Reducing aflatoxin in peanuts using agronomic management and biocontrol strategies in Indonesia and Australia (CP/1997/017)

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Project number	CP/1997/017
Project name	Reducing aflatoxin in peanuts using agronomic management and biocontrol strategies in Indonesia and Australia
Collaborating institutions	Australia: Department of Employment, Economic Development and Innovation (DEEDI), Queensland—formerly the Department of Primary Industries; Department of Agricultural Chemistry and Soil Science, University of Sydney Indonesia: Indonesian Legumes and Tuber Crops Research Institute (ILETRI); Southeast Asian Regional Centre for Tropical Biology (SEAMEO BIOTROP), Bogor; Faculty of Agricultural Technology, Gajah Mada University, Yogyakarta; Balai Pengkajan Teknologi Pertanian (BPTP) (Assessment Institute for Agricultural Technology)
Project leaders	Australia: G.C. Wright Indonesia: A. Rahamianna
Duration of project	1 July 2001 – 1 December 2006 (3 years plus a 2-year extension)
Funding	A$2,844,146 (ACIAR contribution: A$953,736)
Countries	Australia, Indonesia
Commodity	Peanut
Related projects	CS1/1984/019, CP/1988/034, PHT/1988/006, PHT/1991/004

Motivation for the project and what it aimed to achieve

Aflatoxin is a carcinogenic, immune-suppressing and anti-nutritional natural contaminant produced in peanut kernels when they are infected by the soil fungi *Aspergillus flavus* or *Aspergillus parasiticus* under conditions of severe drought and elevated temperatures. Aflatoxin contamination is a major human food and animal feed quality problem throughout the world. The worldwide increase in incidence of diseases caused by the hepatitis B and C viruses is increasing the importance of aflatoxin as a potential health risk since the toxin is implicated in predisposing people who ingest large quantities of aflatoxin to liver diseases. These health concerns are driving a desire to significantly decrease the levels of aflatoxin allowed in foods worldwide.

In Indonesia, over 800,000 tonnes of peanuts are produced annually and consumed domestically. The demand in Indonesia is far greater than the domestic supply, with the consequence that Indonesia is one of the world's largest importers of peanuts. Nearly all peanuts are consumed as a food and represent a vitally important part of the Indonesian diet by providing a rich source of protein, oil and vitamins, especially for the poorer sections of the community.

Aflatoxin can directly affect the health of peanut consumers in Indonesia. Because food safety and security systems are poorly developed or absent, any aflatoxin contamination that occurs is commonly undetected. There is a lack of detailed knowledge on the nature and extent of the problem in the peanut food chain, and hence of potential strategies needed to minimise exposure for Indonesian consumers. The project originated from concerns about the health effects of aflatoxin in the Indonesian food chain and the need to better understand where there might be critical control points that could be targeted to minimise its impact.

Given the critical importance of the aflatoxin problem for human health (in Indonesia) and farmer and industry viability (in Australia), it was clear that both countries shared a common interest in conducting research, development and extension to minimise its effects in the food chain. The Indonesian and Australian governments considered that research to minimise in-field and postharvest aflatoxin contamination in peanuts was a very high priority, and hence supported the project.

The broad aim of the project was to minimise, and eventually eliminate, aflatoxin contamination in Indonesian and Australian peanuts through research, development and extension of appropriate on-farm and postharvest management practices.

In Indonesia, the project focused on identifying the major points of aflatoxin contamination in the Indonesian food chain as a precursor to developing relevant management and varietal interventions to minimise its incidence. In Australia, the project concentrated on a range of in-season harvesting management approaches along with new research to assess the application of biocontrol technology using non-toxigenic strains of the *A. flavus* fungus.

The project also had a strong capacity-building component by providing training to Indonesian scientists in peanut agronomic management, crop modelling, aflatoxin analysis using enzyme-linked immunosorbent assay (ELISA) systems and related mycotoxin research methodology.

The collaborative project was initiated and built on previously successful collaboration that developed during the ACIAR projects listed in the project details above.

The main agencies involved in Indonesia were:

- Indonesian Legumes and Tuber Crops Research Institute (ILETRI)
- Southeast Asian Regional Centre for Tropical Biology (SEAMEO BIOTROP), Bogor, Indonesia
- Veterinary Research Institute (BALITVET), Bogor, Indonesia
- Faculty of Agricultural Technology, Gajah Mada University (GMU), Yogyakarta, Indonesia
- Balai Pengkajan Teknologi Pertanian (BPTP) (Assessment Institute for Agricultural Technology).

In Australia, the main agencies involved included:

- Department of Employment, Economic Development and Innovation (DEEDI), Queensland
- Department of Agricultural Chemistry and Soil Science, University of Sydney.

Outputs—what the project produced

The project uncovered compelling evidence on the alarming extent of aflatoxin contamination in Indonesian peanuts through implementing strategic surveys and quantifying aflatoxin levels at various points throughout the peanut supply chain. The results clearly showed that the main point of contamination occurs in the retail sector and particularly in the 'wet' markets.

High *A. flavus* contamination in fresh peanut kernels at the farm and collector level clearly demonstrated that, while aflatoxin levels may be low on farm, the high levels of kernel *A. flavus* infection (up to 100% in certain situations) can subsequently lead to a rapid increase in aflatoxin levels under poor storage conditions.

The varietal trials conducted by ILETRI led to the identification of a new variety (GH 51) with tolerance to aflatoxin contamination. This variety is in the final stages of multilocation testing by Garuda Food Ltd before being released for commercial production in Central Java.

A computer-based decision-support tool ('Whopper Cropper') for assessment of preharvest aflatoxin risk throughout Indonesian peanut production areas was developed and supplied to collaborating Indonesian scientists.

Biocontrol technology using non-toxigenic strains of *A. flavus* to control on-farm aflatoxin contamination was tested in Australia and shown to have highly variable results, depending on initial native inoculum levels in the soil and those achieved after application of the biocontrol treatment.

A low-cost ELISA analytical system to detect aflatoxin B_1 was established at three Indonesian research centres and project scientists were trained in the ELISA analysis and associated quality-assurance (QA) checks.

Socioeconomic and peanut supply-chain surveys conducted within different peanut production regions highlighted a potential link between socioeconomic status and human health impacts in Indonesia. There is huge potential for the poorer sections of the Indonesian community to become exposed to and ingest higher levels of aflatoxin, owing to either lower prices charged for visually affected (and hence high aflatoxin contaminated) kernels, or the crushing of these highly contaminated kernels into peanut sauces (e.g. *satee*, *bumbu pecel*) that are sold at lower prices in the traditional 'wet' markets.

A market trader in Pati, Central Java, grading fungal-affected and healthy peanut kernels. (Photo: G. Wright)

The project successfully initiated an aflatoxin-awareness program by disseminating aflatoxin-related information at field days, in brochures and through participation in high-level government meetings, which subsequently led to the establishment of a large national program named the 'Aflatoxin Forum Indonesia' (AFI).

Capacity developed by the project

Project personnel acquired skills in aflatoxin and *A. flavus* analytical techniques, including ELISA methods and QA systems, which resulted in the reporting of high-quality aflatoxin data in peanut supply-chain surveys.

Project scientists have developed an improved understanding of the factors affecting aflatoxin contamination in the field, in storage and throughout the supply chain.

The project has been successful in creating a network of researchers, and extension and policy agencies working on aflatoxin throughout Indonesia, which has subsequently led to significant exchange of information and ideas related to research on aflatoxin, and mycotoxins more generally.

The project has led to an improved organisational capacity to undertake strategic and applied research on aflatoxin, as evidenced by significant external funding secured by project personnel for aflatoxin risk studies after completion of the project.

Adoption—how the project outputs are being used

Researchers and policymakers are making use of the information generated in this project on aflatoxin contamination in the Indonesian peanut food chain. ILETRI, SEAMEO BIOTROP and GMU collaborators are now considered aflatoxin experts at the national level, and are regularly invited to give talks, seminars and other presentations at regional and national food safety conferences and workshops, to raise awareness about the aflatoxin contamination problem in the peanut supply chain.

The finding that high on-farm levels of *A. flavus* contamination are the key source of subsequent postharvest aflatoxin contamination is being used by researchers, but its significance as the major cause of aflatoxin production under poor storage conditions and the subsequent occurrence of the toxin in peanut food products in the retail and consumer end of the supply chain is grossly underestimated by all sectors of the peanut food chain.

As a result of varietal trials conducted within this project, a new peanut variety (GH 51) developed at ILETRI with reputed tolerance to aflatoxin contamination has been identified. Garuda Food has indicated it will commercialise this variety and has initiated field trials at various locations to assess its yield and aflatoxin contamination.

A computer-based decision-support tool for assessing aflatoxin risk in Indonesian peanut production areas has been developed, but it is not being used widely by researchers due to unavailability of the high-quality climate data required to run the peanut/aflatoxin model simulations for various target locations.

Evaluation of biocontrol technology to control on-farm aflatoxin in Australia will remain as a research output, and is unlikely to be adopted commercially due to major concerns with reliability, liability and cost-effectiveness.

Low-cost ELISA systems to detect aflatoxin B_1, established at three Indonesian research centres, have had significant adoption by project researchers and research institutions. SEAMEO BIOTROP and BALIVET, in particular, routinely use this technology for aflatoxin monitoring in the peanut and other crop supply chains. Scientists from GMU have developed further capacity in aflatoxin research and will soon be identified as an accredited laboratory for aflatoxin analysis in Indonesia. Staff at various research centres have received QA training.

Dissemination of information on aflatoxin incidence and its management generated by the project has led to significant adoption by research and extension agencies, as well as to the creation of the large AFI extension network program. AFI involves all peanut supply-chain stakeholders as well as government policy officers. It will play a key role in developing and implementing policy measures aimed at keeping aflatoxin levels below a set maximum residue limit (MRL), without creating panic among supply-chain players and consumers.

Impact—the difference the project has made or is expected to make

The quantification of actual, and potential for, aflatoxin contamination throughout the peanut food chain has established a clear link between agriculture and human health. This presents compelling justification for further action from national and provincial governments to develop and implement appropriate policy measures to reduce its impact throughout the Indonesian community.

Expertise in aflatoxin research gained by project scientists enabled them to work with the National Agency for Drug and Food Control (NAFDC) to assess the risk to consumers from long-term ingestion of high levels of aflatoxin-contaminated peanuts and maize. As a result of the increased awareness on impacts of aflatoxin on human health and alarming levels of aflatoxin contamination in the peanut food chain, the Government of Indonesia has formally announced a revision of the MRL for aflatoxin in human food to 15 parts per billion. This regulatory change was a first for the country, and was made in close consultation with Indonesian project scientists. However, the next step is to develop and implement strategic operational policy measures for implementing this MRL, without causing undue financial stress for peanut traders and fear among the community.

Expertise developed by project scientists has resulted in the establishment of a national/international proficiency testing system for aflatoxin, as part of the Centre of Excellence on Mycotoxin Studies (CEMYCOS) involving five institutions: GMU, SEAMEO BIOTROP, BALITVET, NAFDC and Singapore company Romer Labs). This QA system will greatly improve the accuracy of aflatoxin/mycotoxin testing in Indonesia.

The broad membership of AFI, which includes researchers, private research and development (R&D) agencies, grower groups and food and drug regulatory authorities from the central government, allows effective exchange of information on aflatoxin research and the management and impacts of the toxin.

The project resulted in significant benefits for the Australian peanut industry:

- It identified that the DEEDI-developed peanut variety Streeton is tolerant to aflatoxin contamination. This tolerance has been associated with various physiological traits, including better dehydration tolerance, quicker and more uniform pod drying and superior shell integrity. This has resulted in a major varietal shift in the dryland peanut region from longer duration, drought-susceptible types such as NC 7 (22–24 weeks to maturity) to earlier maturing, drought tolerant types such as Streeton (18–20 weeks) and led to the recent release of two new, ultra-early, high oleic varieties, Walter (2007) and Tingoora (2010), which take only 15–16 weeks to mature.
- The R&D conducted within the project led to the formulation of an integrated agronomic package for on-farm aflatoxin-minimisation practices. The package was widely implemented by dryland peanut growers, with the Peanut Company of Australia supporting price incentives for adoption of the aflatoxin management practices. This research demonstrated that aflatoxin contamination can be minimised but not eliminated by following these best-management practices.
- The project led to the development of a computer-based aflatoxin monitoring and management decision-support system to assess on-farm aflatoxin risk using in-season weather data plus crop and soil parameters, in conjunction with the Agricultural Production Systems Simulator (APSIM) peanut crop model. This ultimately led to the development of 'AFLOMAN', a user-friendly internet-based aflatoxin monitoring and decision-support system for growers—see www.apsim.info/afloman.
- The project led to the fostering of collaboration with the University of New South Wales (Dr Robert Driscoll and Dr George Srzednicki) to develop a computer-based peanut-drying model that can assist in minimising postharvest aflatoxin levels and quality losses in peanuts associated with under- or overdrying. It is expected that the model will significantly improve the performance of drying machines in the Australian peanut industry.