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J Points

Targeting of Analytical Sampling - Avoiding the Echo-Chamber Trap

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Summary

This paper gives an approach to prioritisation of sampling and analytical testing when the only data you have available are trends in historical test results.

The pitfalls of relying purely upon trends in "positive" results are highlighted. Rather, an approach is recommended where trends are normalised where possible for trade volumes or for known biases in testing frequencies.

Some examples are shown, and some of the results are counter-intuitive. Issues with a relatively high incidence, as measured using this approach, include undeclared sulphites in dried apricots from Greece, USA, Uzbekistan and Pakistan (rather than from Turkey), aflatoxins in figs, nutmeg and pistachios (rather than in peanuts), and pesticide residues in goji berries.

The approach is particularly applicable to assessing the relative mycotoxin risk in the same product from different countries of origin. Again, the results can be counter-intuitive. Chinese peanuts have a significantly higher incidence of aflatoxins than those from the USA, but the reverse is true for pistachios.

Introduction

There is an ongoing debate about the role of analytical testing at point-of-sale in assuring the safety and authenticity of food. This applies both to testing by enforcement authorities and by food retailers themselves. The control of chemical contaminants and food fraud risk are based upon preventative systems and codes of practice, verified by audit both by large industry players and by accredited Certification Bodies.

Analytical testing has a valuable place in ensuring that preventative controls are effective but is best when targeted at the most relevant point in the supply chain. For example, agrochemical residues such as pesticides or veterinary medicines should be tested at the point of primary production (harvest, slaughter or milking). Process contaminants are best tested during New Product Development or under worst-case manufacturing conditions. Adulterants are best tested on receipt of raw materials.

This seems to leave little place for surveillance testing at the point-of-sale of finished product, other than for enforcement authorities checking for rogues who either falsify or ignore the preventative control systems and in providing a deterrent to malpractice. Such sampling and analysis remains a legal obligation for enforcement authorities. However, even in legitimate and well-run businesses, it is surprising how often end-product surveillance testing highlights a problem. The objective of surveillance testing, in this context, is to identify and strengthen weaknesses in the control systems, rather than to accept/reject a specific batch or consignment.

Targeting of Surveillance Sampling

Surveillance testing can only ever be an extremely occasional spot-check. It is neither necessary nor desirable to base a food safety assurance system on testing a representative proportion of a product or from a country of origin for each contaminant or fraud risk. This has been brought into sharp relief by reduced budgets and resources for testing. It is more important now, than ever, that samples and tests are chosen that are most likely to highlight a problem or issue.

Adequate and meaningful surveillance presents a problem for organisations such as enforcement authorities, who have no visibility of the supply chain details or of the preventative control systems in place. This is illustrated by examples of the types of questions that a food business operator might consider for prioritising their own surveillance testing, Table 1.

Table 1 – Examples of Questions for the Prioritising of Surveillance

Risk	Risk Factor	Whether a Useful Consideration for Enforcement Authorities?
Authenticity	Raw material price suspiciously cheap	No – no visibility
Authenticity	Complex, opaque supply chain for a specific raw material	No – no visibility
Authenticity	Specific vulnerability identified in supply chain *eg* spices that are ground prior to import into EU	No – no visibility
Authenticity	Trading terms permit spot-buying by suppliers when regular sub-suppliers cannot fulfil orders	No – no visibility
General	No requirement in trading terms that all suppliers are certified to a GFSI-recognised scheme	No – no visibility

Risk	Risk Factor	Whether a Useful Consideration for Enforcement Authorities?
Pesticide residues	Weak marketing and control system for agrochemicals in country of origin	Yes – requires some sector-specific knowledge
Pesticide residues, Veterinary residues	Consolidated "cottage industry" supply chain, rather than a small number of large well-controlled growers	Some assumptions can be made based on crop and country of origin
Acrylamide in potato crisps	Potato variety with higher sugar content, or stored long term in cold conditions	No – no visibility
Arsenic in rice and rice products	Rice country of origin – Southern Europe	Only if country of origin is identified on pack
Dioxins in meat	Animal feed not covered by UFAS assurance scheme	Some assumptions can be made based on country of origin
Chlorate in pre-prepared salad	Strong hypochlorite wash used in the bagging factory	No – no visibility

To compound the difficulty, enforcement authorities need to prioritise their resources over a much wider range of potential issues than most food business operators. A potato crisp manufacture may just have to worry about acrylamide, pesticide residues, glycidyl esters, allergen cross-contamination and fraudulent variety substitution. A Local Authority, despite its statutory obligations to food safety and standards, may only have resources for a few hundred (if any!) tests per year. It needs to prioritise between everything from shellfish toxins, to adulterated olive oil, to the migration of packaging inks, to unlabelled allergens, to unapproved ingredients in food supplements.

It is unsurprising that enforcement authorities often rely on historical trends in publicly-reported results to prioritise their sampling. This includes following the lead of the European Commission, in cases where an upward trend in positive results has led to a food being added to the "intensified checks" Regulation 669/2009[1]. This is sometimes termed Horizon Scanning, but in truth is looking at the wrong horizon; the rear-view mirror, rather than at the road ahead. But there is a bigger pitfall with relying solely on previous trends to target future sampling – the echo-chamber effect.

The Echo-Chamber Effect

There are many public sources of collated test results and incidents, from free-to-access databases such as the RASFF (Rapid Alert Service for Food and Feed) portal[2] to subscription services such as Fera's Horizonscan database[3]. Most suffer from the same weakness; only positive results are listed, not negatives. They give no indication of the percentage incidence of an issue amongst the samples tested. An increasing trend in positives might reflect an increased incidence. However, it might also reflect an increase in testing frequency or more comprehensive reporting from a particular data source. Without knowledge of the percentage incidence of positives from the samples tested it is impossible to weigh the relative incidence of one contaminant against another in a specific food, or the relative risk from one country of origin versus another. There are a few exceptions where both negative and positive results are published – *eg* the UK Pesticide Residues in Food surveys[4] – but these are generally too few samples to be statistically significant.

Positive results, reported without the context of the corresponding negatives, always drive increased testing throughout the industry. This can result in a self-perpetuating spiral of testing of a specific food (for example, nitrofuran antibiotic residues in Bangladeshi prawns in the late 2000's[5]) whilst other sources that are higher risk can remain untested. More testing leads to more positive results which leads to more testing. Worse-than-random decisions can arise when sampling policy is based upon these trends. For example, a known issue with pesticide residues in yardlong beans from Thailand and The Dominican Republic led to them being included in Regulation EC/669/2009 for intensified checks (50% of consignments to be tested) at EU import. Subsequent data, however, indicated the same problems with yardlong beans from other countries; Thailand and Dominican Republic just happened to be the ones that had been tested the most (and were tested much more, following inclusion in the Regulation, driving a further apparent upward trend in positives). Thus, if a food manufacturer had chosen to delist Thai yardlong beans in 2010 they could have inadvertently switched to an alternative source that had just as high a risk of pesticide residues but was not subject to the same checks and controls at EU import or by Local Authorities.

Data Normalisation – Incident Frequency

In the absence of expressing positive results as a percentage of samples tested, there are other approaches to normalising the positive results published on sources such as the RASFF database or Horizonscan. One method is to normalise trends as the number of positive results per production tonnage, or per import tonnage, using free online data sources such as FAOSTAT[6], the INC Global Statistical Review[7], or the FAO's annual fisheries reports[8]. This is still imperfect; publication of trade data lags by a year or two, the approach does not recognise that one commodity or source may be tested more than another, it may over-represent low-weight commodities such as spices or it may under-represent commodities such as rice where most production is consumed in countries where there is less testing and reporting of problems. Nevertheless, it can give a very different picture of relative risk, as illustrated by Figures 1 and 2.

Figure 1 illustrates global incidents, as collated on Fera Horizonscan database; including all issues described as chemical contaminant, unauthorised additives or ingredients, allergens or authenticity.

Figure 2 shows the same data normalised for global production figures taken from FAOSTAT (the most recent year data available for each commodity – generally 2013), from FAO report "The State of World Fisheries and Aquaculture 2014", and from the International Nut and Dried Fruit INC - Global Statistical Review 2014-2015. It gives a very different picture.

Figure 1 – Absolute Number of Incidents (Chemical and Authenticity) – Top 10 Food Ingredients

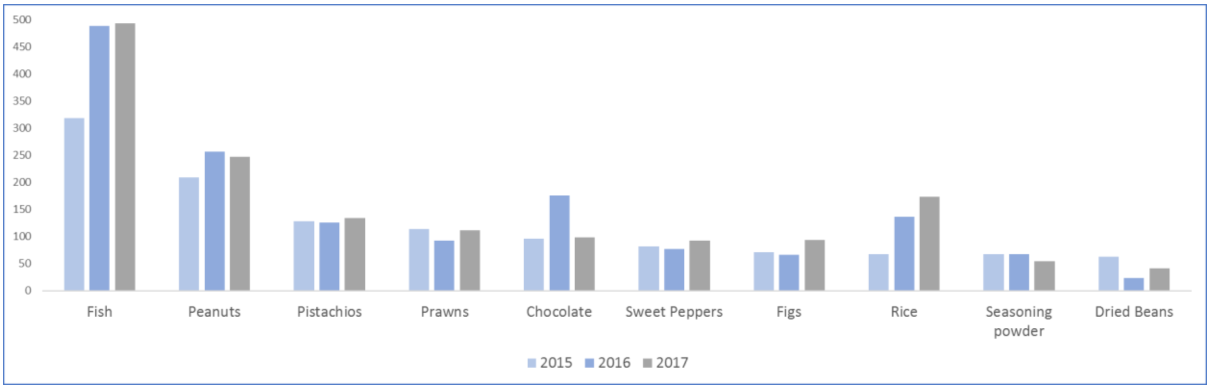
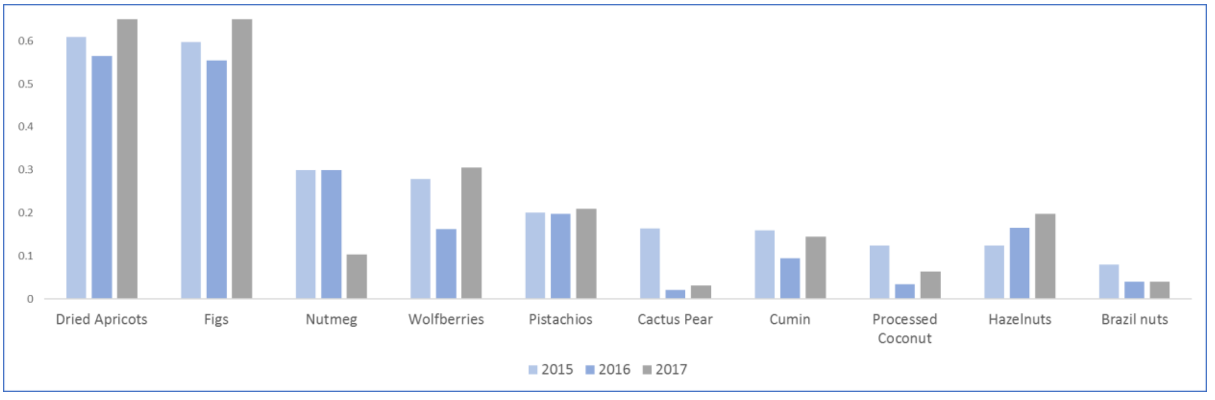
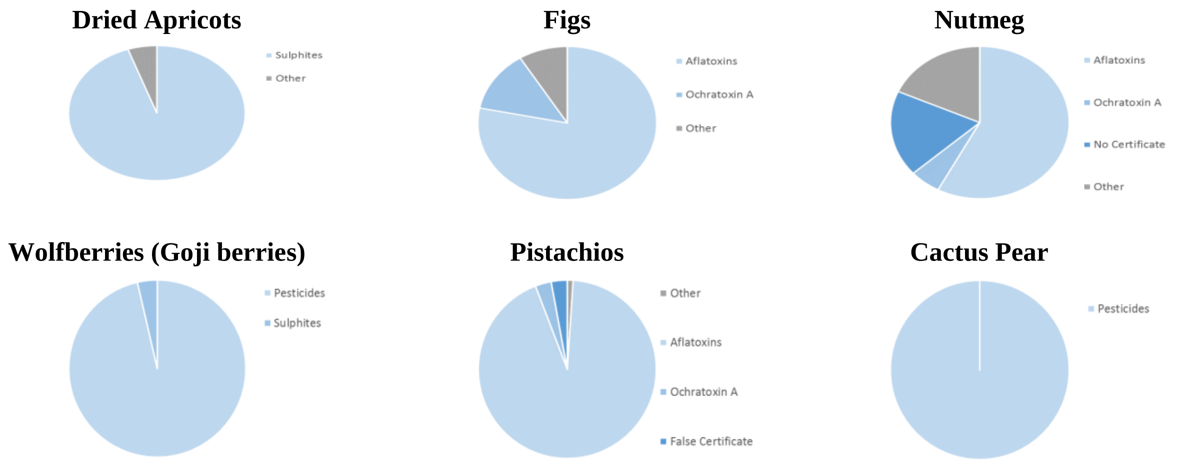


Figure 2 – Normalised Data: Number of Incidents per Thousand Tonne Production – Top 10 Food Ingredients



Drilling into the top issues for the highest-ranked foods shows that the Pareto principle applies: a small number of issues account for the bulk of the incidents, Figure 3.

Figure 3 – Incident Issues for the Six Highest-ranked Foods (2015, 2016, 2017 data aggregated)



The next question is whether any particular country of origin is higher risk. Again, it is invaluable to normalise data if possible. For example, for undeclared sulphites in dried apricots, an absolute count would suggest that the risk is firmly centred on those originating from Turkey. However, the collated data for sulphites mainly consist of test results from within the EU and at EU designated points of entry; Turkey is, by far, the biggest exporter of dried apricots into the EU. When positive results are normalised against export volumes (with the caveat that sample numbers are small) it appears that dried apricots from some of the smaller producing countries have a far higher relative incidence, Figures 4 and 5.

Figure 4 – Sulphites in Dried Apricots Absolute Count, Country of Origin

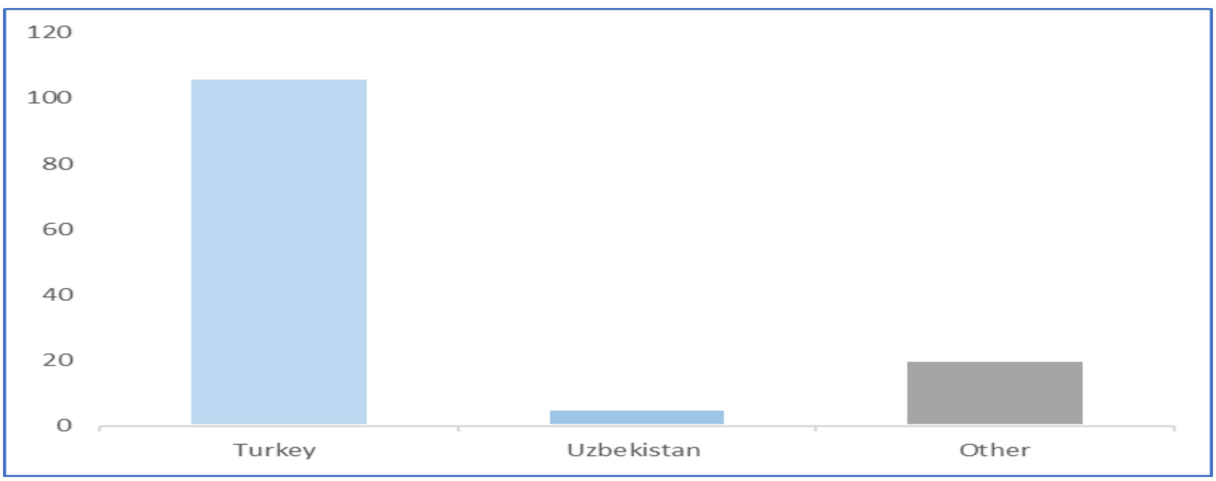
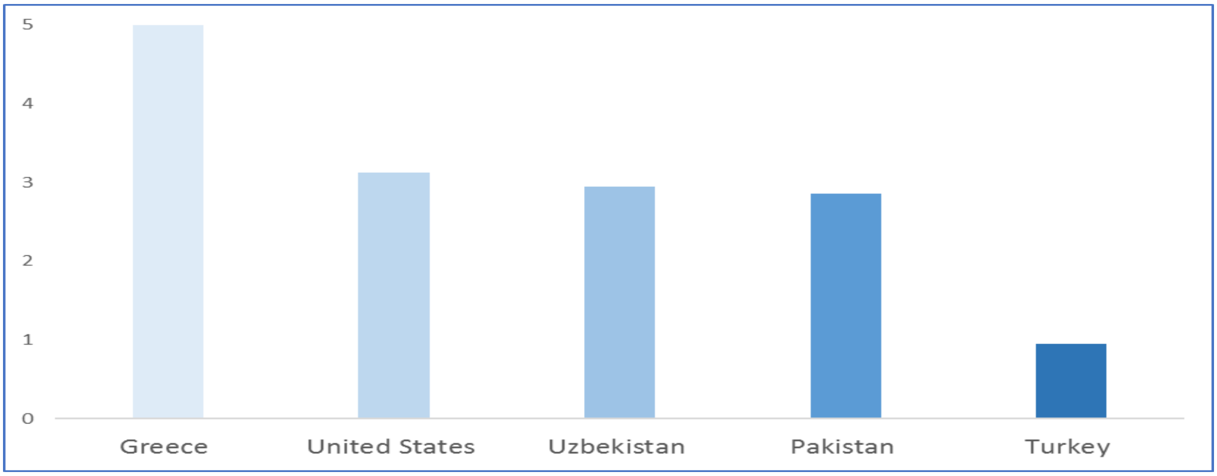


Figure 5 – Sulphites in Dried Apricots Normalised by Export Volume (per 1,000 Tonnes)



Data Normalisation – Country of Origin (Mycotoxins)

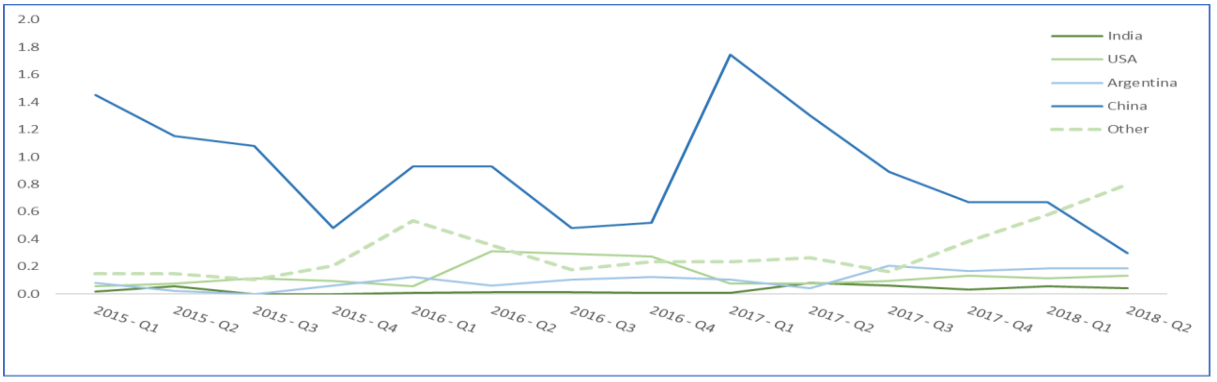
One specific example where data normalisation can give useful insight is in assessing the relative risk of mycotoxins in nuts and dried fruit from different countries of origin.

Although mycotoxin-forming mould growth is clearly climate related different nut-producing regions tend to have similar climates. Minimising the risk of mould growth is highly dependent upon good agricultural processing, storage and transport practices and there is best practice and guidelines that apply to each type of crop. However, if you are an enforcement agency looking to carry out surveillance testing on the final product you are unlikely to have sight of how the crops were harvested, dried or stored.

In this case, there are fewer caveats associated with normalising results for national production volumes than with other food types and contaminants. This is because testing rates for mycotoxins in nuts tend to be fairly uniform regardless of country of origin; mycotoxins are seen as high risk irrespective of origin, likely to appear in unpredictable hotspots, and therefore many industry Codes of Practice requirements and public-sector testing schemes will involve sampling universally at regular and relatively frequent intervals. Commission Regulation 669/2009 currently specifies frequencies of sampling only for aflatoxins in peanuts from Brazil and Sudan, with the frequency for Brazil being stepped down compared to historical levels. Historical sample numbers have not been overly skewed by targeting at specific origins. Testing frequencies have remained unchanged over time, as have international trade statistics. There are plenty of results to draw out trends. All mycotoxin data presented here in Figures 6-9 are normalised using the 5-year average export tonnage, excluding shell, from the INC 2015-16 Global Statistical Review.

The results of this approach are surprising. Many industry and laboratory professionals would highlight Argentine peanuts, Chinese peanuts and US pistachios as being at highest risk of aflatoxin contamination, and this seems supported by the number of historic incidents. But the reality is somewhat different, as shown in Figure 6. They only have a high number of incidents because they are the largest exporters.

Figure 6 – Reported Aflatoxin Incidents per 1,000 Tonne Exports Peanuts, January 2015 – June 2018

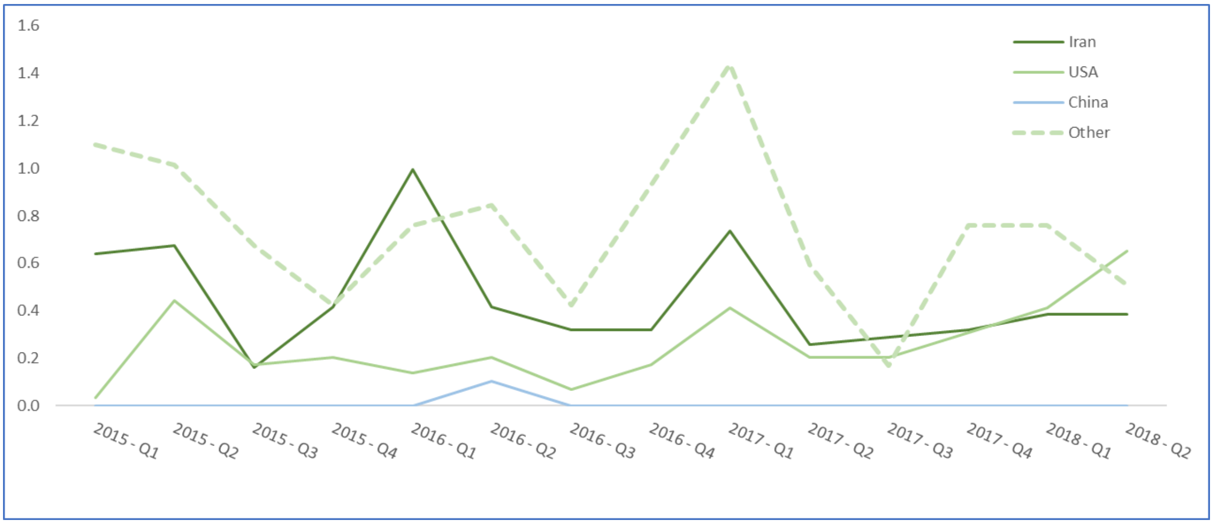


The major exporters, excluding transit countries, are India (39% of global export tonnage), USA (14%), Argentina (13%) and China (7%). Most Indian exports go to Vietnam, are likely to be subject to less testing than trade to the EU or US, and so incidence is likely to be underestimated in this analysis.

There is a notable difference in relative incidence between China (higher) and USA/Argentina (lower). Smaller producers (*eg* Egypt, Madagascar, Indonesia) have a higher incidence rate than either the USA or Argentina. The 2018 increase in incidence-rate from "other" countries is attributable mainly to Egypt and The Gambia. There is no evidence of seasonality.

Similarly, normalised trends can be shown for aflatoxins in pistachios, dependent upon country of origin, as in Figure 7.

Figure 7 – Reported Aflatoxin Incidents per 1,000 Tonne Exports Pistachios, January 2015 – June 2018

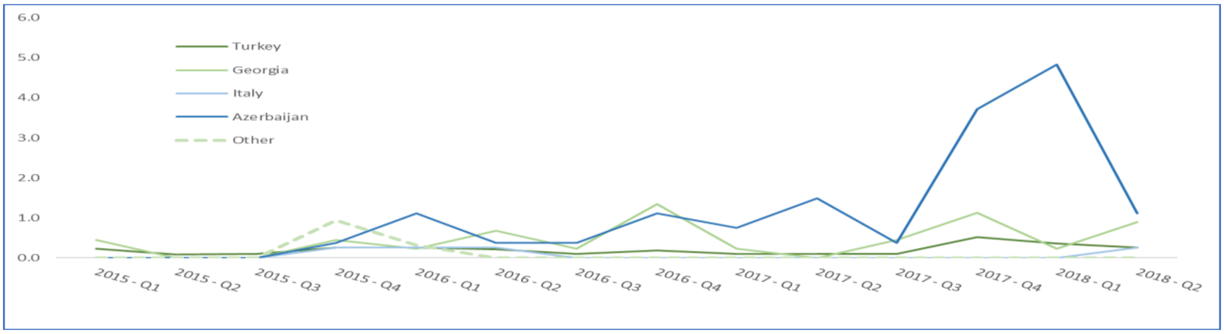


The major exporters are Iran (38%), USA (36%) and China (12%).

China is notable by the low relative incidence. Other than this, differences between countries are less marked than for peanuts. The historical gap between Iran (higher incidence) and USA (lower incidence) has now closed. As with peanuts, the smaller exporting countries (*eg* Turkey, Afghanistan, Lebanon) have a consistently higher incidence rate than the major exporters.

Figure 8 shows a similar analysis of aflatoxin trends in hazelnuts.

Figure 8 – Reported Aflatoxin Incidents per 1,000 Tonne Exports Hazelnuts, January 2015 – June 2018

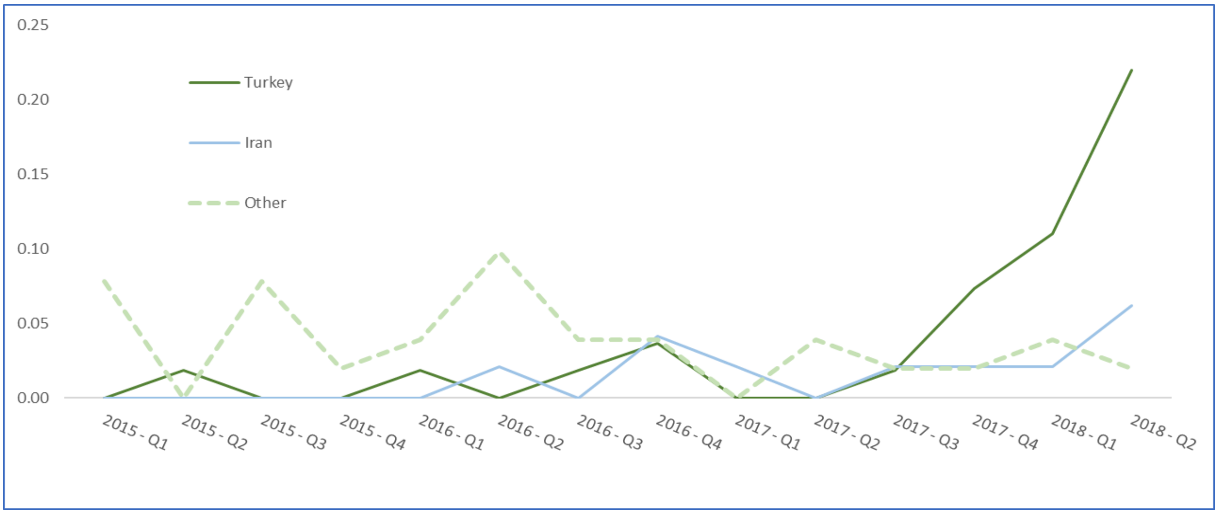


The export market is dominated by Turkey (71%), followed by Georgia (8%), Italy (7%) and Azerbaijan (5%).

Georgia and Azerbaijan have a consistently higher relative incidence rate than Turkey or Italy. This was exacerbated by a spike in the incidence rate of aflatoxins in Azerbaijan hazelnuts in late 2017.

Finally, Figure 9 shows an analysis of ochratoxin A trends in dried vine fruits.

Figure 9 – Reported Aflatoxin Incidents per 1,000 Tonne Exports Dried Grapes, January 2015 – June 2018



International Nut and Dried Fruit export statistics are categorised as "dried grapes" *ie* including both raisins and sultanas ("golden raisins"). The major exporters of dried grapes are Turkey (30%), USA (19%), Iran (14%) and Chile (9%). USA and Chile are excluded from this analysis, as much of their trade is in sultanas and flame-dried raisins. Sultanas are dried by a different method and are at minimal risk of ochratoxin-producing moulds; they are not comparable to raisins in this respect.

There have been allegorical reports of Iranian raisins being re-badged as Turkish to circumvent trade sanctions against Iran, but little evidence. Trade statistics in this analysis are taken at face value.

Until the last 12-months, the relative incidence in raisins from smaller exporters (*eg* Uzbekistan, South Africa) has been higher than for the two major exporters of Turkey and Iran. Neither the face-value trade data nor reported incidents suggest a reason for the recent rise in the relative incidence from Turkey.

Conclusions

Assessing the likelihood of chemical contaminant or authenticity issues in food is a difficult and subjective process, requiring a detailed knowledge of the production conditions, economics and supply chain of each ingredient. Most of this knowledge is not visible to enforcement authorities, who are still required to rank risks in order to prioritise their scarce testing resources. To this end, any attempt at incidence ranking is better than none.

The advent of "Big Data" will make incidence assessment simpler; once "negative" as well as "positive" test results are published then the incidence of different issues can be estimated. Until this time, drawing conclusions based purely upon the absolute number of previous positive results is inadvisable. The echo-chamber effect is a real risk, leading to over-targeting of resources on niche and narrow risks. It is important to think critically about how and why the historical results were generated, if there is an inherent bias and if there is any way to correct for this bias.

Corrections may be subjective and imperfect but – again – any attempt is better than none. It is possible to normalise data using public information sources, but the process is time-consuming and needs much manual sense-checking. It is important to recognise where risk-ranking conclusions are sensitive to uncertainties in these assumptions and data manipulation.

Attempting such data normalisation is worthwhile and can lead to counter-intuitive conclusions. For example, contrary to widespread belief, both the USA and Argentina are at lower risk than other producers – particularly China – for aflatoxins in peanuts. Conversely, the risk of aflatoxins in Chinese pistachios is relatively low. There has been an unexplained steep increase in the relative incidence of ochratoxin A in Turkish raisins over the past year.

References

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