Agriculture, Biosecurity, Nutrition
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Safer coffee

An FAO project has developed good hygiene practices for coffee producers aimed at reducing contamination of raw beans by a potent fungal toxin

Most coffee-drinkers have probably never heard of ochratoxin A (or OTA). It's a natural poison that is highly toxic to the kidneys and possibly carcinogenic, it's produced by a mould sometimes found on raw, or "green", coffee beans - and it's not completely eliminated when the beans are roasted.

The presence of ochratoxin A in the coffee beverage was discovered as recently as 1988. Soon after, the European Union initiated a programme to harmonize regulations on mycotoxins in foodstuffs - including maximum limits for OTA in coffee. That prospect set alarm bells ringing in the $70-billion-a-year world coffee business: a study commissioned by the European Coffee Federation (ECF) - representing green coffee importers, coffee roasters and instant coffee manufacturers - found that an OTA limit of 5 parts per billion (ppb) could lead to the rejection of 7% of green coffee imports and that all coffee exporting countries would be affected.

The ECF argued that OTA control measures at European ports would be far more costly, and far less effective, than action to reduce contamination at its source - in coffee-producing countries. The producers agreed, and not only out of concern for food safety: with more than 20 million small-farm families in more than 50 developing countries dependent on coffee growing, and coffee representing a big share of many countries' export income, they were keen to avoid the economic disruption of massive shipment rejections.

Prevention, reduction. That's where FAO came in. At the request of the International Coffee Organization, which represents coffee exporting and importing countries, and the UN's Common Fund for Commodities, FAO launched in 2001 a project for "enhancement of coffee quality through the prevention of mould formation". Says Renata Clarke, the FAO food safety specialist who led the $6.3 million project: "The basic strategy was to enable coffee-producing countries to develop and implement their own national programmes for the prevention and reduction of OTA contamination."

Over the next five years, the project worked with 30 countries that account for 93% of the world's green coffee exports. It deepened scientific understanding of factors causing OTA contamination, devised prevention strategies for key points in the supply chain, and developed good hygiene practices that are now being disseminated to coffee farmers, processors and transporters worldwide.

Among the first tasks was to investigate factors causing mould in coffee, in order to develop a Hazards Analysis and Critical Control Points (HACCP) model for controlling its formation, as well as prevention strategies for primary processing, drying, handling and storage. In cooperation with coffee institutes in Brazil, Colombia, Côte d'Ivoire, India, Indonesia, Kenya and Uganda, the project conducted surveys to see how farmers harvested and processed their coffee, and how farm practices and toxigenic fungi might be interacting.

Extensive soil sampling indicated that the main OTA-producing mould, *Aspergillus ochraceus*, is more common in the soil surrounding the roots of coffee trees than in other soils. "Coffee that has been in contact with soil for more than a few days represents an OTA risk," the project concluded. "Any such coffee should be removed from the food chain." Preliminary experiments also produced evidence that exposure of coffee flowers to spores of *Aspergillus ochraceus* can lead to infection of the bean. Another line of inquiry was the reported link between OTA contamination and defects in green coffee beans. Some evidence gathered by the project does indicate a "strong association" between certain defects and OTA contamination - but not in all cases. A survey in Kenya, for example, found that almost all OTA content was concentrated in beans classed as "diseased" and "insect damaged". But surveys in other countries revealed no association between defects and OTA.

Whatever the link, project managers were alarmed by another finding - that defective coffee beans were routinely mixed into lower quality coffees, which were

often roasted in producing countries for local consumption. "If there is a suggestion that OTA is disproportionately present in defects," says Renata Clarke, "there is a clear implication for public health in the domestic markets of coffee producers."

Critical transition. Drying practices also came in for close scrutiny. The drying of coffee cherry is a critical transition phase, between the fully wet condition - in which toxigenic and spoilage moulds are blocked by hydrophilic organisms and seed physiology - and the fully dried state, which prevents any mould development. Intermediate moisture levels provide a favourable environment for OTA-producers. "For an effective risk-based plan for coffee processing," says Renata Clarke, "the drying step required special attention. The risks of OTA associated with drying had to be defined as precisely as possible."

Coffee is most commonly dried by spreading it in a thin layer under the sun. The project found that the most critical factor regulating drying rate is the weather - rain and dew, high humidity or clouds that reduce solar radiation. Also important was the amount of coffee cherries spread out on drying terraces: thicker layers significantly reduce drying rate. However, in many trials, occurrence of OTA-producers and OTA contamination was not related to differences in drying practices.

Clarke says there is still "a major gap" in knowledge about the combination of conditions that lead to a significant OTA accumulation during drying. Although specific moisture levels may favour the presence of OTA-producers, the moulds' development and OTA production only occurs when certain other conditions are met: "Since we do not know what the exact 'required conditions' are, the best advice remains to dry as quickly as possible to avoid contamination."

After drying, green coffee is usually stored for days, weeks or even months, during which time moisture levels must be kept low enough to rule out mould growth. In well designed storage facilities, only very slight increases in moisture were registered over a six-month period, and never reached a level that allowed any risk of moulds. But in many countries, dried beans are often stored in unsuitable, improvised facilities (e.g. under the bed). In those cases, coffee rehydration can reach levels that could allow mould growth. Project trials found that "passive" rehydration of coffee - caused by absorption of moisture from the environment - led to a small increase in the frequency of OTA producing fungi.

Finally, the project also looked at whether international transport of green coffee beans created conditions that favour development of OTA producers and OTA accumulation. Measurements of relative humidity in containers during shipping showed that condensation can occur and cause re-wetting of the beans. The project recommended measures to avoid rewetting such as ensuring that exported coffee is adequately dry at loading and kept dry by covering it with absorptive material.

From its trials and surveys conducted over five years, the project concluded that, post-harvest, the most effective way of preventing mould formation and OTA contamination in coffee is to ensure a safe moisture content level as quickly as possible and prevent rewetting. Tests confirmed that the ICO's existing recommendation for maximum moisture content in green coffee (12.5%) is consistent with prevention of growth of OTA producers. But the project also revealed that OTA contamination of coffee beans still on the tree can be significant, and further work is needed to understand mechanisms involved in mould contamination and OTA accumulation during primary production.

Good hygiene practices. "Managing the risk of OTA contamination in coffee requires better management of the coffee supply chain, from the tree to the finished product," says Renata Clarke. "The key factors in successful management are good hygiene practices along the chain, rapid drying, and avoiding the re-wetting of coffee by ensuring clean and dry storage and transportation."

To assist producing countries in introducing those good practices, the results of field trials and surveys have been incorporated in one of the project's major outputs, *Guidelines for the prevention of mould formation in coffee*, and a comprehensive CD-ROM resource tool has also been published to assist coffee institutes in developing hygiene programmes. Additionally, good hygiene practices are being incorporated into the institutes' work on good agricultural and farm management practices, for dissemination through farm extension services.

The project also mounted a series of regional, sub-regional and national training activities to raise awareness of food hygiene principles within the coffee sector. Training-of-trainer (ToT) courses - aimed at extensionists, coffee scientists, food safety agencies and research institutions - were conducted in Ecuador, Guatemala, India, Indonesia, Kenya, Rwanda and Uganda. Similar courses using training materials developed by the project have been held in Thailand, Uganda and Vietnam. In addition, the project organized or participated in seminars in Guatemala, Indonesia, Kenya, Thailand, Uganda and Viet Nam to sensitize decision makers' to the problem of OTA contamination.

The knowledge and tools generated by the OTA project are available on an FAO website for use by all the world's coffee producers. The International Coffee Organization, in particular, has a crucial role to play in disseminating the project's findings to producer countries and in monitoring follow-up of the project's recommendations.