: Wildlife and domestic animals. Covered: farms' covered status under the FSMA-PSR. PSA training: Produce Safety Alliance. Under $30,160, Between $30,160 -$603,202: Above $603,202: total farm earnings.

Worker Health and Hygiene Training

Worker health and hygiene training, focused on the challenges of implementing Produce Safety Practices (PFSP) related to worker health and hygiene training, revealed several important trends. Growers with coverage (44.4%) and those with PSA training (36.9%) reported significant difficulties, indicating that maintaining effective health and hygiene training is challenging even with these resources. This suggests that comprehensive training programs for worker health and hygiene can be particularly complex to implement. Growers without PSA training (39.1%) and those not

covered (29.6%) faced even greater challenges, with the non-covered group showing the lowest implementation rate (Table 17). This highlights how the absence of coverage and training severely impacts the ability to effectively implement these practices. The lack of proper training and resources often leads to lower compliance rates and increased difficulties in maintaining safety standards (Leape et al., 2006).

The data also showed that growers with no organic practices (37.8%) faced similar challenges as those using organic practices or certified (34.6%), suggesting that the issue of worker health and hygiene training is consistent across different practice types. Additionally, lower-income growers (31.8%) struggled more compared to those in middle-income (39.9%) and high-income groups (39.7%). Financial limitations can restrict access to effective training programs and resources. Overall, these findings underscore that worker health and hygiene training remains a challenging aspect of PFSP implementation, influenced by coverage, training, and income. Addressing these challenges requires enhanced support and resources (Adalja y Lichtenberg, 2018).

Table 17

Question 3 Produce Safety Practice that has been the most challenging to implement

Category	Yes	No	n
Covered (A)	0.444	0.556	205
PSA training (B)	0.369	0.631	355
No PSA training (A)	0.391	0.609	46
Not covered (B)	0.296	0.704	196
No organic practice (A)	0.378	0.622	320
Use organic practices or certified (B)	0.346	0.654	81
Under $30,160 (A)	0.318	0.682	132
Between $30,160 - $603,202 (B)	0.399	0.601	153
Above $603,202 (C)	0.397	0.603	116

Note. Reason: Worker health and hygiene training. Covered: farms' covered status under the FSMA-PSR. PSA training: Produce Safety Alliance. Under $30,160, Between $30,160 -$603,202: Above $603,202: total farm earnings.

Question 4 What Barriers Are Growers Facing?

Covered and not covered

The barriers growers faced in implementing Produce Safety Practices (PFSP) under the FSMA-PSR highlight several key challenges. For growers with coverage (i.e., those whose farms were covered under the FSMA-PSR), the primary barriers included time (45.4%) and money (22.9%). These barriers were more prominent compared to growers without coverage, who reported time (25.9%) and money (18.8%) as significant challenges (Table 18). The challenge related to practice-specific knowledge was voted by (10.4%) of covered growers versus (7.1%) of non-covered growers, indicating a slightly greater issue among those with coverage. Similarly, mindset issues such as confidence and motivation were reported by (17.1%) of covered growers compared to (11.7%) of non-covered growers, suggesting that mental and motivational factors also play a role.

Access to training and education was (11.7%) of covered growers and (9.4%) of non-covered growers, showing a modest challenge. Barriers such as awaiting final regulation (0.4% vs. 1.9%) and changing buyer expectations (3.8% vs. 1.5%) were less significant. These findings suggest that time and money are major barriers for both groups, with additional challenges related to mindset and practice-specific knowledge. Addressing these issues may require tailored support and resources to improve PFSP implementation.

Table 18

Question 4 What barriers are growers facing?

	Covered, n	Not covered, n	Covered, %	Not covered, %
1 - Money	55	50	22.9	18.8
2 - Time	109	69	45.4	25.9
3 - Practice specific knowledge	25	19	10.4	7.1
4 - Mindset (confidence, motivation)	41	31	17.1	11.7

	Covered, n	Not covered, n	Covered, %	Not covered, %
5 - Access to training/education	28	25	11.7	9.4
6 - Awaiting final regulation	1	5	0.4	1.9
7 - Changing buyer expectations	9	4	3.8	1.5
8 - N/A	36	65	15.0	24.4
No Response	42	86	17.5	32.3

Note. Category covered, not covered. Covered: farms' covered status under the FSMA-PSR.

PSA and No PSA Training

Growers with PSA training (i.e., those who have undergone Produce Safety Alliance training) identified time (35.7%) and money (21.2%) as significant barriers. In contrast, growers without PSA training reported time (31.9%) and money (18.1%) as their primary challenges (Table 19).

The challenge related to practice-specific knowledge was reported by 9.7% of non-PSA trained growers and 8.5% of PSA-trained growers, indicating that while it was a notable issue, it was less significant compared to time and financial constraints. Mindset issues such as confidence and motivation were cited by 6.9% of non-PSA trained growers and 15.4% of PSA-trained growers, suggesting that mindset challenges were more pronounced among those with formal training.

Access to training and education was reported by 13.9% of non-PSA trained growers and 9.9% of PSA-trained growers, reflecting a moderate barrier. Other barriers, such as awaiting final regulation (1.4% vs. 1.2%) and changing buyer expectations (0% vs. 3.0%), were relatively minor. The “N/A” category showed that 15.3% of non-PSA trained growers and 20.7% of PSA-trained growers did not identify any barriers. Notably, the no-response rate was higher among non-PSA trained growers (36.1%) compared to PSA-trained growers (23.5%).

Table 19

Question 4 What barriers are growers facing?

Choice	No PSA training, n	PSA training, n	No PSA training (%)	PSA training (%)
1 - Money	13	92	18.1	21.2
2 - Time	23	155	31.9	35.7
3 - Practice specific knowledge	7	37	9.7	8.5
4 - Mindset (confidence, motivation)	5	67	6.9	15.4
5 - Access to training/education	10	43	13.9	9.9
6 - Awaiting final regulation	1	5	1.4	1.2
7 - Changing buyer expectations	0	13	0.0	3.0
8 - N/A	11	90	15.3	20.7
No Response	26	102	36.1	23.5

Note. Category PSA training, No PSA training. PSA training: Produce Safety Alliance.

Organic and No Organic Practices

Growers who do not use organic practices reported time (35.3%) and money (20.9%) as their primary barriers, reflecting the significant impact of these factors on their ability to implement safety practices. In contrast, growers using organic practices or certified systems reported similar challenges, with time (34.6%) and money (20.2%) also being major issues. Practice-specific knowledge was reported equally by both groups, at (8.7%), indicating that this barrier does not differ significantly between those using organic practices and those who do not. Mindset issues, such as confidence and motivation, were cited by (13.2%) of non-organic growers and 18.3% of organic growers, suggesting that challenges are somewhat more common among those who use organic practices.

Access to training and education was noted as a barrier by 10.0% of non-organic growers and (12.5%) of those using organic practices, indicating a moderate challenge for both groups. Minor barriers included awaiting final regulation (1.2% vs. 1.0%) and changing buyer expectations (2.7% vs. 1.9%), reflecting that these issues are less significant overall (Table 20).

Table 20

Question 4 What barriers are growers facing?

Choice	No organic practice, n	Use organic practices or certified, n	No organic practice, %	Use organic practices or certified, %
1 - Money	84	21	20.9	20.2
2 - Time	142	36	35.3	34.6
3 - Practice specific knowledge	35	9	8.7	8.7
4 - Mindset (confidence, motivation)	53	19	13.2	18.3
5 - Access to training/education	40	13	10.0	12.5
6 - Awaiting final regulation	5	1	1.2	1.0
7 - Changing buyer expectations	11	2	2.7	1.9
8 - N/A	79	22	19.7	21.2
No Response	99	29	24.6	27.9

Note. Category Use organic practices, No organic practices.

Income Breakers

In Table 21, growers with total farm earnings under $30,160 reported time (22.0%) and money (21.4%) as the primary barriers to implementing safety practices. In comparison, those with earnings between $30,160 and $603,202 identified time (37.1%) and money (18.6%) as their main challenges. Growers with earnings above $603,202 noted time (50.8%) and money (23.1%) as their most significant obstacles. The challenge of practice-specific knowledge was reported by 8.2% of growers with earnings under $30,160, 7.2% of those between $30,160 and $603,202, and 11.5% of those with earnings above $603,202, suggesting that higher-income growers face more issues related to this barrier (Imami et al., 2021).

Mindset issues, such as confidence and motivation, affected 11.5% of growers with lower earnings, 11.9% of those in the middle-income bracket, and 21.5% of higher-income growers, indicating a greater prevalence of mindset-related challenges among wealthier growers. Other

barriers, including awaiting final regulation and changing buyer expectations, were minor across all income levels.

Table 21

Question 4 What barriers are growers facing?

Choice	Under $30,000	Between $30,000-$603,000	Above $603,000	Under $30,000	Between $30,000-$603,000 %	Above $603,000%
1 - Money	39	36	30	0.214	0.186	0.231
2 - Time	40	72	66	0.220	0.371	0.508
3 - Practice specific knowledge	15	14	15	0.082	0.072	0.115
4 - Mindset (confidence, motivation)	21	23	28	0.115	0.119	0.215
5 - Access to training/education	18	15	20	0.099	0.077	0.154
6 - Awaiting final regulation	2	4	0	0.011	0.021	0.000
7 - Changing buyer expectations	2	3	8	0.011	0.015	0.062
8 - N/A	51	34	16	0.280	0.175	0.123

Note. Category Income breakers. Under $30,160, Between $30,160 -$603,202: Above $603,202: total farm earnings.

Question 5 To Gain Market Access, Have You Implemented Produce Food Safety Practices?

Growers with farms covered under FSMA-PSR reported a (47.8%) implementation rate of PFSP, whereas those with PSA training had a (38.7%) implementation rate. Growers without PSA training had a significantly lower rate of (26.1%). This indicates that PSA training positively influences PFSP implementation, though the FSMA-PSR coverage also plays a crucial role.

Among growers with no organic practices, (36.8%) implemented PFSP compared to 39.0% of those using organic or certified practices as can been seen on Table 22. This small difference suggests an advantage in PFSP implementation for those involved in organic practices.

Income level also impacted PFSP implementation. Growers with earnings under $30,160 had a (27.1%) implementation rate, those with earnings between $30,160 and $603,202 had a (35.1%) rate, while growers with earnings above $603,202 had a notably higher rate of (50.8%). Higher-income growers

are more likely to implement PFSP, potentially due to better financial capacity and higher market demands.

Table 22

Question 5 To gain market access, have you implemented Produce Food Safety Practices?

Category	Yes	No	n
Covered (A)	0.478	0.191	209
PSA training (B)	0.387	0.291	357
No PSA training (A)	0.261	0.391	46
No organic practice (A)	0.368	0.308	321
Use organic practices or certified (B)	0.39	0.28	82
Under $30,160 (A)	0.271	0.473	129
Between $30,160 - $603,202 (B)	0.351	0.318	154
Above $603,202 (C)	0.508	0.1	120

Note. Covered: farms' covered status under the FSMA-PSR. PSA training: Produce Safety Alliance. Under $30,160, Between $30,160 - $603,202: Above $603,202: total farm earnings.

Comparison Between US and International Countries

Question 1. Have you implemented Produce Food Safety Practices

In the "Covered" category (FSMA-PSR coverage), there is a clear difference between the responses of domestic (98%) and international (36%) producers who are not covered by the regulation. The probability associated with this difference is very low (<.0001), indicating a statistically significant difference. This suggests that the *Food Safety Modernization Act* (FSMA) has a strong impact on domestic producers, leading to higher adoption of food safety practices. International producers, not required to comply with FSMA, may not feel the same regulatory pressure to implement these practices, explaining the lower adoption rate (Eruaga, 2024). In contrast, in the categories of PSA Training and Organic, no significant differences are observed between domestic and international producers (1.0000 and 0.8834, respectively). This indicates that producers who receive training from the Produce Safety Alliance or practice organic farming tend to implement food safety

practices consistently, regardless of their location as shown on Table 23. These results suggest that training and organic practices foster a strong and uniform food safety culture, without local regulations playing as critical a role as in the case of producers covered by FSMA (Bugingo et al., 2024). Regarding the income category, no significant differences were observed in the adoption of food safety practices between the different income groups, both domestically and internationally (Pr > X2 = 1.0000 across several categories). This suggests that the implementation of these practices does not depend on the size or income level of the farm, indicating that food safety is a consistent priority for farms regardless of their economic capacity. This finding is important as it counters the assumption that smaller or lower-income farms might have fewer resources to adopt these practices (Humphrey, 2017).

In the "Covered" category (FSMA-PSR coverage), there is a clear difference between the responses of domestic (98%) and international (36%) producers who are not covered by the regulation. The probability associated with this difference is very low (<.0001), indicating a statistically significant difference. This suggests that the Food Safety Modernization Act (FSMA) has a strong impact on domestic producers, leading to higher adoption of food safety practices. International producers, not required to comply with FSMA, may not feel the same regulatory pressure to implement these practices, explaining the lower adoption rate (Eruaga, 2024). In contrast, in the categories of PSA Training and Organic, no significant differences are observed between domestic and international producers (1.0000 and 0.8834, respectively). This indicates that producers who receive training from the Produce Safety Alliance or practice organic farming tend to implement food safety practices consistently, regardless of their location as shown on Table 23. These results suggest that training and organic practices foster a strong and uniform food safety culture, without local regulations playing as critical a role as in the case of producers covered by FSMA (Bugingo et al., 2024). Regarding the income category, no significant differences were observed in the adoption of food safety practices between the different income groups, both domestically and internationally (Pr > X2 = 1.0000 across several

categories). This suggests that the implementation of these practices does not depend on the size or income level of the farm, indicating that food safety is a consistent priority for farms regardless of their economic capacity. This finding is important as it counters the assumption that smaller or lower-income farms might have fewer resources to adopt these practices (Humphrey, 2017).

Table 23

Question 1. Have you implemented Produce Food Safety Practices?

Category	Responses	US (%)	International (%)	Pr > X^2
Covered under FSMA	Yes	98% [a]	98% [a]	1.0000
	No	92% [a]	36% [b]	<.0001
PSA Training	Yes	95% [a]	95% [a]	1.0000
	No	96% [a]	93% [a]	0.8273
Organic Practices	Yes	94% [a]	92% [a]	0.8834
	No	95% [a]	95% [a]	1.0000
Annual gross revenue	<30K	90% [a]	89% [a]	0.9404
	30-60K	96% [a]	96% [a]	1.0000
	>603K	99% [a]	99% [a]	1.0000

Note. Pr>X^2: A significant level of 0.05 was used for the statistical analysis between US and International on each category using Chi Square Test; a-b letters indicate significant differences between each category. Covered: farms' covered status under the FSMA. Produce Safety Alliance. Under $30,160, Between $30,160 -$603,202: Above $603,202: total farm earnings.

Question2. Reasons Why you Implemented Produce Safety Practices

Meet FSMA Regulations

In the "Covered" category, the responses of domestic (86%) and international (58%) producers

show a statistically significant difference (0.0196). This suggests that being covered by FSMA regulations is a strong motivator for implementing food safety practices among domestic producers. A similar significant difference is seen in the "Not Covered" group, with domestic producers (60%) implementing food safety practices at a higher rate than international producers (27%), even without regulatory pressure (0.0004). This indicates that, even outside the regulatory scope, domestic producers may feel greater responsibility or market pressure to adopt safety practices. The "No Organic" category also shows a significant difference (0.0271), with domestic producers (71%) implementing food safety

practices more frequently than international producers (47%). This suggests that conventional farming systems in the U.S. might be more aligned with food safety regulations or market demands, regardless Similarly, income levels show no significant differences between domestic and international producers, particularly in the higher income brackets. Both "Between $30,160 - $603,202" and "Above $603,202" categories display identical rates (78-79%) for implementing safety practices (0.9364), implying that financial capacity is not a decisive factor in this context. Lower-income producers ("Under $30,160") also show no significant difference (0.1432), though the trend suggests slightly lower implementation rates among international producers of organic certification (Afatsawu y Kheni, 2022). In the "Organic" category, the difference between domestic (81%) and international (58%) producers approaches significance (Pr > X2 = 0.0511). While not statistically significant at the 0.05 level, it indicates a trend where organic producers in the U.S. might be more influenced by regulatory or market forces than their international counterparts, possibly due to consumer demand for organic products being tied to rigorous safety standards

(Organic Produce Network, 2024).In categories like PSA Training and income brackets, there are no significant differences in responses between domestic and international producers. For PSA-traines

producers, both domestic (76%) and international (65%) producers show similar motivations for implementing food safety practices (0.3543), indicating that training is likely to create a consistent emphasis on food safety across borders.

The lack of significance in the "No PSA Training" group (0.3023) suggests that, without training, producers may not perceive as strong a need for compliance, and this perception does not change by the location as can be seen on Table 24.

Similarly, income levels show no significant differences between domestic and international producers, particularly in the higher income brackets. Both "Between $30,160 - $603,202" and "Above $603,202" categories display identical rates (78-79%) for implementing safety practices (0.9364), implying that financial capacity is not a decisive factor in this context. Lower-income producers ("Under $30,160") also show no significant difference (0.1432), though the trend suggests slightly lower implementation rates among international producers.

Table 24

Question2. Reasons why you implemented Produce Safety Practices

Category	Responses	US (%)	International (%)	Pr > X^2
Covered under FSMA	Yes	86% [a]	58% [a]	<.0001
	No	60% [b]	27% [b]	0.0004
PSA Training	Yes	76% [a]	65% [a]	0.3543
	No	52% [b]	42% [b]	0.3023
Organic practices	Yes	81% [a]	58% [a]	0.0511
	No	71% [b]	47% [b]	0.0271
Annual gross revenue	<30K	60% [a]	45% [a]	0.1432

Category	Responses	US (%)	International (%)	Pr > X^2
	30-60K	78% [b]	79% [b]	0.9364
	>603K	78% [b]	79% [b]	0.9364

Note. Pr>X^2: A significant level of 0.05 was used for the statistical analysis between US and International on each category using Chi Square Test. a-b letters indicate significant differences between each category. Covered: farms' covered status under the FSMA. Produce Safety Alliance. Under $30,160, Between $30,160 -$603,202: Above $603,202: total farm earnings.

Maintain Market Access

Several categories show no significant differences between U.S. and international producers. In the "Covered" category, both U.S. and international producers report the same percentage (72%) for implementing food safety practices to maintain market access, with no significant difference (1.0000). Similarly, in the "Not Covered" category, although U.S. producers (60%) implemented practices slightly more than international producers (46%), this difference is not statistically significant (0.1739.

For the "PSA Training" group, there is no significant difference between U.S. (67%) and international (59%) producers (0.4760). This shows that training programs have a similar impact across regions, emphasizing the global nature of food safety standards (Altomonte, 2024). Likewise, "No PSA Training" producers exhibit no significant differences (0.7868), underscoring that, despite the lack of formal training. The "Organic" category approaches significance (0.0944), with 74% of U.S. organic producers implementing food safety practices, compared to 55% of international organic producers (Table 25). This may reflect stronger consumer expectations and regulatory pressures within the U.S. organic market (Kim & Garcia, 2021), but further research would be necessary to confirm this trend. Significant differences are evident in the "Under $30,160" and "Above $603,202" income brackets. In the "Under $30,160" group, U.S. producers (79%) are significantly more likely to implement practices compared to international producers (43%) (0.0011).

Conversely, in the "Above $603,202" group, international producers (76%) are significantly more likely to implement food safety practices than U.S. producers (51%) (0.0265). This might be explained by international producers' need to comply with food safety standards to participate in global markets.

Table 25

Question2. Reasons why you implemented Produce Safety Practices?

Category	Responses	US (%)	International (%)	Pr > X^2
Covered under FSMA	Yes	72% [a]	72% [a]	1.0000
	No	60% [b]	46% [b]	0.1739
PSA Training	Yes	67% [a]	59% [a]	0.4760
	No	60% [a]	63% [a]	0.7868
Organic practices	Yes	74% [a]	55% [a]	0.0944
	No	70% [a]	60% [a]	0.3805
Annual gross revenue	<30K	79% [a]	43% [a]	0.0011
	30-60K	57% [b]	61% [b]	0.7127
	>603K	51% [b]	76% [b]	0.0265

Note. Pr>X2: A significant level of 0.05 was used for the statistical analysis between US and International on each category using Chi Square Test. a-b letters indicate significant differences between each category. Covered: farms' covered status under the FSMA. Produce Safety Alliance. Under $30,160, Between $30,160 -$603,202: Above $603,202: total farm earnings.

Personal Commitment

In the "Covered" category, 48% of U.S. producers and 40% of international producers cited personal commitment, with no significant difference (0.3938). This suggests that the value placed on food safety transcends regulatory frameworks. For the "Not Covered" category, both U.S. (75%) and international (66%) producers showed no significant difference (0.4485), indicating that personal

commitment to food safety is similar among producers regardless of their regulatory coverage. In the "PSA Training" and "No PSA Training" categories, no significant differences were noted (0.9276 and 0.8638, respectively), suggesting that training does not significantly alter the level of personal commitment among producers.

The "Organic" category also demonstrated no significant differences (0.4760), further supporting the notion that personal commitment is a universal driver among organic producers (Table 26). In income brackets, U.S. producers in the "Under $30,160" category (79%) and international producers (77%) showed no significant difference (Pr > X2 = 0.8728), reflecting a shared commitment to food safety across income levels.

Table 26

Question2. Reasons why you implemented Produce Safety Practices?

Category	US (%)	International (%)	Pr > X^2
Covered	48% [a]	40% [a]	0.3938
Not Covered	75% [b]	66% [b]	0.4485
PSA Training	61% [a]	60% [a]	0.9276
No PSA Training	69% [a]	67% [a]	0.8638
Organic	67% [a]	59% [a]	0.4760
No Organic	60% [a]	59% [a]	0.9270
Under $30,160	79% [a]	77% [a]	0.8728
Between $30,160 - $603,202	57% [b]	54% [b]	0.7758
Above $603,202	51% [b]	51% [b]	1.0000

Note. Pr>X^2: A significant level of 0.05 was used for the statistical analysis between US and International on each category using Chi Square Test. a-b letters indicate significant differences between each category. Covered: farms' covered status under the FSMA. Produce Safety Alliance. Under $30,160, Between $30,160 -$603,202: Above $603,202: total farm earnings.

Record Keeping

In the "PSA Training" category, 61% of U.S. producers reported record keeping as challenging compared to 35% of international producers, with a significant difference (0.0080). This disparity suggests that producers who received formal training may still struggle more than their international counterparts, possibly due to differences in regulatory (Table 27). For the "Organic" category, 65% of U.S. organic producers found record keeping challenging, while only 31% of international organic producers reported the same, resulting in a significant difference (0.0005). This may reflect the more stringent documentation requirements in the U.S. for organic certification.

In the "No Organic" category, U.S. producers faced challenges (58%) compared to 37% of international producers, also significant (0.0312). This indicates that organic status influences the perception of record-keeping challenges differently across regions.

Income levels also show significant challenges. Producers earning "Under $30,160" faced challenges (58% U.S. vs. 31% international), with a significant difference (0.0042). Similarly, for those in the "Between $30,160 - $603,202" category, 57% of U.S. producers reported challenges compared to 36% of international producers (0.0233). For those "Above $603,202," 64% of U.S. producers found it challenging versus 40% internationally (0.0186). These findings suggest that income levels may influence the capacity to implement effective record-keeping practices.

Table 27

Question 3: Produce Safety Practice that has been the most challenging to implement?

Category	Responses	US (%)	International (%)	Pr > X^2
Covered under FSMA	Yes	58% [a]	55% [a]	0.7778
	No	61% [a]	47% [a]	0.1779
PSA Training	Yes	61% [a]	35% [a]	0.0080

Category	Responses	US (%)	International (%)	Pr > X^2
	No	49% [a]	41% [a]	0.3991
	Yes	65% [a]	31% [a]	0.0005
Organic practices	No	58% [a]	37% [a]	0.0312
	<30K	58% [a]	31% [a]	0.0042
Annual gross revenue	30-60K	57% [a]	36% [a]	0.0233
	>603K	64% [a]	40% [a]	0.0186

Note. Reason: Record Keeping. Pr>X^2: A significant level of 0.05 was used for the statistical analysis between US and International on each category using Chi Square Test. a-b letters indicate significant differences between each category. Covered: farms' covered status under the FSMA. Produce Safety Alliance. Under $30,160, Between $30,160 -$603,202: Above $603,202: total farm earnings.

Wildlife and Domestic Animals.

In the "Covered" category, 36% of U.S. producers reported challenges, while 43% of international producers felt similarly, with no significant difference (0.4310). This suggests that the challenges posed by wildlife management are similar for producers in both regions (Table 28).

In the "Not Covered" category, 48% of U.S. producers faced challenges compared to 55% of international producers, also not significant (0.4904). Regarding the "PSA Training" category, 42% of U.S. producers found the practice challenging, while 41% of international producers reported the same, showing no significant difference (0.9126). This suggests that training alone may not effectively address the complexities of managing wildlife and domestic animals (Cornell CALS, 2024).

In the "Organic" category, 40% of U.S. organic producers reported challenges, compared to 41% of international producers, with no significant difference (0.9115). For "No Organic," 42% of U.S. producers faced challenges compared to 41% internationally (0.9126). This consistency indicates that organic status does not greatly influence perceptions of wildlife management challenges.

Table 28

Question 3: Produce Safety Practice that has been the most challenging to implement.

Category	US (%)	Internacional (%)	Pr > X^2
Covered	36% [a]	43% [a]	0.4310
Not Covered	48% [a]	55% [a]	0.4904
PSA Training	42% [a]	41% [a]	0.9126
No PSA Training	44% [a]	41% [a]	0.7449
Organic	40% [a]	41% [a]	0.9115
No Organic	42% [a]	41% [a]	0.9126
Under $30,160	50% [a]	46% [a]	0.6831
Between $30,160 - $603,202	43% [a]	43% [a]	1.0000
Above $603,202	33% [a]	34% [a]	0.9028

Note. Reason: Wildlife and domestic animals. Pr>X^2: Chi Square test was used with a significant level of 0.05 and was used for the statistical analysis. a-b letters indicate significant differences between each category. Covered: farms' covered status under the FSMA-PSR. PSA training: Produce Safety Alliance. Under $30,160, Between $30,160 -$603,202: Above $603,202: total farm earnings.

Worker Health and Hygiene Training

In the "Covered" category, 36% of U.S. producers indicated that worker health and hygiene training is a significant challenge, while 43% of international producers reported the same, with no significant difference (Pr > X2 = 0.4310). This similarity suggests that the challenges of training in this area are perceived similarly, regardless of regulatory coverage (Table 29).

In the "Not Covered" category, 48% of U.S. producers faced challenges compared to 55% of international producers, also not significant (Pr > X2 = 0.4904). This finding implies that having received training does not significantly alleviate the challenges faced in implementing health and hygiene practices (Guevara, 2024).

In contrast, among those without "PSA Training," 44% of U.S. producers reported challenges compared to 41% internationally, again with no significant difference (0.7449). This further supports the notion that training may not be the decisive factor in addressing these implementation challenges. Regarding the "Organic" category, 40% of U.S. organic producers reported challenges, compared to 41% of international producers, with no significant difference (0.9115). For those categorized as "No Organic," 42% of U.S. producers faced challenges compared to 41% internationally (0.9126). These results indicate that organic certification does not significantly affect the perceived challenges.

Table 29

Question 3: Produce Safety Practice that has been the most challenging to implement.

Category	US (%)	Internacional (%)	Pr > X^2
Covered	36% [a]	43% [a]	0.4310
Not Covered	48% [a]	55% [a]	0.4904
PSA Training	42% [a]	41% [a]	0.9126
No PSA Training	44% [a]	41% [a]	0.7449
Organic	40% [a]	41% [a]	0.9115
No Organic	42% [a]	41% [a]	0.9126
Under $30,160	50% [a]	46% [a]	0.6831
Between $30,160 - $603,202	43% [a]	43% [a]	1.0000
Above $603,202	33% [a]	34% [a]	0.9028

Note. Reason: Worker health and hygiene training. Pr>X^2: A significant level of 0.05 was used for the statistical analysis. A p-value less than 0.05 indicates statistically significant difference in each row using the Chi Square test. a-b letters indicate significant differences between each category. Covered: farms' covered status under the FSMA-PSR. PSA training: Produce Safety Alliance. Under $30,160, Between $30,160 -$603,202: Above $603,202: total farm earnings.

Question 5. To Gain Market Access Have You Implemented PFSP?

In the "Covered" category, 66% of U.S. producers have implemented PFSP, while 65% of international producers reported the same, with no significant difference (Pr > X2 = 0.9304). This similarity suggests that producers in both regions view PFSP as a necessary step to gain market access, regardless of their regulatory coverage.

In the "Not Covered" category, 29% of U.S. producers implemented PFSP compared to 31% of international producers, which is also not significant (0.7963). This indicates that even producers without formal coverage recognize the importance of PFSP for market access. Regarding "PSA Training," 57% of both U.S. and international producers reported implementing PFSP, with no significant difference (1.0000). This suggests that training through the Produce Safety Alliance does not significantly alter the likelihood of implementing PFSP, as producers may be motivated by market demands rather than training alone.

For those without "PSA Training," 41% of U.S. producers implemented PFSP compared to 40% of international producers, also showing no significant difference (0.9115). This finding reinforces the notion that external market pressures may drive PFSP implementation, regardless of training status as shown on Table 20. Income levels reflect similar trends. Among producers earning "Under $30,160," 34% of U.S. producers reported implementing PFSP compared to 36% of international producers (0.8111). In the "Between $30,160 - $603,202" category, both U.S. and international producers reported 52% implementation (1.0000). For those "Above $603,202," 84% of U.S. producers and 83% of international producers reported implementing PFSP, again with no significant difference (0.9383) (Farmers Market Coalition, 2024)

Table 30

Question 5. To gain market access have you implemented PFSP?

Category	Responses	US (%)	International (%)	Pr > X^2
Covered under FSMA	Yes	66% [a]	65% [a]	0.9304
	No	29% [b]	31% [b]	0.7963
PSA Training	Yes	57% [a]	57% [a]	1.0000
	No	41% [a]	40% [a]	0.9115
Organic practices	Yes	57% [a]	52% [a]	0.6320
	No	55% [a]	49% [a]	0.5563
Annual gross revenue	<30K	34% [b]	36% [b]	0.8111
	30-60K	52% [b]	52% [b]	1.0000
	>603K	84% [a]	83% [a]	0.9383

Note. Pr>X^2: A significant level of 0.05 was used for the statistical analysis. A p-value of less than 0.05 indicates a statistically significant difference in each row using the Chi Square test. a-b letters indicate significant differences between each category. Covered: farms' covered status under the FSMA-PSR. PSA training: Produce Safety Alliance. Under $30,160, Between $30,160 -$603,202: Above $603,202: total farm earnings.

Conclusions

The analysis has demonstrated that the effective implementation of public policies, such as FSMA-PSR, is crucial for improving food safety in agriculture. The research suggested that policies should be designed not only to enforce regulations but also to provide a support framework to facilitates the adoption of safe practices among farmers, especially those with fewer resources, which includes an approach that integrates incentives, education, and ongoing technical assistance to ensure that regulations are not seen as a burden, but as a catalyst for sustainable improvement in food safety.

The research highlighted the potential of technology as a transformative factor in food safety. From real-time monitoring tools to digital traceability systems, technology could provide effective solutions for overcoming challenges in the implementation of safety practices. However, the adoption of these technologies requires significant investments and a shift in farmers' mindset. It was concluded that promoting technological innovation must be accompanied by specific training programs and the development of infrastructure to make these technologies accessible to all farmers, regardless of their size or geographic location.

Farms covered by the FSMA regulation demonstrated significantly higher implementation of food safety practices compared to non-covered farms. This suggested that regulatory compliance is a crucial motivator for adopting these practices, whereas non-covered farms may require additional incentives to voluntarily implement food safety measures.

Recommendations

It is recommended to expand and diversify food safety training programs, focusing not only on technical requirements but also on practical application in various agricultural contexts. Training should be accessible to farmers of all regions and economic levels, including continuous education, hands-on workshops, and digital resources tailored to specific needs.

Food safety policies should consider farmers' socioeconomic and geographic disparities. Provide financial and technical support for low-income farmers and incentives for sustainable practices, ensuring that regulations do not disproportionately burden small producers.

It is suggested to facilitate farmers' access to advanced technologies for traceability and food safety. Provide infrastructure and support, focusing on small and medium-sized farms to enhance effective adoption and benefit from innovations.

Referencias

Adalja, A. y Lichtenberg, E. (2018). Implementation challenges of the food safety modernization act: Evidence from a national survey of produce growers. *Science Direct*.

Afatsawu, P. y Kheni, N. (2022). Empirical Study of Compliance with Occupational Health and Safety Legislation: A case study of the Construction site. *International Journal of Applied Research in Social Sciences*, *4*(5), 173–189. https://doi.org/10.51594/ijarss.v4i5.354

Altomonte, L. (2024). *An Introduction to Food Safety Standards*.

Bailey, R. (2022, 4 de noviembre). New Evidence on Insurance and Health Behavior. *Chicago Policy Review*. https://chicagopolicyreview.org/2022/04/11/new-evidence-on-insurance-and-health-behavior/

Bovay, J. y Sumner, D. A. (2018). Economic Effects of the U.S. Food Safety Modernization Act. *Applied Economic Perspectives and Policy*, *40*(3), 402–420. https://doi.org/10.1093/aepp/ppx039

Boys, K. A., Ollinger, M. y Geyer, L. L. (2015). The Food Safety Modernization Act: Implications for U.S. Small Scale Farms. *American Journal of Law & Medicine*, *41*(2-3), 395–405. https://doi.org/10.1177/0098858815591524

Bugingo, C., Blasini, D., Orellana, R., George, L., Acuña-Maldonado, L., Silva, M. y Bihn, E [Elizabeth]. (2024). *Empowering Growers and Ensuring Produce Safety Through the PSA Grower Training Course*.

Cavazza y Serpe (2010). The impact of safety training programs on workers' psychosocial orientation and behaviour. *International Review of Social Psychology*, *23*(2-3), 187–210. https://www.researchgate.net/publication/236005752_The_impact_of_safety_training_programs_on_workers'_psychosocial_orientation_and_behaviour

Clements, D., Acuña-Maldonado, L., Fisk, C., Stoeckel, D., Wall, G., Woods, K. y Bihn, E [Elizabeth.]. (2019). *FSMA Produce Safety Rule: Documentation Requirements for Commercial Soil Amendment Suppliers*. https://agriculture.vermont.gov/sites/agriculture/files/documents/Produce_Program/PSA%20Documentation-Requirements-for-Commercial-Soil-Amendment-Suppliers.pdf

Cornell CALS. (2024). *Wildlife and Animals Management*.

Crawford, W. (2019). Chapter 5 - The Food Safety Modernization Act (FSMA)'s role in the safety of functional foods and their ingredients. En D. Bagchi (Ed.), *Nutraceutical and Functional Food Regulations in the United States and Around the World* (pp. 61–74). Academic Press. https://doi.org/10.1016/B978-0-12-816467-9.00005-8

Drew, C. A. y Clydesdale, F. M. (2015). New food safety law: Effectiveness on the ground. *Critical Reviews in Food Science and Nutrition*, *55*(5), 689–700. https://doi.org/10.1080/10408398.2011.654368

Duarte, A., Brito, L., Di Serio, L. y Martins, G. (2011). Operational practices and financial performance: An empirical analysis of Brazilian manufacturing companies. *BAR - Brazilian Administration Review*, *8*(4), 395–411. https://doi.org/10.1590/s1807-76922011000400004

Durham, Y., Manly, T. S. y Ritsema, C. (2014). The effects of income source, context, and income level on tax compliance decisions in a dynamic experiment. *Journal of Economic Psychology*, *40*, 220–233. https://doi.org/10.1016/j.joep.2012.09.012

Eruaga, M. (2024). *Enhancing global food safety standards through international collaboration and policy harmonization*.

Etuk, U., Etok, Ekerete, Udo y Uko, A. (2024). Constraints Affecting Farm Accounting Practices Among Rural Farmers in Akwa Ibom State, Nigeria. *Research Gate*. https://www.researchgate.net/publication/382947427_Constraints_Affecting_Farm_Accounting_Practices_Among_Rural_Farmers_in_Akwa_Ibom_State_Nigeria

Farmers Market Coalition. (2024). *Food Safety Modernization Act (FSMA)*.

Fawell, E. y Germida, M. (2012). *Preparing for FSMA: A Focus on Records Maintenance and Access*.

Food and Agriculture Organization of the United Natios. (2021). Organic foods – Are they safer? https://openknowledge.fao.org/server/api/core/bitstreams/b5377c27-d4b1-4cf1-9186-3eb7e702a18b/content

Food and Drugs Administration. (2024a). *Drug Supply Chain Integrity*.

Food and Drugs Administration. FDA. (2020). *Who Will Provide Training for the Food Industry? Public and Private Partners Working Together*.

Food and Drugs Administration. FDA (2024b). Key Requirements: Final rule on produce safety. https://www.ccof.org/wp-content/uploads/2024/04/FSMA-Final-Rule-on-Produce-Safety_Fact-Sheet.pdf

Gambelli, D., Solfanelli, F., Zanoli, R., Zorn, A., Lippert, C. y Dabbert, S. (2014). Non-compliance in organic farming: A cross-country comparison of Italy and Germany. *Food Policy*, *49*, 449–458. https://doi.org/10.1016/j.foodpol.2014.05.012

Gizaw, Z. (2019). Public health risks related to food safety issues in the food market: A systematic literature review. *Environmental Health and Preventive Medicine*, *24*(1), 68. https://doi.org/10.1186/s12199-019-0825-5

Graves, A., Terrell, P., Jadeja, R. y Holcomb, R. (2019). *FSMA Preventive Controls for Human Food: What Are the Costs to My Food Business? - Oklahoma State University*. https://extension.okstate.edu/fact-sheets/fsma-preventive-controls-for-human-food-what-are-the-costs-to-my-food-business.html

Guevara, P. (2024). *An Introduction to Food Hygiene*.

Gupta, S., Kumaresan, P., Saxena, A., Mishra, M., Upadhyay, L., A, A., S, A. y Magrey, A. (2023). Wildlife Conservation and Management: Challenges and Strategies. *UTTAR PRADESH JOURNAL of ZOOLOGY*, *44*(24), 280–286. https://doi.org/10.56557/UPJOZ/2023/v44i243840

Harrison, J. A., Gaskin, J. W., Harrison, M. A., Cannon, J. L., Boyer, R. R. y Zehnder, G. W. (2013). Survey of food safety practices on small to medium-sized farms and in farmers markets. *Journal of Food Protection*, *76*(11), 1989–1993. https://doi.org/10.4315/0362-028X.JFP-13-158

Humphrey, J. (2017). *Food safety, trade, standards and the integration of smallholders into value chains*.

Imami, D., Valentinov, V. y Skreli, E. (2021). Food Safety and Value Chain Coordination in the Context of a Transition Economy: The Role of Agricultural Cooperatives.

International Fresh Produce Association. (2024). *FSMA 204 Resources*.

Jobbs, J. (2003). Incentives for the adoption of Good Agricultural Practices. https://www.fao.org/4/ag854e/ag854e00.pdf

Kheradia, A. y Warriner, K. (2013). Understanding the Food Safety Modernization Act and the role of quality practitioners in the management of food safety and quality systems. *The TQM Journal*, *25*(4), 347–370. https://doi.org/10.1108/17542731311314854

King, H. (2022, 10 de octubre). Sanitation Prerequisite Programs as a Necessary Component of FSMS for Foodservice Establishments. *Food Safety*. https://www.food-safety.com/articles/8055-sanitation-prerequisite-programs-as-a-necessary-component-of-fsms-for-foodservice-establishments

Leape, L., Rogers, G., Hanna, D., Griswold, P., Federico, F., Fenn, C. A., Bates, D. W., Kirle, L. y Clarridge, B. R. (2006). Developing and implementing new safe practices: Voluntary adoption through statewide collaboratives. *Quality & Safety in Health Care*, *15*(4), 289–295. https://doi.org/10.1136/qshc.2005.017632

Linton, R. y McSwane, D. (2013). FDA Food Safety Modernization Ac. *Science Direct*.

Liu, P. y Eaton, T. E. (2023). Barriers to training Hmong produce farmers in the United States: A qualitative study. *Food Control*, *147*, 109560. https://doi.org/10.1016/j.foodcont.2022.109560

Lysenko, D. y Schott, S. (2018). Food Security and Wildlife Management in Nunavut. *SSRN Electronic Journal.* Publicación en línea avanzada. https://doi.org/10.2139/ssrn.3141873

Mata, S. y Bauer, B. (2024, 2 de diciembre). How FDA's Foreign Supplier Verification Programs (FSVP) Help Meet Food Safety Standards. *Food Safety*. https://www.food-safety.com/articles/9247-how-fdas-foreign-supplier-verification-programs-fsvp-help-meet-food-safety-standards

McBride, W. (2024). *Results of a Survey Measuring Business Tax Compliance Costs*. https://taxfoundation.org/research/all/federal/us-business-tax-compliance-costs-survey/

Narine, L., Harder, A. y Danyluk, M. (2019). Floridian Producers' Concerns About the Food Safety Modernization Act. *Food Protection Trends*.

National Library of Medicine. (1998). *The Current US Food Safety System*.

Organic Produce Network. (2024). *Organic Certification Requirements: The Strict USDA Standards*.

Overbosch, P. y Blanchard, S. (2023). Chapter 25 - Principles and Systems for Quality and Food Safety Management. En V. Andersen, H. Lelieveld y Y. Motarjemi (Eds.), *Food safety management: A practical guide for the food industry* (pp. 497–512). Academic Press. https://doi.org/10.1016/B978-0-12-820013-1.00018-8

Pacini, C., Wossink, A., Giesen, G., Vazzana, C. y Huirne, R. (2003). Evaluation of sustainability of organic, integrated and conventional farming systems: a farm and field-scale analysis. *Agriculture, Ecosystems & Environment*, *95*(1), 273–288. https://doi.org/10.1016/S0167-8809(02)00091-9

Tai, S. (2016). *Whole Foods: The FSMI and the Challenges of Defragmenting Food Safety Regulation.* https://doi.org/10.2139/ssrn.2850687

Tarnate, J. (2019). *Food Safety culture and technology enchance Food Safety Modernization Act*.

Trinetta, V., Gragg, S. y Umut Yucel (2021). The Very Real Impact of the Food Safety Modernization Act: A Roundtable Symposium Addressing FSMA's Effect on Academia and Industry. *Food Protection Trends*. https://www.foodprotection.org/members/fpt-archive-articles/2018-07-the-very-real-impact-of-the-food-safety-modernization-act-a-roundtable-symposium-addressing-/

U.S. Food and Drug Administration. (2023). *FSMA Final Rule on Produce: Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption Safety*. https://www.fda.gov/food/food-safety-modernization-act-fsma/fsma-final-rule-produce-safety.

Uddin, N. y Bari, M. L. (2019). Chapter 3 - Governmental Policies and Regulations Including FSMA on Organic Farming in the United States and Around the Globe. En S. A. Micallef y D. Biswas (Eds.),

Safety and Practice for Organic Food (pp. 33–62). Academic Press. https://doi.org/10.1016/B978-0-12-812060-6.00003-9

United States Department of Agriculture. (2021). *Food safety: Importance of food safety*.

United States Food and Drug Administration. (2023). *FSMA Final Rule on Produce: Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption Safety*. https://www.fda.gov/food/food-safety-modernization-act-fsma/fsma-final-rule-produce-safety.

Versteeg, M. F. (1992). Showing compliance with probabilistic safety criteria and objectives. *Reliability Engineering & System Safety*, *35*(1), 39–48. https://doi.org/10.1016/0951-8320(92)90020-L

Vigar, V., Myers, S., Oliver, C., Arellano, J., Robinson, S. y Leifert, C. (2019). A Systematic Review of Organic Versus Conventional Food Consumption: Is There a Measurable Benefit on Human Health? *Nutrients*, *12*(1), 7. https://doi.org/10.3390/nu12010007

Walters, K. y Rodriguez Joel (2017). The Importance of Training and Development in Employee Performance and Evaluation. *Research Gate*. https://www.researchgate.net/publication/332537797_The_Importance_of_Training_and_Development_in_Employee_Performance_and_Evaluation

Williams, D., Falcone, E. y Fugate, B. (2021). Farming down the drain: Unintended consequences of the Food Safety Modernization Act's Produce Rule on small and very small farms. *Business Horizons*, *64*(3), 361–368. https://doi.org/10.1016/j.bushor.2021.02.004

Wirth, D. (2023). *Chapter 13: The Food Safety Modernization Act and international trade rules in: Research Handbook on International Food Law*. https://www.elgaronline.com/edcollchap/book/9781800374676/book-part-9781800374676-26.xml