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Residual unprotection: aflatoxin research and regulation in Senegal's postcolonial peanut infrastructures

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ABSTRACT

In the early 1960s, a potentially carcinogenic substance, aflatoxin, was identified in peanuts. In this article, I explore how aflatoxin was known – and unknown – through and for the infrastructures designed, from the late nineteenth century, to stimulate and support peanut farming in Senegal. Anticipated European standards stimulated a narrow field of knowledge and know-how oriented towards control-for-export, bypassing Senegalese farms, food, and bodies. Investigations of aflatoxin's carcinogenicity were actively suppressed, challenged, and silenced. That (post)colonial infrastructures supported peanuts as an export cash crop and a target of European regulation – but not as part of local ecologies and foodways – mattered for how they were deemed (not) worth knowing as potentially contaminated and carcinogenic from the 1960s. I develop the notion of residual unprotection to highlight how the enduring effects of colonial infrastructures distributed (through regulatory gaps) and obscured (through non-knowledge) the potential harmfulness of aflatoxin in Senegal.

KEYWORDS

Aflatoxin; infrastructural harm; peanuts; Senegal; regulation; unprotection

At midday on 24th March 1992, an ammonia tank exploded at a Sonacos peanut processing factory in Dakar's busy port industrial zone. Over the following days and weeks, the reported death toll rose from 41 to 75, then 116; more than a thousand were injured (Anonymous, 1992). The Senegalese press filled with criticism of sluggish emergency services, inadequate hospital capacity and unready government crisis plans, as well as with accusations of negligence on the part of Sonacos, a parastatal firm, in the protection of workers and the environment. In his first public statement after the accident, which was tag-lined 'Ammonia, a necessary evil … ' in the pro-government newspaper *Le Soleil*, the Director-General of Sonacos Abdoulaye Diop shifted the focus to why ammonia was vital to the Senegalese economy. Responding to increasingly stringent European standards, Sonacos had in 1981 implemented a 'revolutionary' ammonia-based process to remove aflatoxin from peanut meal (Diop cited by Faye, 1992).[1] Omitting to specify what aflatoxin is (a set of metabolites of common soil fungi) and why it was regulated (as a suspected liver carcinogen), Diop insisted that without this innovative detoxification method, there would be 'no [Senegalese] peanut economy,' and 'peanuts would have no value' (Ibid.).

Others also traced the accident to European regulatory exigencies but openly questioned claims of aflatoxin's harmfulness. In the weekly *Walfadjiri*, Tidiane Kasse (1992) charged that aflatoxin's '*supposed* carcinogenic properties' (emphasis mine), had been amplified by a 'smear campaign that

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significantly harmed the export of [Senegalese peanut products].' He went on to accuse Sonacos of putting more effort towards complying with 'the technical standards required to ensure the health of European community *cattle*' (emphasis mine, he refers here to the fact that peanut meal was used, and regulated, as livestock feed) than ensuring the 'safety of its [own] workers.' A month later, this newspaper reprinted a French journalist's more detailed critique of aflatoxin regulation as a ploy, justified by inconclusive evidence of its carcinogenicity, to tilt the European market in favour of American soy rather than Senegalese peanuts. Quoting a French agronomist, the journalist Pierre Barrot (1992) concluded that the aflatoxin question was a scientific façade to what was, in truth, a commercial dispute 'for which Senegal has paid the highest economic … and human price.'

These early responses to the explosion evoke the direct, albeit accidental and momentary harms of a regulatory infrastructure. Standards set in Europe, based on uncertain knowledge of aflatoxin's carcinogenicity, brought ammonia to Senegalese peanuts, workers, and bystanders. In Senegal's weakly regulated industrial environment, the detoxification of peanut meal created latent hazards (Guissé, 1995), a form of 'slow violence' (Nixon, 2011) that one day suddenly accelerated into an acutely fatal event. As Kasse and Barrot hint, this regulatory infrastructure generated an unequal spatial and political distribution of protection, favouring European cattle and milk-drinkers, and perhaps American soy, while leaving Senegalese exposed to chemical hazards and market restrictions, and perhaps also to toxic peanuts. Starting from this articulation of direct regulatory and infrastructural harm, I set out in this article to explore the more diffuse forms of unprotection – the indirect and uncertain but nonetheless active harm arising from unequal, denied, withdrawn or deferred protection (see Tousignant, 2018) – that arose from and alongside the regulation of aflatoxin in Senegalese peanuts.

Unprotection can be found in the 'limitations and omissions' (Rodgers & O'Neill, 2012) of a regulatory infrastructure that was, from the outset, set up to maintain the exportability of Senegalese peanuts. The Senegalese state, and its expert advisors, approached aflatoxin as a trade problem, defined as such by scientific and regulatory determinations of its health risks *made by and for others*. A detoxification-based strategy for tackling aflatoxin targeted peanuts destined for export. The bulk of Senegalese harvests were, in the mid-twentieth century, exported as cooking oil. The extraction process removed aflatoxin, thereby concentrating it into the residual oilcake, which, from the early 1980s, was then treated with ammonia to be sold as feed. This strategy bypassed – and rendered irrelevant – aflatoxin that might form and persist in Senegalese peanut fields, plants, storerooms, foods and bodies. If one considers that aflatoxin was potentially carcinogenic in humans, as European legislation and many experts did from the 1970s (more definitive, consensual 'proof' arose in the early 1990s), one can chart and condemn the Senegalese exposures that were permitted, as unmonitored and unmitigated, by a regulatory infrastructure designed to protect European consumers. While attending to this narrow version of regulatory unprotection (i.e. regulation distributes protection unevenly, thereby maintaining harmful exposures for some), I also aim, in this article, to explore how productions of (non-)knowledge of aflatoxin's carcinogenicity and controllability shaped and justified its regulation in Senegal. I seek in particular to take seriously the work done by and for *uncertainty* – and related forms of partial and negative knowledge such as doubt, denial, invisibility, ignorance and implausibility – in both creating and obscuring an unequal geography of protection. By calling the resulting gaps in protection *residual*, I seek to call attention to how the prioritization of peanuts-for-export in Senegal, and therefore of certain kinds of aflatoxin knowledge and control, generated a leftover space of ignorance and exposure.

A dense body of social scholarship shows that uncertainty plays a key role in enabling toxic harm, and that this toxic uncertainty is *produced* – materially, politically, and socially – through

situated, often orchestrated, interactions among substances, organisms, relations of power and of (re)production, as well as epistemic practices and regimes (see, e.g. Auyero & Swistun, 2008; Fiske, 2018; Liboiron et al., 2018; Murphy, 2006; Proctor, 1994; Senanayake & King, 2019). Scientific infrastructures (equipment, expertise, methods, etc.) and the values embedded in and sustained by them obviously participate shaping the conditions of what Olga Kuchinskaya (2014), in her work on post-Chernobyl radiation in Belarus, calls *articulation:* the range of practices and processes (scientific and non-scientific) involved in making a hazard publicly visible. Kuchinskaya further suggests that articulation, defined more expansively, can also include 'explicating the work that has to be done to mitigate [the hazard], along with the conditions and resources available for this work [… to] account for existing infrastructural resources and shape future ones' (Olga Kuchinskaya, 2014, p. 9). In other words, articulation is conditioned not only by present infrastructures of knowledge-production, but also by pre-existing and plausible infrastructures for acting on this knowledge and its implications. Infrastructures, then, shape the (un)knowability of a hazard, but also, importantly, the *value* of this knowledge as a basis for protection.

The political-economic relations of Senegalese peanuts shaped the stakes of knowing aflatoxin as carcinogenic in obvious ways, as flagged above: this knowledge was figured as a threat to Senegal's peanut-dependent economy, but as a source of protection for European health (and American soy). Here, I further explore the nuances of these differential meanings by tracking how aflatoxin's (potential) toxicity – its knowability and controllability as such – was *materially* grounded in Senegalese peanut infrastructures. These include the regulatory infrastructure created to control aflatoxin's presence in European foodways, an assemblage of tools (for legislating, testing, sampling, detoxifying) deployed to make (some) Senegalese peanuts safe. They also include the more conventional types of infrastructure, such as transport networks, marketing links and agricultural support systems, that were developed, especially in the first half of the twentieth century, to stimulate the production and circulation of Senegalese peanuts. That these infrastructures were designed so that peanuts could be an imperial then postcolonial cash crop, and later a target of European regulation, but *not* embedded in Senegalese farming ecologies, foodways and bodies, mattered, materially as well as politically, for how they were (not) worth knowing as potentially contaminated and carcinogenic from the 1960s. How ignorance, doubt and uncertainty about aflatoxin were generated in and for these peanut infrastructures is the central focus of this article.

Unknowing toxicity, infrastructures of unprotection

Historians of science, health, work, environments, and chemicals have extensively argued that regulation is only partially protective *by design*. It works to permit rather than prevent the circulation of toxic substances on which industrial growth depends (Boudia & Jas, 2014; Guthman, 2019). In the long-held 'threshold paradigm' of regulatory toxicology (Boudia & Jas, 2014), the 'dose makes the poison' (Vogel, 2008) so that levels of exposure are defined as safe and therefore allowable (Cram, 2016; Jas, 2007), often by measuring isolated substances and the response of model organisms in controlled settings (Murphy, 2006; Sellers, 1997;). Uncertainty about toxic effects is sometimes artfully 'manufactured' – as doubt, controversy and denial – on behalf of powerful industries looking to avoid or loosen regulatory limits (e.g. Brandt, 2007; Markowitz & Rosner, 2002; Proctor, 1994). Yet even protective regulatory intentions are underpinned by epistemologies of toxicity that generate wide areas of uncertainty, imperceptibility and ignorance, notably about the harmful effects of low-level, cumulative and combined exposures in landscapes and across the life-course (Langston, 2010; Murphy, 2006; Nash, 2007). Although new epistemologies of toxic harm are emerging

(Fortun & Fortun, 2005; Frickel, 2004; Vogel, 2008), scholars generally agree that regulatory systems were built on, and continue to be marked by, ways of measuring and monitoring substances that are out of synch with the fast pace of chemical innovation (e.g. Boudia & Jas, 2014), omnipresent and cumulative exposures (e.g. Nash, 2007), as well as nonlinear and delayed toxic effects (Murphy, 2017).

Some historians, such as Linda Nash and Michelle Murphy, describe how 'dominant evidentiary representations of [toxic] harm' (Liboiron et al., 2018, p. 333) exclude, discredit and dismiss – thereby often rendering *uncertain* – embodied and experiential forms of knowledge. This is a central theme in a growing body of ethnographic literature on what Alex Nading (2020, p. 211, following Mel Chen) has called 'toxic worlding:' how people live with toxicity, are affected by and 'learn […] to affect in return.' Observing life in zones of 'sacrifice,' especially in and around polluting extractive industries, ethnographers have pointed to the workings of power and social relations in acts of making toxicity (in)visible. While there has been particular interest in efforts to subvert and expand, notably by democratizing and decolonizing, scientific delimitations of toxicity (e.g. Brown, 1987; Hoover, 2017), observers have also grappled with situations in which exposure has been met with resignation, denial and inaction (Auyero & Swistun, 2008; Davies, 2018; Lora-Wainwright, 2017; Neumann, 2016). Some have thus called to expand the range of what ethnographers might register as toxic knowledge and politics to include, for example, 'slow observation' (Davies, 2018, p. 2019), 'resigned activism' (Lora-Wainwright, 2017) and making 'habitable' (Langwick, 2018). This work points to the need to attend closely to subtle practices that silence and 'confuse' the presence of toxicity (Auyero & Swistun, 2008). Yet it also, importantly, considers how the acceptance, denial or overlooking of toxic effects might be seen as necessary for building lives and relations in specific places and economies (Auyero & Swistun, 2008; Lora-Wainwright, 2017; Neumann, 2016), which, despite being perceptibly and/or measurably hazardous, are, they suggest, *not worth knowing as such*. Critical analyses have generally focused on how dominant epistemologies of toxicity reflect differential valuations of life and distribute harm unequally (e.g. Guthman & Brown, 2016), while determining who can legitimately make claims of contamination (e.g. Fiske, 2018). Yet the unknowing of toxicity 'from below' should also be located within the space of 'toxic politics,' defined by Liboiron et al. (2018, p. 333) as struggles over what forms of life are allowed to 'reproduce and flourish' and others instead 'strained or extinguished.'

Infrastructure has been a growing focus of critical scholarship, which examines how material and technological systems – from roads to databases – order social and economic relations along with spatial and temporal (dis)connections, and are the object of political choices and struggles (see the introduction to this issue). Rodgers and O'Neill (2012) introduced the term *infrastructural violence* to account for how such technopolitical arrangements can exert harmful effects. Stefanie Graeter (2020) is among the few to make direct and explicit use of this term with reference to toxic exposure. Their study of the Peruvian mineral port of El Callao shows how extractive mining infrastructures are incorporated by local residents as/with heavy metals, who thereby become 'human infrastructures of toxic storage' in exchange, in part, for the promise, in a space of exclusion from provisioning infrastructure, of access to basic services. Others have used the terms 'chemical' or 'toxic' infrastructures to designate the circulation of synthetic substances that support the workings of heavy industry as well as 'industrial' modes of waging war, controlling disease, and growing crops (Murphy, 2015, Nading, 2017; Touhouliotis, 2018; Davies, 2018, 2022; Guthman, 2019; Hetherington, 2020). By pointing out the infrastructural dimensions of toxicants, these scholars call attention to the systems of production and destruction that they enable, but also to their dispersed, durable and delayed effects. Toxic infrastructure is thus a medium of 'slow

violence' (Davies, 2018; Nixon, 2011) and 'imperial ruination' (Stoler, 2008). These temporalities blur the distinction made by Rodgers and O'Neill (2012) between 'active' and 'passive' infrastructural violence – the first defined as violent by design, the latter through limitation and omission. The concept of unprotection also challenges this active/passive opposition. Infrastructures that make toxicity visible, credible, and controllable (as well as *worth* knowing and controlling) for some but not for others, thereby protecting unevenly, can be seen as indirect albeit 'active' sources of harm.

My focus on aflatoxin and peanuts calls up two little-explored issues in the literature on toxic infrastructures and knowledge: non-synthetic toxins and weakly industrialized agriculture. Critical toxic scholarship has, by and large, focused on substances generated by industrial processes, often called *toxicants (*e.g. Boudia & Jas, 2014; Nading, 2020). While recognizing that 'naturally-occurring' *toxins* can 'do political work,' for example in criminal poisonings, Liboiron et al. (2018, p. 334) relegate these to the periphery of 'toxic politics.' Yet as Anna Tsing's innovative ethnography of matsutake (2015) shows, even fungal metabolisms can be situated within industrial-capitalist processes and politics. Aflatoxin has been deeply entangled in systems of agricultural production and commercial exchange – and, in an extreme example, was allegedly weaponized by Saddam Hussein (Goldberg, 2002). Contests over its harmfulness have high regulatory and economic (and, perhaps, military) stakes. Some emphasized aflatoxin's 'naturalness' to draw public and potential attention away from calls for the regulation of industrial carcinogens in the 1980s U.S. (Proctor, 1994, pp. 133–152). Yet, as demonstrated by the account of FDA officers (Park & Stoloff, 1989), aflatoxin was very much regulated in the U.S. as a substance on whose allowable presence powerful agricultural and food industries depended. Lucas Mueller (2021) describes how, in the 1960s and 1970s, the negotiation of aflatoxin risk by international agencies unfolded on a terrain of postcolonial relations, ultimately eliding the political-economic demands of African states as well as the health and livelihoods of their citizens. Aflatoxin has clearly been implicated in projects to sustain specific forms of power over life, thereby falling squarely within the realm of 'toxic politics' (Liboiron et al., 2018).

Agricultural infrastructures have been called violent (most explicitly by Li, 2018; but see also Gordillo, 2018; Guthman, 2019; Hetherington, 2020), particularly those of capital, land, machine and pesticide-intensive 'boom crops' such as soy and oil palm. Predominantly grown by smallholders with little equipment and chemicals,[2] Senegalese peanuts seem very different from 'killer soy,' indeed as a victim of the latter's takeover of postwar global markets (Berlan et al., 1976). By the mid-twentieth century, however, the peanut was accused of an 'excessive' hold (Portères, 1956) 'crushing sovereignty' (Pélissier, 1966) and 'total supremacy' (Mamadou Dia cited by Péhaut, 1961, p. 234) over Senegalese land, labour and revenues, and as causing degraded soils, deforestation, farmer debt, spatial inequality, and food insecurity.

Neither French firms nor the colonial administration intervened directly in land ownership or farming work. Yet several studies emphasize the key role played by colonial infrastructures, particularly of transportation (rail, roads, ports) and the *Sociétés Indigènes de Prévoyance* (SIPs), a material-institutional network set up to maintain seed stocks and loans in the early twentieth century (but reinforced in the 1930s), in prompting and pressuring Senegalese farmers to grow and sell peanuts for export. The expansion of transport networks made bigger areas of land available to peanut farmers, who removed trees and nomadic herders, as well as displaced other plants such as fallow scrub and food crops (Cruise O'Brien, 1975; Moitt, 2001; Pélissier, 1966). Debt incurred to private traders or the SIPs locked farmers into cash crop production (Bernards, 2021; Boone, 1992). Infrastructures thus harnessed farmers' interests in and obligation to grow peanuts as a

source of cash for taxes, debt repayment, and imported commodities (including food), as well as a form of allegiance to spiritual leaders, notably of the Murid order (*tariqa*), which emerged under colonial rule and organized disciples into 'pioneer fronts' to expand the peanut belt (Boone, 1992; Copans, 1980). By tapping into cheap (and forced) labour, including the productive work of freshly cleared land and of 'indigenous' agricultural techniques and adaptations (Chevalier, 1936; Pélissier, 1966), these infrastructures maximized returns on minimal public and private investments. The system they supported did not, critics charged, cover the full costs of producing peanuts, notably those of feeding labouring bodies and of replacing soil fertility (Bernards, 2021; Boone, 1992; Founou-Tchuigoua, 1981). The main beneficiaries of this system were French import-export firms that controlled the two-way trade in peanuts and imported goods (cloth, sugar, soap, rice, etc.). It was in their interest to minimize the (re)investment of their 'merchant capital' in production, thereby leaving the material conditions and practices – as well as the risks – of peanut farming in the hands of Senegalese smallholders. Colonial peanut infrastructures might thus be said to have mediated a *slow extraction* – distributed across imperial distance between spaces of industrial development and consumption, and those of environmental degradation (Ross, 2017) – of Senegalese (re)productive capacities.

This extraction was also 'slow' in its extended postcolonial duration. After independence (1960), peanut infrastructures were extended and nationalized to boost production and invest in state-building, economic diversification, and welfare provision (Oya, 2006). Yet the reinvestment of state revenues in farming and rural development remained modest (Boone, 1992). These export-oriented infrastructures continued to extract surpluses from farmers to sustain the spiritual, bureaucratic, and commercial elite (Bernards, 2021; Boone, 1992; Copans, 1980; Cruise O'Brien, 1975). In this article, I build on these analyses of the Senegalese peanut economy as I examine state and expert responses to claims, arising in the early 1960s, that peanuts might be carcinogenic. While aflatoxin arose as a threat to the nationalization and decolonization of these infrastructures, its control was ultimately constrained by what I identify as colonial legacies of infrastructural underinvestment, thereby illuminating ongoing infrastructural effects as a form of 'imperial ruination' (Stoler, 2008).

Border control

Aflatoxin was characterized, chemically and as toxic, following the mass-poisoning, in 1960 of turkeys fed in England with peanut meal imported from Brazil. The initial visibility of aflatoxin was thus articulated, as Mueller (2021) points out, at the intersection of analytical methods, global trade in 'tropical' crops, and industrialised livestock agriculture. Mueller further describes how this visibility was amplified by international efforts, led by the UN agency members of the Protein Advisory Group (the FAO, UNICEF and WHO), supported by American philanthropic funding, to frame protein malnutrition as a critical but technically (rather than politically) solvable obstacle to child and economic development in the global South (Mueller, 2021, pp. 142–143). Peanuts, including Senegalese peanuts, featured centrally in this programme as a cheap source of protein. The Senegal-based West African research organization ORANA, a late-colonial institution, was working on a peanut-based nutritional supplement since the late 1950s (Dupin et al., 1962). As a partner in this project, the FAO quickly dispatched Senegalese peanut samples to a London lab, which detected aflatoxin in over half of these, then in 1962 arranged for an ORANA pharmacist, J. Toury, to train in aflatoxin testing methods (Goarin & Toury, 1964).

In Senegal, Toury launched, with ORANA colleagues and experts in agronomic, medical, veterinary and food sciences, a modest aflatoxin research programme. In their arguments for Senegalese government support, these experts – all French technical assistants – quickly reframed aflatoxin as a high-stakes economic issue. By late 1963, having formed an Aflatoxin Working Group (AWG), they called for an urgent response to European regulation, which they predicted was imminent (Goarin & Toury, 1964). They warned: 'it would be terribly imprudent for Senegalese authorities to put in place a new agricultural program demanding significant investment without equipping itself with the maximum of precautions to ensure its success.' Senegal should, they urged, follow other peanut-producing countries by investing in aflatoxin control to save its economy.

The agricultural programme to which they referred was the centrepiece of Senegalese postcolonial development planning. It represented a partial reversal of the colonial policy of investing as little as possible in peanut production. Its core move was to turn the colonial SIPs into 'genuine rural cooperatives,' (Boone, 1992, pp. 90–91). From the 1930s, the SIP network had served as an entryway into farms. Christophe Bonneuil (1999, p. 215) refers to their distribution of seed varieties developed by colonial agricultural research as a 'trojan horse' for more energetic, but still limited state interventions into farming techniques. The latter were initiated following Roland Portères' 1952 'scathing indictment' of how peanut cash-cropping was harming local ecologies and food availability (Boone, 1992, pp. 86–87). Postcolonial rural cooperatives would form the basis of integrated national development, empowering farmers through better prices and improved productivity. Paired with the '*animation rurale*' – a programme of mass basic and civic education – cooperatives would also create opportunities for direct political participation. This programme, however, threatened vested interests in the peanut economy, those of French commercial houses but also of the powerful Murid on whose political support the Senegalese government depended. Earlier ambitions of reform led by Mamadou Dia, were replaced, after he was ousted from government in 1962, with 'quantitative goals' to be achieved through a 'modest infusion of technical inputs' (Boone, 1992, p. 106). While this resulted in increased use of animal traction and fertilizer, gains in total peanut production were largely achieved by cultivating expanded land surfaces rather than by improving yields.

Shaped from the outset by the anticipation of European regulation, the AWG's work mainly, and increasingly exclusively focused on developing methods of mitigation that would maintain peanuts' exportability. While the search for control strategies initially targeted peanuts for local consumption in nutritional programmes, notably in a large UNICEF-funded field trial (ORANA 1964), by the late 1960s the priority has clearly shifted to peanuts-for-export. Nevertheless, agronomists – who, by the mid-1960s, dominated Senegal's aflatoxin research – first pursued solutions that would be practiced on or around the farm, such as treated seeds, optimally-timed harvesting and sped-up drying. Because these 'agronomic' measures could, in theory, be applied to all peanuts, they might protect Senegalese eaters as a corollary benefit of meeting export-oriented regulation. Such measures were promoted by researchers as a way of securing state investments in nationalised peanut infrastructures; yet their implementation would also rely heavily on these channels for the provision of seeds, equipment, and advice (agricultural extension) as well as for purchasing harvests. Circa 1973, the AWG proposed an ambitious programme to control aflatoxin through mass *vulgarization* and a new purchasing system; they were optimistic that the peanut system could be reconfigured to produce quality, not just quantity (Anonymous, 1973). The 1970s was the golden age of agricultural extension in Senegal, with the number of agents growing from 571 to 1182 (Gaye, 2000, p. 19). The AWG proposed to hire a further 150 agents to provide farmers with 'dense guidance' about when to sow and pick which peanut varieties, as well as how to

eliminate sickly plants and 'rationally' dry the harvest. At cooperative purchasing points, state buyers would then sort kernels, using density-sorting apparatus and a dual pricing structure, into high- and low-grade products. The programme would cost 115 million CFA (23M French Francs or 4.9M US Dollars at the time),[3] including monitoring tests.

The proposal's rejection by the ministries of planning and of rural development (according to a letter left in the pages of a library copy of the report) signalled a shift from 'agronomic' to 'technological' methods of aflatoxin control. Peanut meal detoxification was seen as the most promising among these, alongside more sophisticated sorting apparatus and selected/engineered resistant plant varieties. The appeal of detoxification was amplified by historical underinvestment in peanut farming infrastructures, and reluctance to dramatically expand these – although aflatoxin's unpredictability, and the elusiveness of simple solutions, were also factors (Goarin & Goarin, 1969). By 1969, agronomists evoked detoxification methods, then under development in the U.S., as a 'backup' if aflatoxin proved uncontrollable by farm-level interventions (Goarin & Goarin, 1969). The following year, FAO experts reported to a Senegalese government commission that, even if contamination was 'fundamentally situated at the level of farmer's fields […] peanut meal detoxification […] was the *only practicable and guaranteed way* of rendering Senegalese oilcake exportable' (Pattinson & Deuse, 1970). Labour intensive measures, such as early threshing were, they warned, economically viable only for the higher-value edible peanuts, not for the massively farmed crop destined for crushing. Resistant varieties would take too long to develop, given that EEC legislation was imminent (feed standards were published in 1973). With detoxification, 'a decontaminated product would leave the factory,' (Pattinson & Deuse, 1970) impervious to weather variations (the first of several severe drought years hit in 1968; see Gaye, 2000, p. 2). These experts thus envisaged detoxification as a means of rendering farming conditions irrelevant to aflatoxin control, and of avoiding the cost and constraints of their infrastructural management. By the mid-1970s, the creation of Sonacos also extended state control over the site of detoxification, namely the now-nationalised oil-processing factory.

In 1980, the discovery of aflatoxin-contaminated milk in France, from cows fed on Senegalese peanut meal, exposed lax regulation and elicited calls to expand and tighten monitoring (Jacquet & Lafont, 1981, Anonymous, 1981b). Barrot (1989) reports that, in 1980, a French agronomist urged the Senegalese Ministry of Agriculture to act fast. Detoxification was initiated on a commercial scale at Sonacos in 1981 (Ba, 1983). Using ammonia under low pressure, the process was a 'triumph,' a *New Scientist* article reported (Mannon & Johnson, 1985). Detoxification was also, the Senegalese expert Amadou Ba noted in 1983, a 'technological imperative' where farming conditions made it impossible to grow high quality crops. Writing on the eve of the introduction of the 'New Agricultural Programme' (NPA), which would initiate a massive withdrawal of the Senegalese state from agricultural support, particularly for peanut farming, Ba argued that Senegalese farmers did not have access to enough credit, income, labour, fertiliser and equipment to apply agronomic measures such as rapid harvesting and drying to mitigate aflatoxin contamination, thus making it 'illusory' to expect the delivery of clean peanuts to the factory (Ba, 1983).

Anticipated, then actual European regulation thus oriented aflatoxin research in Senegal away from evaluations of its presence, effects and controllability in Senegalese foods and farms. Even while prioritizing control-for-export, the search for 'agronomic' measures kept open the prospect of 'collateral' protection for Senegalese peanut-eaters. At the same time, postcolonial investments in farming and trading infrastructures were briefly and modestly increased. 'Technological' measures, including oilcake detoxification, edible peanut sorting and testing and seed engineering, could work with little or no agricultural support, especially as the peanut economy was liberalized in the early

1980s. These solutions, however, shifted the locus of control either to the 'insides' of Senegalese peanut infrastructures, namely as engineered seeds that could be inputted to the farming process, or on its outer edges: sorting, processing, and detoxifying a portion of the harvest as it was exiting the country. Persistent underinvestment in these infrastructures, built for an imperial economy and oriented towards the production of a bulk export crop – valued for its quantity rather than its quality – provided experts and the state with little hold on farming practice. Farmers were offered few resources or incentives to grow better peanuts, and no opportunities to share, with experts, their thoughts on how, and with what, to care for plants, soils, and foods.

Unknowing toxicity

There are few recorded critiques of the blind-spots of export-oriented Senegalese aflatoxin research. An exception is the record of a conversation with Marie-Thérèse Basse, the director of Senegal's Food Technology Institute, in which she bluntly stated that the 'consequences to human health' went unstudied by an EEC regulation-induced program exclusively focused on generating 'a product that would be acceptable to the European market.' [4] Basse further criticized the Senegalese government's 'head-in-the-sand policy' [*politique de l'autruche*]. This striking image suggests not just a passive looking-away from aflatoxin's potential carcinogenicity (everywhere and in Senegal), but rather its active *unknowing*. There is a fragmented written and oral record of scientific experts and political authorities questioning and preventing research on aflatoxin's harmfulness; affirming or producing counter evidence of harmlessness; or simply avoiding the topic, as one researcher told me, aflatoxin was 'not spoken of' in 1970s Senegal. These clues suggest that the narrow field of aflatoxin knowledge was, in Senegal, carefully hedged in by ignorance, doubt, and silence.

By the time aflatoxin was characterised as a potential liver carcinogen, Senegal was already known for its exceptionally high rate of primary liver cancer.[5] Starting in the 1940s, medical scientists collected clinical notes and histological specimens (liver biopsies and necropsies) from Dakar's main teaching hospital for aetiological investigation (Bado, 2021). Their collections and findings took on value, over the following decades, amid a surge of interest in liver cancer as a 'paradigmatic case' for geographical pathology. This cancer's spatial distribution – frequent in parts of Asia and Africa, rare in the North – suggested an inscription of distinctive carcinogenic environments that might be read deep within cancerous tissues, to illuminate mechanisms of cancer causation in general (i.e. not specifically in or for Africans) (Mueller, 2019).

When the International Agency for Research on Cancer (IARC) was created in 1966, setting liver cancer as one of its core research programs, its experts looked to Senegal as an ideal site for aflatoxin-cancer correlation studies.[6] Yet while IARC-backed studies of cancer incidence and of hepatitis B – another potential liver carcinogen – were welcomed in Dakar, its requests for epidemiological studies of aflatoxin were met with persistent opposition. IARC's director noted, in 1968, 'practical difficulties resulting from the economic importance of certain crops,'[7] namely peanuts, while an officer reported, in 1969, that 'prospects for a field survey of aflatoxin [in Senegal] are not so good.'[8] IARC and others turned to other countries – Kenya, Mozambique, Swaziland, Thailand and China – to study aflatoxin as a carcinogen.

High-placed Dakar-based medical experts, notably the three first deans of Dakar's faculty of medicine – Maurice Payet, Henri Camain and the Franco-Senegalese Marc Sankalé – were heavily involved in research on liver cancer's aetiology. While they encouraged studies of viral hepatitis, Payet and Sankalé explicitly cultivated doubt about aflatoxin's carcinogenicity, linking, in articles and talks, this epistemological debate to its economic stakes. To wrongly jump from (animal)

experimental data to (human) clinical situations would, Payet wrote in 1965, lead to 'catastrophic consequences' for African peanut exporting countries. Ten years later, addressing an international medical audience in Dakar, he, with Sankalé and colleagues, was unequivocal: for these countries' governments 'to recognize the carcinogenic role of aflatoxin amounts to [their economies'] ruin' (Payet et al., 1975). They pointed out that the sensitivity of different species of lab animal to aflatoxin-induced tumours varied widely, thereby precluding assumptions of human susceptibility (Sankalé, Gendron, & Courbil, 1983).[9] They further challenged apparent geographical juxtapositions of aflatoxin-prone crops and liver cancer. While peanut-eating *seemed* to map neatly onto high liver cancer incidence – with Senegal an exemplary case in point – they pointed to smaller-scale variations in the intensity of aflatoxin exposure that loosened this convergence. Strikingly, they pointed out that aflatoxin exposure was probably highest among poor Senegalese farming families, notably women, because they ate peanuts that were, according to agronomic research, most likely to be highly contaminated; namely, visibly damaged kernels, artisanal oil and flour made from residual press-cake. While this exposure was thus concentrated, liver cancer incidence was, they said, evenly distributed across Senegalese social space (a claim for they were unlikely to have epidemiological data) yet higher in men. They did not deny the likelihood of high Senegalese exposures to aflatoxin but pointed out that evidence for hepatitis B's carcinogenic role was, by the mid-1970s, stronger and more consistent. Unlike their American and younger French collaborators, Payet and Sankalé did not publicly consider aflatoxin's possible involvement as an additional or 'adjuvant' co-carcinogen.[10]

Besides suppressing research and cultivating doubt, Senegal-based experts also appear to have avoided discussing aflatoxin and its risks. An IARC observer noted, with reference to a 1969 statement by Senegal's syndicate of medical professionals (in relation to another liver cancer project), that the topic of aflatoxin 'seems decidedly out of favour in Senegalese circles.'[11] In 1981, a headline paraphrased a nuclear medicine professor's response to a journalist's question about aflatoxin as a cause of 'Liver Cancer: 3 deaths a day in Senegal. Aflatoxin not to blame [*nullement mise en cause*]' (Anonymous 1981a). That the question was asked indicates some awareness and concern among a well-informed audience, but clearly, the medical researcher had shut it down. Recall also that the shift from agronomic to off-farm technological measures of control dispensed with the need to explain or discuss aflatoxin (or fungus) with farmers, thereby fostering silence about its existence and potential risks.

Neither the Senegalese state nor public experts invested much in producing 'counter' evidence to demonstrate aflatoxin's harmlessness. An exception was veterinary research on the effects, on livestock, of eating aflatoxin-contaminated meal. In the 1960s, Senegal-based studies showed that aflatoxin-fed cattle retained their productivity and fertility. In the early 1970s, Ahmadou Lamine N'Diaye, the first African professor of veterinary science, collaborated with leading French experts in human and veterinary toxicology. The latter had developed a method of 'relay toxicity,' which they argued was better suited than classic methods for evaluating the risks of feed contaminants as they passed through multiple and altered metabolisms. With N'Diaye, they published at least two articles, one suggesting that ingesting DDT could decrease aflatoxin sensitivity in ducklings (Ferrando et al., 1974), and the second finding that milk from aflatoxin-fed goats was only weakly toxic to duckling (thus calling for 'less stringent' regulatory consideration, Ferrando et al., 1977). Back in Dakar, N'Diaye, appointed director of the veterinary sciences school, assigned Mamadou Diom a thesis topic on aflatoxin in poultry feed (again finding little adverse effect). Diom's report (1978), in which he openly suspected that European regulatory standards were set to favour soy, argued that 'relay toxicity' could more accurately capture the 'real dangers' of aflatoxin in feed

and milk and thus guide 'regulation [that would be] accepted by both producers and consumers.' In Senegal, N'Diaye was celebrated, in a 2015 newspaper headline, as 'the vet who proved the non-toxicity of African peanut oilcake' (Sane, 2015).

Diom's comments about soy and the contested basis of European regulation juxtapose an epistemological geography of aflatoxin – shaping who could or would want to produce what kind of knowledge about risk, harm, and safety – with a shifting economic geography of crop production and trade. French/European aflatoxin regulatory standards were decided during a period of tension over the loosening of Franco-Senegalese economic ties. Under imperial rule, the creation of a nearly closed imperial circuit of trade for cheap Senegalese peanuts and Indochinese rice, and overpriced French manufactured goods, ensured that benefits accrued for French import-export firms as well as the colonial state and French industry (Boone, 1992; Founou-Tchuigoua, 1981). After independence, the maintenance of preferential prices for Senegalese peanuts in France kept the cheaper oil and feed generated by the rapidly rising American 'soy complex' at bay (Berlan et al., 1976). In 1967, however, EEC member states had to open their markets, putting Senegalese peanuts in direct competition with American soy (Berlan et al., 1976; Dupin, 1960). Produced by small-scale, low-capital farming, Senegalese peanuts worked as an imperial commodity that was part of an unequal and slowly extractive trade network (Boone, 1992). This system of production was ill-adapted, however, to a liberalised global market dictated by the agro-industrial model of soy (Berlan et al., 1976; Hetherington, 2020). By the early 1970s, Senegalese peanut meal had already lost a big part of its French market to soy (Barrot, 1989). It is unsurprising, then, that the scientific and political legitimacy of these standards were questioned by experts in, or on behalf of, Senegal. These conditions made aflatoxin unknowable, and not worth knowing, as carcinogenic in Senegal.

Residual eating

The nutritional projects in which aflatoxin was initially made visible in Senegal had proposed to turn peanuts from an imperial commodity into a technocratic solution. The ORANA's high-protein supplement would divert a by-product of Senegal's massive exports – the peanut meal left from crushing – that ORANA experts argued was more valuable as local food than as exported feed (for which, they pointed out, the market was volatile). They suggested adding a new loop in Senegal's peanut infrastructure: private (not-yet nationalised) oil-crushing firms would manufacture a commercial peanut flour from the residual meal, which would then be marketed to farming communities via the very same, now-nationalised circuit through which the state purchased their peanut harvest. While acknowledging, in passing, that Senegalese farmers were already eating some of the peanuts they grew, ORANA scientists presented the flour as a nutritionally superior form of peanut eating (Dupin, 1960).

The peanut flour project was interrupted by FAO concerns about aflatoxin, but ORANA experts also worried about other kinds of Senegalese peanut-eating as a route of exposure. In 1964, Toury warned his colleagues at Dakar's medical faculty annual symposium: 'the peanuts that remain in the soil at harvest time, and which are later collected for family consumption are revealed, by animal experiments, to be particularly toxic; it thus seems that recent discoveries on mycotoxins will soon be called upon to ask important public health questions' (Toury, 1964). Later, in 1971, Marie-Thérèse Basse worried that the development of electronic sorting methods would create safe exportable lots, leaving the most contaminated peanuts for Senegalese consumption.[12] In other words, she warned local aflatoxin exposure might be directly exacerbated by control-for-export. Yet in 1964, Toury was pointing out that Senegalese peanut-eating was *already* residual to the export

economy, and that this longstanding residuality might be newly shown, by aflatoxin research, to be harmful to health. As seen above, export-oriented research avoided investigating this exposure and its potential for harm. Here, I further suggest that the residual or 'extra-infrastructural' nature of Senegalese peanut-eating helped keep it invisible to, and unreached by, aflatoxin research and control.

That Senegalese eat a substantial portion of their peanut harvest has long and often – but usually in passing – been mentioned by observers. In a 1936 treatise on peanuts, the French imperial botanist Auguste Chevalier noted that a fifth of the harvest was reserved for 'self-consumption.' Such overviews of Senegalese peanuts say little more about local eating, in contrast with abundant detail on farming and marketing for export (e.g. Péhaut, 1961). Analysts usually oppose peanuts-as-cash to rice and millet as food. The 1952 Portères report, for example, calculated ratios of peanut production to millet harvests and rice imports to show that cash-cropping had created a 'subsistence deficit' (Founou-Tchuigoua, 1981). Post-independence politicians decried worsening terms of trade by comparing the market value of peanuts against the amount of rice they could buy (Cissé, 1968). The Marxian economist Bernard Founou-Tchuigoua (1981) instead argues that, by growing their own millet for food, Senegalese farmers could put more labour into growing peanuts than was compensated by their sale price. Thus, he writes, monocrop is a misnomer for peanuts in Senegal, which colonial trade rendered extractive through this 'duocrop' system. Other scholars have been fascinated by how peanut cash, during the colonial and post-independence years, animated relations between colonial subjects and state, as well as between religious leaders and their disciples (Copans, 1980), peasants and bureaucrats (Cruise O'Brien, 1975), communities and landscape (Pélissier, 1966), and so on.

The prioritisation of exports pushed Senegalese peanut-eating underground, both literally (as peanuts gleaned from the soil after harvest) and figuratively. As Senegalese production grew spectacularly in the first half of the twentieth century (tripling twice by mid-century: Boone, 1992), local peanut-eating grew in quantity and as a proportion of harvests, according to Portères, from 16 thousand to 150 thousand tonnes per year (1952; cited in Founou-Tchuigoua, 1981). In the early 1930s, following a drop in peanut prices as well as poor harvests, this 'self' consumption threatened exports: farmers planted fewer peanut and ate their seed stocks (Boone, 1992, p. 41) as well as directed a larger share of their harvest to 'village' oil-presses, which grew to more-than-artisanal scale (Founou-Tchuigoua, 1981). In response, the colonial administration reinforced the SIP system, making membership obligatory, which through seed and other loans bound farmers to peanut cash (Bernards, 2021; Boone, 1992). The state also, in 1931, prohibited local oil crushing, further pressuring farmers to sell their harvest for export (Founou-Tchuigoua, 1981). Peanut-eating, including through clandestine oil-pressing, thus developed, Founou-Tchuigoua (1981) observes, 'beyond the intervention of private or state capital,' as an extralegal and, more generally, an extra-infrastructural activity. The colonial export economy thus incurred both economic and nutritional losses to Senegalese farmers, as a speaker addressing colonial authorities in 1949 pointed out: ' … farmers know that by pressing 100 kg of peanuts [they will get oil of greater value than the sale of the same peanuts] and will in addition have oil-rich meal left for their own consumption […] I do not understand that you forbid Senegalese farmers from pressing their peanuts, while in France, farmers are not forced to sell their grapes to Y or Z and they are free to manage their own goods' (Founou-Tchuigoua, 1981). So-called artisanal oil-pressing was illegal in Senegal until 2010, albeit increasingly tolerated, as well as semi-industrialised, from the 1980s (Gaye, 1998). Post-independence nationalization further tightened the 'official' peanut circuit in the 1960s and 1970s by prohibiting private traders and the sale of peanuts not-for-export. While this restriction was quietly

lifted in 1988, the domestic market has continued to be widely referred to as 'parallel' (Gaye, 1998, p. 2000:13). This market, including for unrefined oil, grew from the 1980s, probably amplifying Senegalese exposures to aflatoxin, but its scale and effects remain under-documented (Clavel et al., 2013).

Like Toury, and even Payet and Sankalé, experts I spoke to in 2019 evoked harvest and sorting leftovers (kernels remaining in the ground, or damaged kernels sorted out during shelling) as particularly contaminated, suggesting that these converted socioeconomic inequality into exposure. Women and children, for example, are more likely to eat the peanuts gleaned from the ground after harvest. In the late 1980s, Matar Gaye (1998) calculated that mostly female 'artisanal' oil-processors could only turn a modest profit if they bought cheaper damaged kernels (*sax sax* or sorting leftovers). Later, Gaye (2000) also observed that a higher proportion of harvests was held back for domestic consumption in years of drought – which, as agronomists have observed since the 1960s, creates conditions conducive to aflatoxin contamination. These dispersed observations do not allow for a precise calculation of how market dynamics have affected Senegalese aflatoxin exposure. It seems clear, however, that Senegalese peanut circuits were configured under colonialism, long before aflatoxin's 'discovery', to channel the biggest and best portion of harvests towards export markets, with effects that have endured through decolonization and liberalization. Whether merely regulated as, or also acknowledged to be (potentially) carcinogenic, aflatoxin highlights ways in which Senegal's agricultural and trade infrastructures have produced Senegalese peanut-eating as residual.

Conclusion

The production of partial knowledge, ignorance and doubt about aflatoxin in Senegal happened in and for export-oriented infrastructures of peanut farming, trading, processing and regulation. The anticipated economic pressures of European regulation motivated the prioritisation of research on how to control aflatoxin in exported feed. The range of solutions pursued was then further narrowed, away from farms and farmers, towards technical intervention on inputs and outputs, at the inner and outer 'edges' of agricultural and trade infrastructures. This shift responded to practical challenges arising from lack of investment in peanut farming. Besides this indirect shifting of action and attention away from Senegalese exposures, medical and perhaps also political authorities deliberately, at times explicitly in the name of peanut export economies, disconnected aflatoxin from Senegalese liver cancer, which they instead tied to hepatitis B. They did this by selectively allowing international researchers to access Senegalese medical infrastructures and biological 'materials,' and by silencing or questioning available evidence for aflatoxin's carcinogenicity. Meanwhile, Senegalese peanut-eating was not only overlooked by aflatoxin research and regulation. It was also, more broadly, made invisible by infrastructures set up to grow and trade peanuts for export, and by partial records and analyses of the exchanges – among soil, bodies, institutions, countries – that these infrastructures supported or neglected. Aflatoxin was only worth knowing, in Senegal, in ways that facilitated and fit into export-oriented infrastructures. Decolonizing projects to extend the reach of these infrastructures into farming practices and conditions (though provision and extension services), and peanut-eating (as a protein supplement), made these briefly visible and relevant to aflatoxin research. Ultimately, however, farming and peanut-eating have remained extra-infrastructural, unknown by and not worth knowing for aflatoxin research and control.

The aflatoxin-contamination of Senegalese-eaten peanuts was not, by and large, directly *caused* by the regulation of peanuts-for-export. Still, Senegalese peanut-eating and aflatoxin exposures

have happened in a space configured by agricultural, trade and regulatory infrastructures designed to maintain the volume and acceptability of exports. By describing these exposures, and the ways in which they were left outside the pursuit of regulatory protection, as *residual,* I want to capture the dispersed and long-lasting effects of choices concerning how to maximize and distribute the benefits of farming, trading, and eating, and which/whose losses and damages should therefore be accepted or overlooked. Such choices, whether made by colonial administrators in the 1930s, postcolonial advisors in the 1960s, or Sonacos in the 1980s, were materialized and institutionalized in infrastructures of agricultural support, transportation, trade, and processing. These infrastructures mediated a differential valuation of peanut eaters and their potential harming/protection. *Residual unprotection* designates the (re)production of exposure at the margins of prioritized pursuits of toxic knowledge and control, and, more broadly, of safe and profitable food, seeking to capture what Ryan Galt (2014) calls 'food systems in an unequal world.' The term is thus a call to broaden and multiply the pathways through which we trace uneven distributions of harm and protection through infrastructural design and (under)investment.

Notes

1. There are different sub-types of aflatoxin (A1, B1, etc.). For the sake of simplicity, I use the singular in this article to refer to this category of substances.
2. Although Senegalese farmers have paid for peanut seed, varietal research and seed supply have generally remained public (rather than corporate).
3. The CFA Franc was pegged to the French Franc at a rate of 1/0.2 before 1994, the conversion to USD was done using fxtop.com's historical currency converter.
4. A.J. Tuyns, 'Report on a visit to Dakar, 21–25 February 1971,' File L4/3 DAKAR, Jacket 1, IARC Archives, Lyon, France.
5. Cancer that originates in, rather than metastasizing to, the liver. The main type globally and in Senegal is liver cell (or hepatocellular) carcinoma.
6. See File L4/3 DAKAR, IARC Archives.
7. Confidential letter, John Higginson to Robert Camain, 14 November 1968, File L4/2/1, IARC Archives.
8. Albert J. Tuyns, 'Report on duty travel to Dakar (Senegal) and to Abidjan (Ivory Coast),' File L4/3 DAKAR, IARC Archives.
9. M. Payet, « Considérations diagnostiques et étiologiques, à propos de 1200 cas de Cancer Primitif du Foie, » n.d. (circa 1965), Box 113, Folder 2, Blumberg Papers, APS.
10. B. Larouzé, 'Rapport concernant le voyage du professeur Blumberg au Sénégal, » December 1977, Box 36, Folder 16; B. B. Larouzé, « Communication à Fadel N'Diaye, » 1977, Box 141 Folder 5; A. Froment, « Activités de l'Institut for Cancer Research au Sénégal, » 1978, Box 76, Folder 8, Blumberg Papers, APS.
11. A. J. Tuyns, 'Duty travel to Dakar and Abidjan, 28 May to 13 June, 1969,' File L4/3 DAKAR, Jacket 1, IARC Archives.
12. A. J. Tuyns, 'Report on a visit.'

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References

Anonymous. (1973). *Moyens à mettre en oeuvre pour l'exécution d'un projet de vulgarisation sur la prévention de l'aflatoxine de l'arachide au Sénégal*. Campagne agricole 1973/74. Document A61-33, Centre de Documentation de l'ISRA, Dakar.

Anonymous. (1981a). Cancer du foie: 3 morts chaque jour au Sénégal. L'aflatoxine nullement en cause. *Le Soleil* (28 April).

Anonymous. (1981b). Des aliments pour bétail contaminés par une substance cancérigène ont été récemment importés en France. *Le Monde* (25 March).

Anonymous. (1992). Le nuage de la mort. Une citerne d'ammoniac explose: 41 tués, 403 blessés. *Le Soleil*, Dakar.

Auyero, J., & Swistun, D. (2008). The social production of toxic uncertainty. *American Sociological Review*, *73* (3), 357–379. https://doi.org/10.1177/000312240807300301

Ba, A. (1983). *Les sous-produits du traitement industriel de l'arachide: utilisations actuelles et perspectives de valorisation*. Rapport de stage de titularisation. Document CN0302768 Q100 BA, Library of the Centre National de Recherches Agricoles, Bambey.

Bado, J.-P. (2021). *Que savait-on des cancers et du cancer primitif du foie en Afrique 19eme-20eme siècles? Mensonges et vérités*. Éditions Connaissances et Savoirs (ebook).

Barrot, P. (1989). *Ces moisissures qui rongent les marchés agricoles*. 1 August, Syfia Press Agency.

Barrot, P. (1992). Aflatoxine. Le piège mortel des Américains. *Wal Fadjiri*, 29 April–7 March, 6.

Berlan, J. P., Bertrand, J. M., Lebas, L., & Marlone, M. (1976). Les conditions de la concurrence internationale entre soja, arachide et colza. *Économie Rurale*, *116*(1), 10–22. https://doi.org/10.3406/ecoru.1976.2450

Bernards, N. (2021). 'Latent' surplus populations and colonial histories of drought, groundnuts, and finance in Senegal. *Geoforum; Journal of Physical, Human, and Regional Geosciences*, *126*, 441–450. https://doi.org/10.1016/j.geoforum.2019.10.007

Bonneuil, C. (1999). "Pénétrer l'indigène": Arachide, paysans, agronomes et administrateurs coloniaux au sénégal (1987–1950). *Études Rurales*, *151*(1), 199–223. https://doi.org/10.3406/rural.1999.4122

Boone, C. (1992). *Merchant capital and the roots of state power in Senegal: 1930–1985*. Cambridge University Press.

Boudia, S., & Jas, N. (2014). The greatness and misery of science in a toxic world. In Boudia, S. & Jas, N. (Eds.), *Powerless science? Science and politics in a toxic world* (pp. 1–28). Berghan Books.

Brandt, A. (2007). *The cigarette century: The rise, fall and deadly persistence of the product that defined America*. Basic Books.

Brown, P. (1987). Popular epidemiology: Community response to toxic waste-induced disease in Woburn, Massachusetts. *Science, Technology, & Human Values*, *12*(3/4), 78–85. https://www.jstor.org/stable/689386

Chevalier, A. (1936). Monographie de l'arachide. *Journal D'agriculture Traditionnelle et de Botanique Appliquée*, *16*(181), 673–837.

Cissé, B. M. (1968). Keynote address. In *West African Conference on Nutrition and Child Feeding, Dakar, Senegal*, March 25–29 1968, U.S. Department of Health, Education and Welfare.

Clavel, D., da Sylva, A., Ndoye, O., & Mayeux, A. (2013). Amélioration de la qualité sanitaire de l'arachide au Sénégal: Un challenge pour une opération de recherche-développement participative. *Cahiers Agricultures*, *22*(3), 174–181. https://doi.org/10.1684/agr.2013.0630

Copans, J. (1980). *Les marabouts de l'arachide: la Confrérie mouride et les paysans du Sénégal*. Le Sycomore.

Cram, S. (2016). Living in dose: Nuclear work and the politics of permissible exposure. *Public Culture*, *28*(3), 519–539. https://doi.org/10.1215/08992363-3511526

Cruise O'Brien, D. (1975). *Saints and politicians: Essays on the Organisation of a Senegalese Peasant Society*. Cambridge University Press.
Davies, T. (2018). Toxic space and time: Slow violence, necropolitics, and petrochemical pollution. *Annals of the American Association of Geographers*, *108*(6), 1537–1553. https://doi.org/10.1080/24694452.2018.1470924
Davies, T. (2022). Slow violence and toxic geographies:'Out of sight'to whom? *Environment and Planning C: Politics and Space*, *40*(2), 409–427. https://doi.org/10.1177/2399654419841063
Diom, M. (1978). *Étude des problèmes posés par les aflatoxines dans les aliments du bétail et de l'homme* [Unpublished doctoral dissertation]: Ecole Inter-États des Sciences Vétérinaires, Dakar.
Dupin, D. H. (1960). *Propositions pour une étude sur les possibilités de diffusion et de commercialisation de la farine d'arachide propre à l'alimentation humaine, ORANA*. Document po III 4 797, BNS.
Dupin, H., Toury, J., Giorgi, R., & Cros, J. (1962). *Étude des aliments de l'Ouest Africain envisagés sous l'angle de l'apport en protides, ORANA*. Document po III 4°562, Bibliothèque Nationale du Sénégal (BNS), Dakar.
Faye, A. (1992). Abdoulaye Diop P.D.G. de la Sonacos: Pas de filière arachidière sans traitement à l'ammoniac. *Le Soleil*, 27 March: 1 and 8.
Ferrando, R., N'Diaye, L., Henry, N., Fourlon, C. Gautier, F., & Truhaut, R. (1974). Influence d'un prétraitement du caneton par le DDT sur sa réaction ultérieure vis-à-vis d'un tourteau d'arachide pollué par *Aspergillus flavus*. *Comptes Rendus de L'Académie des Sciences de Paris*, *273*(23 September), 1131–1134.
Ferrando, R., Parodi, A., Henry, N., Delort-Laval, J., & N'Diaye, L. (1977). Milk aflatoxin' et toxicité de relais. *Comptes Rendus de L'Académie des Sciences de Paris*, *284*(7 March), 855–858.
Fiske, A. (2018). Dirty hands: The toxic politics of denunciation. *Social Studies of Science*, *48*(3), 389–413. https://doi.org/10.1177/0306312718781505
Fortun, K., & Fortun, M. (2005). Scientific imaginaries and ethical plateaus in contemporary US toxicology. *American Anthropologist*, *107*(1), 43–54. https://doi.org/10.1525/aa.2005.107.1.043
Founou-Tchuigoua, B. (1981). *Fondements de l'économie de traite au Sénégal (La surexploitation d'une colonie de 1880 à 1960)*. Éditions Silex.
Frickel, S. (2004). *Chemical consequences: Environmental mutagens, scientist activism, and the rise of genetic toxicology*. Rutgers University Press.
Galt, R. (2014). *Food systems in an unequal world: Pesticides, vegetables, and agrarian capitalism in Costa Rica*. University of Arizona Press.
Gaye, M. (1998). *Les politiques d'ajustement dans le secteur agricole sénégalais: analyse critique des implications sur la filière arachidière*. Leuven, PhD.
Gaye, M. (2000). *Région de Diourbel: Politiques nationales affectant l'investissement chez les petits exploitants*. Crewkerne, UK, Drylands Research. Retrieved 21 September, 2021, from https://drylandsresearch.org.uk/pdfs/WP_Gaye_Policy.pdf
Goarin, P., & Goarin, S. (1969). *Contribution à la connaissance de l'aflatoxine de l'arachide du Sénégal*. Note établie pour les 3e session de la Commission Scientifique et technique du conseil africain de l'arachide, CNRA Bambey. Document Po III 4° 1962, BNS.
Goarin, P., & Toury, J. (1964). *Rapport au Gouvernement du Sénégal sur les contaminations de l'arachide par aspergillus flavus, les études en cours et les études à réaliser*. Document Bi III 4° 2802, BNS.
Goldberg, J. (2002). «Aflatoxin, » Retrieved 23 August, 2021, from https://slate.com/news-and-politics/2002/10/aflatoxin.html
Gordillo, G. (2018). Three. The metropolis. In K. Hetherington (Ed.), *Infrastructure, environment, and life in the Anthropocene* (pp. 66–94). Duke University Press.
Graeter, S. (2020). Infrastructural incorporations: Toxic storage, corporate indemnity, and ethical deferral in Peru's Neoextractive Era. *American Anthropologist*, *122*(1), 21–36. https://doi.org/10.1111/aman.13367
Guissé, Y. M. (1995). De l'atelier à la société: Les ouvriers de l'huilerie Sonacos de Dakar. In R. Cabanes, J. Copans, & M. Selim (Eds.), *Salarités et entreprises dans les pays du Sud: Contribution à une anthropologie politique*. Karthala-Orstom.
Guthman, J. (2019). *Wilted: Pathogens, chemicals, and the fragile future of the strawberry industry*. University of California Press.
Guthman, J., & Brown, S. (2016). Whose life counts: Biopolitics and the "bright line" of chloropicrin mitigation in California's strawberry industry. *Science, Technology, & Human Values*, *41*(3), 461–482. https://doi.org/10.1177/0162243915606804

Hetherington, K. (2020). *The government of beans: Regulating life in the age of monocrops*. Duke University Press.
Hoover, E. (2017). *The river is in us: Fighting toxics in a Mohawk community*. University of Minnesota Press.
Jacquet, J., & Lafont, P. (1981). Importance actuelle de la contamination des aliments par les mycotoxines: Mesures à prendre. *Bulletin de l' Académie Nationale de Médecine*, *165*(3), 359–364.
Jas, N. (2007). Public health and pesticide regulation in France before and after Silent Spring. *History and Technology*, *23*(4), 369–388. https://doi.org/10.1080/07341510701527435
Kasse, T. (1992). Frapper haut, frapper fort. *Wal Fadjiri*, 27 March–2 April: 4.
Kuchinskaya, O. (2014). *The politics of invisibility: Public knowledge about radiation health effects after Chernobyl*. MIT Press.
Langston, N. (2010). *Toxic bodies*. Yale University Press.
Langwick, S. A. (2018). A politics of habitability: Plants, healing, and sovereignty in a toxic world. *Cultural Anthropology*, *33*(3), 415–443. https://doi.org/10.14506/ca33.3.06
Li, T. M. (2018). After the land grab: Infrastructural violence and the "Mafia System" in Indonesia's oil palm plantation zones. *Geoforum; Journal of Physical, Human, and Regional Geosciences*, *96*, 328–337. https://doi.org/10.1016/j.geoforum.2017.10.012
Liboiron, M., Tironi, M., & Calvillo, N. (2018). Toxic politics: Acting in a permanently polluted world. *Social Studies of Science*, *48*(3), 331–349. https://doi.org/10.1177/0306312718783087
Lora-Wainwright, A. (2017). *Resigned activism: Living with pollution in Rural China*. MIT Press.
Mannon, J., & Johnson, E. (1985). Fungi down on the farm. *New Scientist*, *105*(28 February), 12–16.
Markowitz, G., & Rosner, D. (2013). *Deceit and denial*. University of California Press.
Moitt, B. (2001). From pack animals to railways: Transport and the expansion of peanut production and trade in Senegal, 1840–1940. *Outre-mers*, *88*(330-331), 241–267. https://doi.org/10.3406/outre.2001.3851
Mueller, L. M. (2019). Cancer in the tropics: Geographical pathology and the formation of cancer epidemiology. *BioSocieties*, *14*(4), 512–528. https://doi.org/10.1057/s41292-019-00152-w
Mueller, L. M. (2021). Risk on the negotiating table: Malnutrition, mold toxicity, and postcolonial development. In A. Creager, & J.-P. Gaudillière (Eds), *Risk on the table: Food production, health, and the environment* (pp. 138–162). Berghahn Books.
Murphy, M. (2006). *Sick building syndrome and the problem of uncertainty*. Duke University Press.
Murphy, M. (2015). Chemical infrastructures of the St Clair River. In *Toxicants, health and regulation since 1945* (pp. 103–115). Routledge.
Murphy, M. (2017). Alterlife and decolonial chemical relations. *Cultural Anthropology*, *32*(4), 494–503. https://doi.org/10.14506/ca32.4.02
Nading, A. M. (2017). Local biologies, leaky things, and the chemical infrastructure of global health. *Medical Anthropology*, *36*(2), 141–156. https://doi.org/10.1080/01459740.2016.1186672
Nading, A. M. (2020). Living in a toxic world. *Annual Review of Anthropology*, *49*(1), 209–224. https://doi.org/10.1146/annurev-anthro-010220-074557
Nash, L. (2007). *Inescapable ecologies*. University of California Press.
Neumann, P. (2016). Toxic talk and collective (in) action in a company town: The case of La Oroya, Peru. *Social Problems*, *63*(3), 431–446. https://doi.org/10.1093/socpro/spw010
Nixon, R. (2011). *Slow violence and the environmentalism of the poor*. Harvard University Press.
Oya, C. (2006). From state dirigisme to liberalisation in Senegal: Four decades of agricultural policy shifts and continuities. *The European Journal of Development Research*, *18*(2), 203–234. https://doi.org/10.1080/09578810600708163
Park, D. L., & Stoloff, L. (1989). Aflatoxin control—How a regulatory agency managed risk from an unavoidable natural toxicant in food and feed. *Regulatory Toxicology and Pharmacology*, *9*(2), 109–130. https://doi.org/10.1016/0273-2300(89)90029-9
Pattinson, J., & Deuse, J. (1970). *Les problèmes de stockage de grains au Sénégal et les mesures entreprises et proposées pour leurs résolutions, FAO and ITA*. Document Po III 4° 2282, BNS. Emphasis added.
Payet, M., Sankale, M., Larouzé, B., Saimot, G., & Blumberg, B. (1975). *Facteurs étiologiques du cancer primitif du foie. Place de l'antigène Australia (manuscript note: to be published in the Proceedings of the French Congress of Internal Medicine, Dakar, November 1975*, Box 113, Folder 1, Baruch Blumberg Papers, American Philosophical Society (APS), Philadelphia, U.S.
Péhaut, Y. (1961). L'arachide au Sénégal. *Cahiers D'outre-mer*, *14*(53), 5–25. https://doi.org/10.3406/caoum.1961.2191

Pélissier, P. (1966). *Les Paysans du Senegal; les civilisations agraires du Cayor a la Casamance*. Libraire Fabrègue.
Portères, R. (1956). L'état des recherches sur la nutrition et l'alimentation au sénégal. *Journal D'agriculture Traditionnelle et de Botanique Appliquée*, *3*(11), 769–778. https://doi.org/10.3406/jatba.1956.2346
Proctor, R. N. (1994). *Cancer wars: How politics shapes what we know and don't know about cancer*. Basic Books.
Rodgers, D., & O'Neill, B. (2012). Infrastructural violence: Introduction to the special issue. *Ethnography*, *13* (4), 401–412. https://doi.org/10.1177/1466138111435738
Ross, C. (2017). *Ecology and power in the age of empire: Europe and the transformation of the tropical world*. Oxford University Press.
Sankale, M., Gendron, Y., Courbil, L-J. (1983). Le cancer primitif du foie en milieu tropical. Données classiques et récentes. *Médecine Tropicale*, *43*(3), 239–252.
Sane, I. (2015). Le vétérinaire qui a prouvé la non-toxicité des tourteaux d'arachide d'Afrique. Pr Amadou Lamine Ndiaye, Président de l'académie nationale des sciences et techniques du Sénégal. (29 June), *Le Soleil*.
Sellers, C. C. (1997). *Hazards of the job: From industrial disease to environmental health science*. Univ of North Carolina Press.
Senanayake, N., & King, B. (2019). Health-environment futures: Complexity, uncertainty, and bodies. *Progress in Human Geography*, *43*(4), 711–728. https://doi.org/10.1177/0309132517743322
Stoler, A. L. (2008). Imperial debris: Reflections on ruins and ruination. *Cultural Anthropology*, *23*(2), 191–219. https://doi.org/10.1111/j.1548-1360.2008.00007.x
Touhouliotis, V. (2018). Weak seed and a poisoned land: Slow violence and the toxic infrastructures of war in South Lebanon. *Environmental Humanities*, *10*(1), 86–106. https://doi.org/10.1215/22011919-4385480
Toury, J. (1964). *Communication faite aux Journées Médicales de DAKAR, 4-10 janvier 1964*, Centre de documentation de l'ORANA, Dakar.
Tousignant, N. (2018). *Edges of exposure*. Duke University Press.
Tsing, A. L. (2015). *The mushroom at the end of the world*. Princeton University Press.
Vogel, S. A. (2008). From 'the dose makes the poison' to 'the timing makes the poison': Conceptualizing risk in the synthetic age. *Environmental History*, *13*(4), 667–673. https://doi.org/10.1093/envhis/13.4.629