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## Economically Motivated Adulteration of Honey: Quality Control Vulnerabilities in the International Honey Market

### ABSTRACT

**E**conomically-motivated adulteration (EMA) is the adulteration of food for financial advantage. The high value of honey puts it at risk for EMA because of strong economic incentives. The honey market is a truly global market, with over 60% of honey used in the U.S. coming from imports. There is currently no U.S. federal standard of identity for honey, which hampers regulatory efforts to ensure the safety and quality of honey. Several types of EMA have been identified in the honey industry, including dilution with less expensive syrups, intensive supplemental feeding of honey bees, unapproved use of antibiotics, and masking the true country of origin. Various factors have led to quality control vulnerabilities in the international honey market, including decreased domestic production, the lack of a federal standard of identity, insufficient analytical methods, trade policies, and country-specific testing for antibiotic residues. Despite regulatory efforts, regulatory

agencies and trade organizations have struggled to ensure safe, high quality, appropriately labeled honey in the international market. This lack of quality control has potentially far-reaching consequences for public health, prices on the worldwide honey market, and the livelihood of beekeepers.

### INTRODUCTION

**E**conomically motivated adulteration (EMA), according to the U.S. Food and Drug Administration (FDA) working definition, is the “fraudulent, intentional substitution or addition of a substance for the purpose of increasing the apparent value of the product or reducing the cost of its production, i.e., for economic gain” (36). EMA can occur in all food products and is often referred to as food fraud. In a broad sense, we consider EMA in food to include knowingly selling any food product that is not up to standards (15). EMA is not a new problem. It was addressed by ancient Egyptian meat laws, Greek and Roman wine laws, and U.S. food laws as far back as 1784 (9). Higher value food items are often targets of EMA because of the strong economic

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incentives. In the sweetener industry, common targets for EMA include maple syrup and honey.

The Codex Alimentarius, established by the Food and Agricultural Organization and the World Health Organization, serves as a set of voluntary international food standards, guidelines and codes of practice that “contribute to the safety, quality, and fairness of the international food trade” (7). The Codex Alimentarius defines honey as “the natural sweet substance produced by honey bees from the nectar of plants or from secretions of living parts of plants or excretions of plant sucking insects on the living parts of plants, which the bees collect, transform by combining with specific substances of their own, deposit, dehydrate, store and leave in the honey comb to ripen and mature” (6). One of the challenges with identifying EMA in honey is the lack of a federal standard of identity for honey in the U.S. Some states are working to resolve this ambiguity. Florida has a standard of identity that is very similar to the Codex Alimentarius definition, and the state legislature of Wisconsin is considering a definition for honey that will conform to the standard contained in the Codex Alimentarius (17, 46). The E.U. has a standard of identity for honey that is almost identical to that of the Codex Alimentarius (13).

Several types of EMA have been identified in the honey industry. These include additives used to dilute and extend honey, intensive supplemental feeding of honey bees to increase honey production, use of antibiotics and other chemicals in honey bee populations in a way that results in residues in honey, and masking the true country of origin of honey to avoid tariffs and testing.

One common type of EMA involves extending or diluting honey with other less expensive sweeteners. Commonly identified extenders are corn, cane, and beet syrups (16, 21). In 2011, the average bulk price for honey was about 173 cents per pound, while high fructose corn syrup was about 32 cents per pound and refined beet sugar was about 56 cents per pound (32). With a three- to five-fold difference in price, the use of honey extenders can lead to significant economic advantage.

Supplemental feeding of honey bees with sugar syrups may be necessary to supply the nutritive requirements of colonies in areas and at times when natural food sources are inadequate and may also be important to build colonies (24). Supplemental feeding may be used to provide sustenance during the winter and early spring, before honey production begins. However, if this process is used during honey production, it can lead to a product that is similar to honey adulterated with added sugar syrups (8). The qualities of honey produced with intensive supplemental feeding include a sugar profile different from that of pure honey and dilution of the natural nutritional properties of honey. Because of these changes in quality of the final product, the authors consider intensive supplemental feeding of honey bees to be another form of EMA of honey.

Certain antibiotics and other chemicals may be used in beekeeping to ensure the health of the bees in a colony. In the U.S., 10 chemicals are approved for use in honey bee colonies, three of which are antimicrobials (20). The use of approved drugs includes a required withdrawal time, which refers to the period of time during and after treatment in which honey from the treated hive should not be collected for consumption. This process helps to ensure that drug residues are not introduced into the human food supply. When unapproved drugs are used or when approved drugs are used without an appropriate withdrawal period, antibiotic and other drug residues can be present in the honey. This is a third type of EMA that has been identified in honey production.

Last, in recent years, multiple instances of masking the true country of origin of honey have been documented (24, 45). This enables honey producers from certain countries to avoid additional testing or tariffs that may be imposed upon import into other countries. Shipment of honey through intermediate countries and subsequent relabeling, often called “transshipment” or “honey laundering,” is one method for masking the true country of origin (23). Another method is removal of pollen through honey filtering, since pollen can be used to identify the geographic origin of honey.

## **FACTORS IN LOSS OF QUALITY CONTROL IN THE HONEY MARKET**

### **Decreased domestic production**

In the past two decades, the honey market in the U.S. has shifted significantly from one in which honey production is primarily domestic to one in which more than half of honey is imported. One reason for this decline is colony collapse disorder, an unidentified syndrome in honey bees. Colony collapse disorder caused colony losses of about 33 percent each year in the U.S. from 2006 to 2011 (29). Peak honey production in the U.S. occurred in 1969, with almost 267 million pounds produced. By 2012, that level had decreased by almost 45% to 147 million pounds (32, 45). Imports correspondingly increased each year from 1969 to 2012, reaching 298 million pounds and accounting for over 66% of the available supplies in 2012 in the U.S. (see Fig. 1).

### **Lack of a federal standard of identity**

In 1995, a Michigan jury ruled in favor of a honey processor indicted for the intentional sale of adulterated honey, partly because of a lack of government honey regulations (5, 33). Although no federal standard of identity currently exists for honey in the U.S., an effort has been made by the U.S. honey industry to create one. In 2006, a Citizen’s Petition submitted to the FDA by various stakeholders proposed an amendment to the U.S. Code of Federal Regulations to include a standard of identity that was similar to the Codex Alimentarius definition (1). The FDA response indicated that a decision on the petition was

## Domestic honey production and imports, United States 1965–2010

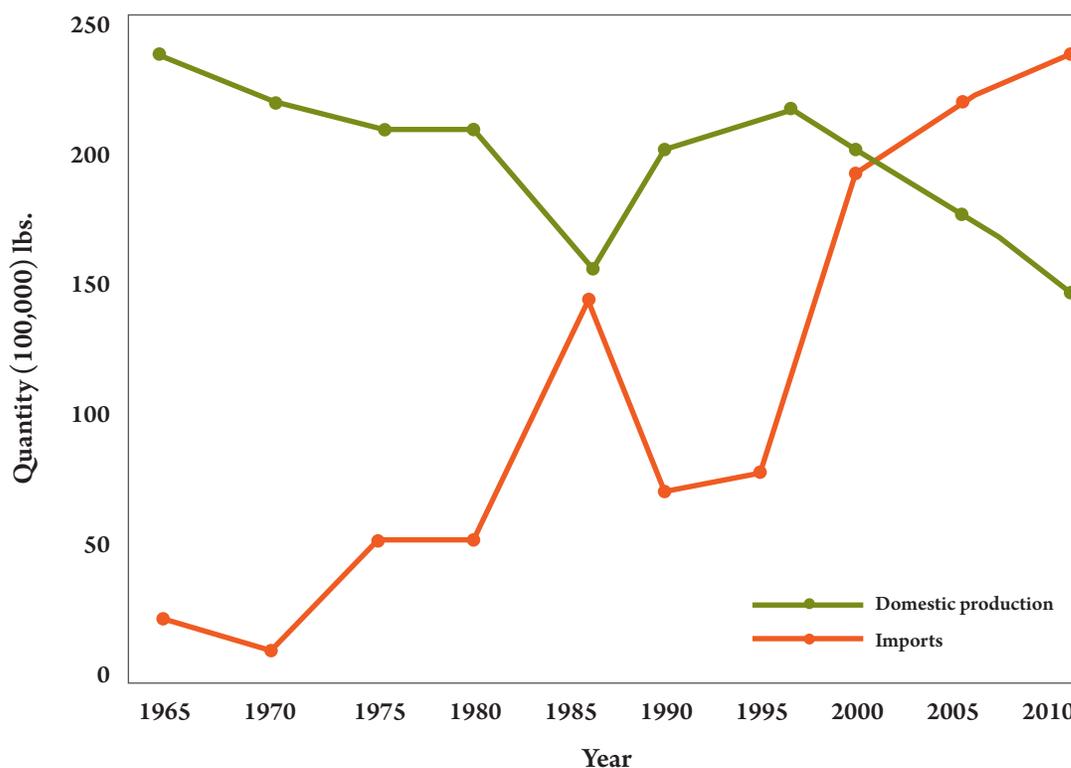


Figure 1. Quantities of domestic honey production and U.S. imports, 1965–2010. (Source: United States Department of Agriculture Agricultural Research Service and United States International Trade Commission Interactive Tariff and Trade DataWeb)

not reached because of “other agency priorities and the limited availability of resources” (1). Similar petitions were filed in 2007 and again in 2009 (18). The industry gained support in 2010 when 15 U.S. senators submitted letters to the FDA stressing the importance of adopting a federal standard of identity for honey. More recently, the U.S. House of Representatives approved a bill that, if passed into law, requires the Secretary of Agriculture to submit a report describing “how an appropriate federal standard for the identity of honey would be in the interest of consumers, the honey industry, and United States agriculture” (28). Some individual states have created standards of identity for honey (17, 46). However, these state standards can be enforced only within the respective states. A federal standard of identity for honey would enhance regulatory enforcement ability by providing a legal definition for honey sold in the U.S.

Quality control or “self-policing” within the honey industry is variable. A survey of honey packers in the U.S. conducted in 1999 found that only 58% of the respondents reported testing honey for EMA (16). More recent media reports suggested that some packers were regularly testing to ensure the quality of their imported honey, while others were unwilling to discuss the topic (22). According to the CEO of the National Honey Board, many packers test their

honey for purity, authenticity, and source, but no specific data is available on who is testing and what analytical methods are used (4).

### Insufficient analytical methods

The common analytical methods for honey used by the food industry include those that can identify the presence of C4 sugars, such as those in corn syrup, and C3 sugars, such as those in rice syrup (4). Stable carbon isotope ratio mass spectrometry (SCIRA) can be used to identify adulteration of honey with syrups that imitate the sugar profile of honey (12). The detection limit for this laboratory method is approximately 20%, which would still allow for dilution with other sugar syrups to a degree that could result in substantial economic advantage. The Association of Analytical Communities (AOAC) International official method for testing EMA in honey, AOAC 998.12, couples SCIRA with isolated honey protein levels. This method improved the test sensitivity and lowered the detection limit to 7%, which would still allow some adulteration but would identify high-level adulteration. In addition, the use of this method for regulatory agency identification of honey EMA is complicated by the current inability of FDA to conduct the SCIRA portion of this test, AOAC 991.41. According to a

honey import alert issued by the FDA, “FDA laboratories do not have the instrumental capability to analyze honey according to the Official Methods of Analysis of AOAC International, AOAC Official Method 991.41, which requires an isotope ratio mass spectrometer” (40). This would require the FDA to send samples out for third party analysis, making testing more useful as a survey of the industry than as an intervention strategy.

**Trade policies**

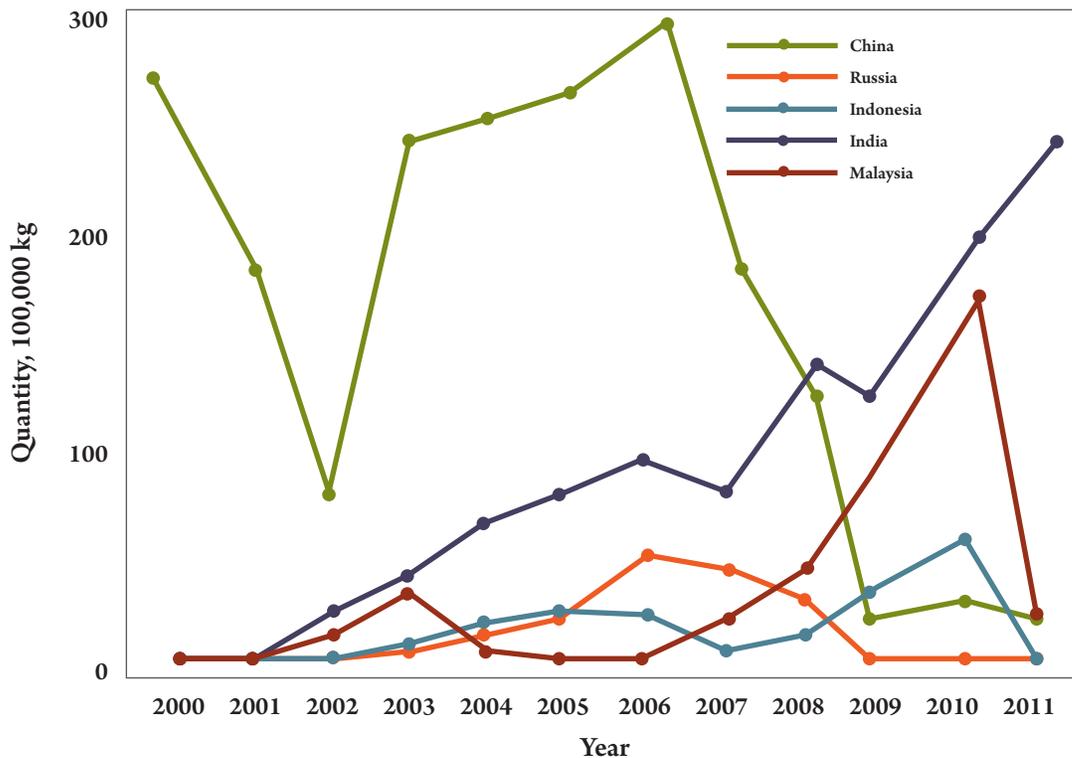
In October 1994, a petition was filed with the U.S. International Trade Commission (USITC) and the U.S. Department of Commerce on behalf of the American Beekeeping Federation and the American Honey Producers Association alleging that the U.S. honey industry was threatened by the importation of inexpensive Chinese honey. In November of that year, the USITC issued a preliminary determination stating that “there is a reasonable indication that an industry in the United States is materially injured or threatened with material injury by reason of imports of honey from The People’s Republic of China (China), that are alleged to be sold in the United States at less than fair value” (42). The export of products in large quantities at less-than-

market value is referred to as “dumping” on the market. As a result of this determination, an anti-dumping tariff was applied to imports of Chinese honey.

A similar determination was made by the USITC in 2000 regarding honey imports from both Argentina and China (43). In 2000, more than 16% of total honey imports into the U.S. originated in either China or Argentina. That figure dropped to 12% in 2001 and less than 4% in 2002 (25). In 2012, the USITC voted unanimously that the existing order on honey imports from China should remain in place (44). In addition to the U.S. tariff on Chinese honey upheld in 2000, the E.U. instated a ban on honey imports from China in 2002 (2). This led to a surplus of Chinese honey in the international market.

At the same time that imports from China were decreasing, there was a corresponding increase in honey imports from countries that historically did not produce or export large amounts of honey (see Fig. 2). To avoid large tariffs upon import into the U.S. and to circumvent the ban on honey in the EU, Chinese honey manufacturers set up routes to transship honey (23). Transshipment refers to the transport of honey through intermediary countries, and subsequent

**Yearly imports of honey into the U.S. from 5 countries**



Note: quantities include 4 grades of bulk honey and honey packaged for retail sale

Figure 2. Quantities of U.S. imports of honey from countries that traditionally have not produced large amounts of honey (Source: U.S. Customs and Border Protection; not official U.S. trade statistics)

relabeling to conceal the true country of origin, a process that has also been called “honey laundering.” One large honey laundering scheme in the U.S. resulted in eleven individuals and six companies being indicted on U.S. federal charges alleging a global conspiracy to illegally import Chinese honey. A total of 606 shipments of Chinese-origin honey entered the United States between March 2002 and April 2008, though declarations incorrectly stated that the honey originated in Russia, India, Indonesia, Malaysia, Mongolia, Philippines, South Korea, Taiwan, and Thailand (34). The defendants allegedly conspired to illegally import more than \$40 million worth of Chinese-origin honey to avoid anti-dumping duties totaling nearly \$80 million. The indictment also alleged that honey continued to be sold to the U.S. despite the fact that it had tested positive for antibiotic residues. Some of the honey was rejected by one purchaser because of the presence of antibiotics and was subsequently resold despite the known contamination with antibiotics (3).

In an attempt to avoid receiving transshipped Chinese honey from India, The E.U. banned honey imports from India in June of 2010 (23). This act was followed by a public outcry by producers and consumers asking for similar action to be taken in the U.S. (22). However, the U.S. ultimately did not ban any honey imports.

#### **Increased testing for antibiotic residues in Chinese honey**

The presence of antibiotic residues is regulated in all food products of animal origin. Antibiotics and other chemicals are used in the honey industry to ensure the health of bee colonies. In the U.S., very few antibiotics and other chemicals are approved for use in bee colonies, and they are approved for use only at specific doses, with a withdrawal period required to decrease the possibility of antibiotic residues entering the food supply (20). For example, the antibiotic oxytetracycline is approved for the prevention of European and American foulbrood (a bacterial disease that affects honey bee populations) at 200 mg per colony, three times, at 4–5 day intervals, with a 45-day withdrawal period. Honey produced during the withdrawal period cannot be collected and introduced into commerce for human consumption.

Honey imported from China has tested positive for residues of antibiotics that are not approved for use in bee colonies in the U.S., such as chloramphenicol, enrofloxacin, and ciprofloxacin (26). Honey imported into the E.U. from several countries, including China, Turkey, Argentina, Czech Republic, Uruguay, and Mexico, has been shown to contain antibiotic residues, including chloramphenicol, metronidazole, nitrofurantoin, sulfathiazole, streptomycin, lincomycin, oxytetracycline, sulfadimidine, and tylosin (14). Chloramphenicol is an inexpensive, broad spectrum antibiotic that can cause a rare and irreversible condition in humans known as aplastic anemia, even at very low doses; therefore, it is not approved for use in any food producing animals in the U.S. (19). Chloramphenicol has been used on honey bee colonies in China since approximately

1997, when an outbreak of foulbrood threatened the beekeeping industry in China (11). Other antibiotics that have been identified in honey, such as enrofloxacin, are approved for use in some food producing animals but are not approved for use in honey bees in the U.S. (20). Enrofloxacin is in a class of antibiotics that is considered by FDA to be important to human health, and measures have been taken to reduce the use of such classes of drugs to mitigate the development of widespread resistance (37). Because of the history of antibiotic residues in Chinese honey, most notably residues of chloramphenicol, shipments of Chinese honey have been subject to additional testing by the FDA before entering U.S. commerce (41). The desire to avoid additional scrutiny provides additional incentive for companies to transship honey to mask the true country of origin.

#### **DISCUSSION**

The many factors already outlined have negatively affected quality control in the international honey market, allowing for the sale of honey that does not have a standard level of quality. A marked increase in imported honey has arguably led to less regulatory oversight of the honey consumed in the U.S. However, the largest impact on the international honey market has come from the shift in primary production sources and policies aimed at protecting U.S. honey producers from unfair trade and inferior honey.

General food protection advancements in recent years will likely affect the honey industry. The FDA Food Safety Modernization Act (FSMA), signed into law on January 4, 2011 (27), specifies that importers need to have a program in place to verify that the food products they import from foreign suppliers are not adulterated or misbranded (39). As identified in the FSMA Proposed Rule for Preventive Controls for Human Food, importers will need to verify that their suppliers are in compliance with reasonably appropriate risk-based preventive controls that provide the same level of public health protection as those required under FSMA (35, 38). One of the dangers of transshipped honey is that it can lead to importation of honey that has circumvented this portion of the U.S. food safety requirements, since the origin of the honey is falsely declared.

In 2012, the total U.S. consumption of honey was 400 million pounds (32). The generally accepted serving size for honey is 21g, which means that approximately 8.6 billion servings of honey were consumed in the U.S. in 2012 (30). During the same time, almost 70% of the honey consumed in the U.S. was imported (31).

These estimates, paired with what appears to be a pervasive problem of EMA of honey, are worrisome for public health. Serious human health concerns regarding the presence of chloramphenicol and other antibiotics that can lead to microbial resistance have been discussed previously. Although rare, there is documentation of allergic reaction to antibiotics in some individuals exposed to antibiotic residues in other types of food (10). Additionally, the widespread

EMA of honey illustrates a lack of control that could provide an opportunity for intentional adulteration of honey with something even more concerning for public health. This presents an opportunity for the FDA and other public health agencies to be proactive in preventing such incidents caused by consumption of honey.

Honey regulation has been hampered by a lack of a federal standard of identity for honey, the limits of detection of analytical methods, and trade policies. These trade policies include temporary bans on honey imports, anti-dumping regulations, and implementation of stiff import tariffs on honey from certain countries. The anti-dumping tariff placed on Chinese honey, along with additional testing of Chinese honey for chloramphenicol at the U.S. border, has provided a strong incentive for EMA in the honey market. Despite regulatory efforts, large countries and trade organizations have not been able to ensure safe, high quality imported honey. This combination of circumstances has resulted in a lack of quality assurance across the entire market. The lack of consistent quality assurance across the market for honey has allowed adulterated products to reach the consumer, leading to a loss of consumer confidence and increasing the risk of public health consequences. Widespread adulteration of honey may also affect global honey prices and the livelihood of beekeepers.

Addressing the issues outlined in this paper would help improve quality control in the honey market, particularly

with honey imported into the U.S. Creation of a federal standard of identity for honey would enhance regulatory and industry oversight of the quality of honey being sold and consumed in the U.S. This would best be accomplished with industry and regulatory support of initiatives against EMA of honey, including increased inspection and testing by both parties. Finally, an exploration of the effect of trade policies on the identity and quality of imported honey is necessary to address transshipment and mislabeling of honey that is ultimately consumed in the U.S.

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