Digging deep in the sociality of interaction: knowledge-making in agricultural science

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Reading Notes for Workshop Participants

Hello, and thank you in advance for your feedback on this draft. What follows is a coauthored piece that aims to offer a friendly amendment to a recent view advanced by Longino on the sociality of interaction and its role in the generation of scientific knowledge. Our methodology is, in one sense, straightforward: we aim to provide a counterexample to a detail of her view through an extended series of case studies.

In another sense, the manuscript is far from straightforward, as the case studies center on scientific topics that have few if any predecessors in the philosophy of science literature. We write here about potatoes and potato research, and one of our main questions for early readers is: what else do you need to know about potatoes in order to follow our point? What details do you feel are missing from the descriptions of this research that would help you better to follow our discussions? What should be left out? We have, as the title suggests, dug deep, and additional perspectives on what pieces of the work are required for understanding the Longino-centered point would be appreciated.

The manuscript is also not straightforward in the standard sense of many coauthored papers. While we have written together before, we have not shared work at this stage with a group; it is likely evident when the first author of a paragraph changes. We would also welcome feedback on where this unevenness is most apparent and any suggestions for smoothing transitions.

Third, the core argumentative move of the piece consists in using the potato cases to establish that the practices productive of knowledge are, in at least this domain, inextricable from content and subject matter of the produced knowledge. Does this point come through adequately? What questions on it remain at the close of reading?

We have left off a conclusions section, which we anticipate being brief. Any suggestions on what was especially notable in the cases that should be highlighted in the conclusions would be welcome.

All the best,
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1. Introduction

Sociality of science has long been the topic of investigation in science studies and the social constructivist approaches advanced within critical race theory and feminist epistemology. What might be referred to as the sociality turn has also been present in much of philosophy of science which has turned attention to the practice of science and the activities of scientists as the target of philosophical study. But what is sociality and to what does it refer?

Helen Longino's career has provided a number of canonical and crucial advances in philosophical understanding of the sociality of science, from her early account in *Science as Social Knowledge* (1990) to her analysis of the role of sociality in *Studying Human Behavior* (2002). In her most recent work, "What's Social About Social Epistemology?" (Longino 2022, *Journal of Philosophy* vol. 109(4)) she turns her attention specifically to a particular aspect of the sociality of science, which she terms "the sociality of interaction" (171). In her account, it is the sociality of interaction within scientific groups that makes them knowledge producing, that is, it is their sociality that is essential to their ability to produce scientific knowledge.

Longino argues that although philosophers discuss the social aspect of scientific practice, they often do so with a thin account of what is social: 'attention to scientific practice demands a deeper and more robust conception of the social than philosophers have yet to fully articulate' (169). Thin accounts of the 'social' refer to the reactive experiences individuals have when among others especially when those others are conceived of as holders of information, when there are shared attitudes among individuals, or a particular non-cognitive but causal aspect of inquiry. Longino contrasts these thinner notions with a stronger or thicker notion of social. Her thick notion of social requires more than the reactivity of individuals to those around them. Individuals are more than merely social–part of the environment that requires moving around or responding to when disagreed with. To be thickly social is to be interactive in a way that is robustly and ineliminably participatory.

We are broadly sympathetic to this view. However, in analyzing the sociality of interaction in the sciences, Longino argues that "concern with practices that are productive of knowledge, rather than with the content and subject of knowledge" should be the focus (173). This suggests that it is possible to analyze practices without analyzing the content and subject of knowledge, and further that analysis of content-knowledge in a given scientific domain should not be the focus of attention if the goal of a philosophical investigation is understanding of scientific knowledge production. We disagree.

Our argument centers on case study from agricultural science. In particular, we consider the cooperative system of agricultural- extension, and the knowledge-producing work produced by extension activities within agricultural science. Agricultural extension is a legally and institutionally defined social system that produces interactions between scientists and the public in contemporary U.S. agricultural science. The success conditions of the production of extension knowledge are inherently, and deeply, social. Through a discussion of agricultural scientific research on potatoes, we illustrate how the interactive sociality of extension generates content-knowledge that is deeply intertwined with practice-knowledge.

Our analysis is ultimately a friendly amendment to Longino's view, which takes seriously the centrality of the sociality of interaction in the content and practices that produce scientific knowledge. We contend that looking at knowledge co-production in agricultural extension practices focusing on potato development and production, illustrates how knowledge about agricultural experiment is made through social interaction and why such interaction is essential for epistemic content. What we propose is an admittedly strong form of sociality in which sociality is constitutive of knowledge in a way that without it, that which is being discussed ceases to be knowledge if it is not social.

2. Knowledge coproduction and Longino's contributions to mainstreaming values in scientific epistemology

In *Science and Social Knowledge* (1990), Longino seeks to reconcile ideas about the subjective nature of us, of scientists and of knowers in general with our view of the scientific method and scientific knowledge coming as the result of its use as being objective. Relying on the work of Marjorie Grene, Longino's reconciliation results from shifting the discussion from science to the activity of science and scientific disciplines to social enterprises. The objectivity of scientific inquiry is a direct consequence of the participation of scientists in community with one another — and, in distinct roles, the broader public. Rather than a threat to scientific knowledge, the social character of scientific knowledge secures the objectivity of scientific knowledge.

Although we agree with Longino that it is the sociality of interactivity that should be the focus of philosophical discussion, we disagree with the underlying assumption that practices and the content of knowledge are describable separately. Taking lessons from the agricultural extension case, we are critical of the separation of the practices productive of knowledge and the content of knowledge. Part of our argument for this rests on a dissolution of the distinction between pure and applied science which seems to underpin the distinction between knowledge and practical knowledge. We believe doing so also strengthens Longino's earlier notion of the ineliminability of the social aspect of epistemology. Taking seriously the constitutive aspect of it in social interaction and the prerequisite for social interaction. Looking at the practices and processes of knowledge generation, and in particular coproduction in agricultural extension practices, we illustrate how knowledge is made through these interactions and why without them it ceases to be or have epistemic content. What we propose is an admittedly extra-strong form sociality where sociality is constitutive of knowledge in a way that without it, that which is being discussed ceases to be knowledge if it is not social. Doing so also takes seriously Longino's non-reductionist claim. In sound-bite form, the thing that makes it what it is —that literally brings it into existence — is social knowledge.

To illustrate the inextricability of the content of knowledge and practices that are productive of knowledge we turn to agriculture, and in particular, to the various people who without their persistent and varied forms of interactive practices, there would not be agricultural knowledge about potatoes.

3. Potatoes, People, and Science

To understand the interactivity of the practices productive of knowledge and how they are intertwined with the products in systems of agricultural scientific research, we consider recent research on potatoes. In discussing potato research, we aim to show that the practices that are productive of knowledge (in this case, the activities of potato research) are inextricable from the content and subject of knowledge (in this case, potatoes). Highlighting the intertwined nature of research practices and products in this case illustrates why we believe it crucial to strengthen Longino's view on the nature of the sociality of interaction.

3.1 Potatoes

First things first: potato research exists, and it comprises a significant industry of many and varied research projects across multiple scientific, geographic, food systems, and ecological dimensions. It is carried out in both academic and industrial settings and in both conventional and organic/regenerative agricultural frameworks. Academic research on potatoes occurs in departments in agricultural colleges, such as plant and soil sciences, plant pathology, and food sciences; it also occurs in departments outside agricultural colleges such as biology and in schools of packaging.

Potato research, like all agricultural research, is shaped by goals — e.g. what should be planted and when?, when should irrigation begin and end?, when should this field be harvested?, how should carbon be captured?, what cover crop will be best for this land? Where and in what way should the crop once harvested be stored and for how long? Community interests — whether these are farmers', agronomists', or potato-chip eaters' interests — direct the sorts of activities by which these goals are pursued and determine the success conditions for meeting these goals. For example, some central goals of potato research include:

1. Understanding pest and disease pressures on potato crops and improving crop resilience
2. Increasing efficiency in planting, growing, harvesting, and storing processes
3. Tailoring the sugar, starch, and micronutrient content of potato tubers for specific purposes, such as optimal potato chip production or increased nutritive content
4. Identifying and decreasing how much energy, especially non-renewable energy, goes into potato production
5. Mapping and sequencing genetics of wild, landrace,[2] and cultivated potato varieties

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[2] Landraces are varieties of plants and animals that are developed over time through domestication and agricultural intervention. They arise as distinct, geographically isolated populations from wild members of their species that eventually exhibit distinguishing phenotypes and/or genotypes from uncultivated varieties, but they are not selectively bred cultivars or breeds.

A majority of scientific research on potatoes occurs by considering potatoes as agricultural objects that interact with human production and consumption, as opposed to treating potatoes as “mere” plants. And even projects that aim to study wild potatoes, such as a recent *Nature* study on wild and landrace potato genotypes titled “Genome evolution and diversity of wild and cultivated potatoes,” (Tang et al. 2022) are often justified by the potential agricultural benefits of the scientific discoveries. Consider the beginning of that study’s abstract:

> “Potato (*Solanum tuberosum* L.) is the world’s most important non-cereal food crop, and the vast majority of commercially grown cultivars are highly heterozygous tetraploids. Advances in diploid hybrid breeding based on true seeds have the potential to revolutionize future potato breeding and production. So far, relatively few studies have examined the genome evolution and diversity of wild and cultivated landrace potatoes, which limits the application of their diversity in potato breeding.”

The reason scientific work is being carried out in this study is for the purpose of understanding potatoes in virtue of their relationship to humans. While the scientific binomen is provided, potato is defined fundamentally as an agricultural “crop,”. Interest in researching the potato’s evolutionary genetic history is not in virtue of its botanical interest as potato qua plant. The dearth of knowledge about its genome evolution and the diversity of wild and cultivated landrace relatives is identified as a problem because it inhibits potato breeding, with the understood implication that breeding occurs for the sake of eventual human consumption.

Potato research is an inherently normative science because of the central role human influence plays over ecological, geological, and environmental conditions. This human influence includes goal-directed farming practices that aim to increase the health and productivity of the land. Whether potato research is directed to water-soil management, storage, or increasing genetic diversity, the content of the knowledge pursued is inextricably linked to the experimental practices that are productive of that knowledge shaped by normative goals of humans. To further illustrate this, we’ll focus for the moment on potato breeding. Potato breeding is an area of significant scientific activity within potato research. Breeding projects can target any of the goals of potato research identified above. For instance, per Goal 1, breeding for pest- and disease-resistance is a long-standing practice in agriculture and is itself an entire field of study in agricultural science. Likewise, creating potato types that require less in-ground maintenance to develop tubers would align with Goal 2, and developing cultivars whose respiration more efficiently sequesters carbon would align with Goal 4.

3.2 Research communities in potato research

In the United States, communities pursuing scientific research on potato breeding occurs across and between two distinct types of researchers: commercial agronomists employed by companies in the potato farming industry, and extension agronomists employed by the country’s land-grant institutions, most of which are large public universities with a tripartite mission in teaching, research, and extension. Extension agronomists are university employees, many of whom have teaching and/or research responsibilities in addition to their extension responsibilities. Extension responsibilities are often compared with outreach responsibilities and consist of activities that make the resources of the university more accessible, more relevant, and more useful to the communities that the university aims to serve.[3]

3.4 Scientific knowledge and communication

One unusual feature of agronomy research, from the perspective of philosophy of science, is that publication of research results in peer-reviewed journal is often an afterthought, if it is a thought at all. The information gleaned from, for instance, potato breeding research conducted by extension agronomists, is more commonly disseminated to user communities through extension bulletins, field days and on-site presentations, industry communications, and personal communications such as group chats between extension workers and local farmers. There are a number of reasons for this state of affairs, notably 1) that information about crop systems is highly local, and 2) that results of industry-driven research are often proprietary to the corporate sponsors of the research.

The proprietary nature of corporate research will have to be the subject of another discussion, but the ways in which the local nature of the results of agronomy research affect its dissemination are perfectly apt for our present purposes. This local focus in research arises from the local nature of the agricultural practices that agronomy research aims to support.

4. A case study of potato trials

Idaho potatoes are not Michigan potatoes: the same potato cannot be grown in two places. According to the Idaho code title 22-1204, Idaho potatoes are those grown in Idaho. Idaho potatoes, growers, and shippers are defined as such according to Idaho code title 22-1204, “the term ‘potatoes’ means and includes only potatoes sold or intended for human consumption and grown in the state of Idaho” and “‘grower’ means one who is actively engaged in the growing of potatoes on five or more acres in the state of Idaho, and who does not provide the primary management to a shipping or processing operation” and “the term ‘shipper’ means and includes one who is properly licensed under federal and state laws, actively engaged in the packing and shipping of potatoes in the primary channel of trade in interstate commerce in the state of Idaho, who does not provide the primary management to a growing or processing operation, and who ships more than he produces” (Section 22-1204).

To say Idaho potatoes are not Michigan potatoes is to share knowledge about what state they are grown in and by whom. However, it is also to say something about the nature of their relationship of identity, that they are, indeed, non-identical. But to what does this non-identity refer? It is more than the uninteresting observation of their numerical non-identity. According to growers, shippers, and potato agronomists, as well as perhaps particularly discerning eaters of potatoes, to say Idaho potatoes are not Michigan potatoes is to say something about their

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[3] The U.S. Cooperative Extension system has been encoded into national law and tied to U.S. land-grant institutions through the 1914 Smith-Lever Act. For a more in-depth philosophical introduction to the epistemic role of extension work, see Bursten and Kendig 2021.

growing or storing conditions, that is, something about their ecological or environmental non-identity.

For instance, something about the differences between Idaho soil and Michigan soil, or about Michigan weather and Idaho weather conditions. Potatoes sold as Idaho potatoes are not potatoes of a particular kind (e.g. russet, Yukon Golds, Reds, or Fingerlings) but potatoes federally registered and certified according to the Idaho Potato Commission. They are potatoes grown in Idaho soil which is largely volcanic. While some components of a potato crop system are shared across different potato-growing regions of the United States — commercial fertilizer is available across state lines, and it is possible to use identical tractor and equipment models in fields in both regions, many are not. It is frequently the case that even in these universalizable aspects of potato crop management, local adaptations are made. Farmers order custom-blended fertilizer for their individual fields, use data from local soil testing; tinker with machinery to make a piece of equipment better suit their needs. Human managed causes the result of their interactivity with soil and climate systems impact all aspects of potato growth, from the timing of planting and harvesting to the timing, quantity, and distribution of nutritive inputs the potato tubers receive.

Potato fields are not homogenous and different areas may have more organic matter, more water or more nutrients depending on the historic use of the areas for crops (e.g. a cotton-maize-soybeans crop rotation may have been used, or peanuts may have been planted previously) or if there were livestock present (e.g. cattle, chickens, swine). They also depend on topography, presence of hedgerows, and irrigation systems. Knowledge of the soil can help the farmer decide their crop rotation and which mix of species to use for their cover crops.These interactions and shape not only what it is that is thought to be in the field, but how to care for it, e.g. what sorts of soils and what kinds of potatoes. The sort of soil thought to be in the field, affects what are thought to be the best agricultural practices to treat it as well as what to plant in it. But it also depends on an ensemble of relationships which includes the relationship of the soil and crop to the farmer, to the farmer's previous planting practices, the ecological effects of previous crop rotations, the farmer's knowledge of local ecology, and the relationship of the crops to the soil and their roots to the microbes present.

The conventional soil management activities that are chosen by the farmer are informed by the commitments to different methods the farmer has or will use in the future. Depending on the resulting normative assessment of the soil following a soil's nutrient analysis, the farmer may adopt different soil management practices. For instance, the farmer might adopt the practice of cover-cropping to manage soil fertility or reduce erosion of topsoil. Doing so can eliminate the need to add phosphorus and potassium fertilizer and additional nitrogen especially for maize and cotton. This choice may be influenced by the local weather and likelihood of losing a crop due to a dry summer. Cover-cropping can increase soil organic matter which in turn can positively affects retention of water, so it is a practice that many farmers rely on to retain much needed soil hydration: "We're seeing so much more moisture that we can hold in the ground. We figure we have increased organic matter by 0.6%-1.6% on the farm. Having 1% more organic matter is just like having another inch of water out there" (Giles 2021: 8). For farmers in drought-prone environments, cover-cropping provides a means by which they can protect their soil and significantly reduce the likelihood of crop loss due to drought. In addition to adjusting nutrient and moisture levels, managing soil has also included mechanical leveling of fields, adjusting drainage, and the removal of large stones in the field.

The fact that individual potato tubers are the products of highly local inputs and local interactions between plants, soil, climate, humans, and machines is not meant to be metaphysically or epistemically mysterious; rather, it simply serves to explain that the reason agronomy research is highly localized is because agricultural practice is highly localized. This locality impacts the ways in which the results of research are disseminated, which has in turn impacted the methodology we have used to obtain information about agronomy research. Rather than relying on peer-reviewed publication records, we collected data from semi-structured interviews conducted with extension workers and farmers in Michigan throughout 2023. Through these interviews we were also able to obtain access to locally and regionally disseminated research results, such as slides presented at meetings between extension workers and farmers.

One such interview produced information about a Michigan-based program in potato variety breeding. From other interviews, it is clear that this is a fairly typical instance of how extension agronomy research progresses, and the progression clearly shows the integration of sociality with experimental products, resulting in epistemic content in which the products and social processes of research are deeply intertwined. We outline the program below.

The program spans decades and includes multiple stages of variety trial testing. Stages include:

1. ***Small-acreage trials***. Extension agronomists supervise small-acreage trial plots of different potato varieties across Michigan's seven microclimates. Small-acreage trials involve:
    a. **Obtaining land for the trial**, which occurs either (i) through agreements with private farmers who lease land to Michigan State University for the period of the trial, or (ii) housing trials on MSU-owned farmland.
    b. **Cultivating seed potatoes** from 12 varieties of potato, which consists of in-lab and in-ground testing of seed varieties.
    c. **Planting**. Extension agronomists often work on site during planting, in concert with teams of students and commercial farm workers, to set up the experiment plots.
    d. **Maintaining trials**. Much of the work of agronomic research is simply the work of growing crops, and most of this work is performed by the regular employees of the farm. The landowner or farm manager works with extension agronomists to schedule maintenance (watering, thinning, fertilizing, application of pesticides, harvest, etc.), determining whether trial plots will receive the same maintenance schedule as the commercial plots surrounding them or whether an experiment-specific schedule is required. When private farms are used, agronomists employed by the farm may be consulted to design schedules. In

either case, extension agronomists are not the primary performers of maintenance.

   e. **Harvesting potatoes and data**. Potato biomass, consisting primarily of tubers but also leaves, stems, and roots, is harvested on schedule with commercial potato harvests. Experimental biomass may also be harvested earlier in the season. Extension agronomists, farm workers, and agronomy students use this biomass to check factors such as sugar and starch quantities, pathology screenings, tissue culture, harvest date data, susceptibility to disease, and stages of growth.

2. ***Upscaling trials*** occur on larger-acreage plots. These trials follow similar design and data collection procedures as small-acreage trials, but their conditions more closely mimic those of large-scale commercial growers. For instance, some types of equipment that are too large to maneuver through small-acreage trial plots can be employed on large-acreage plots, which more closely reproduces the conditions of commercial practices. When asked about the aim of this step, the interviewee emphasized that upscaling trials builds trust between the commercial growers who are the target audience of these trials and the extension agronomists who are collecting data.
3. ***Processor trials*.** Potato processors, who take tuber biomass and turn it into grocery store products, are distinct from growers and work closely with growers in both commercial agriculture and agronomic research. During variety trials, processors are consulted at multiple stages on the performance of different varieties in their different lines of processing, typically potato chips, frozen products such as hash browns and fries, and dried products such as instant potatoes. Tablestock culinary trials may also be performed in this stage.
4. ***Seed certification***. New varieties that are deemed successful through upscaling and processing are earmarked for certification as a new publicly-available potato variety. Tissue cultures are sampled from breeding-line plants (tubers, leaves, stems, and roots) and undergo a registration process. Seed certification is a state-level process governed by state legislature and the state department of agriculture. Michigan Act 94 of 2018, the Seed Potato Act, is the current governance regulating certification of seed potatoes planted by commercial growers in Michigan, whether the seed potatoes themselves come from Michigan or from out of state. The Seed Potato Act also governs sale of seed potatoes in Michigan. Requirements for certification of Michigan-grown seed potatoes that will be sold and planted in Michigan include grading, field inspection, postharvest inspection, and specification of field year. The Seed Potato Act also specifies that Michigan seed potato production shall be overseen by an advisory committee consisting of two commercial growers who do not grow seed potatoes, the current chair of the Michigan Seed Potato Association, an employee of Michigan State University, and a member of the Michigan Department of Agriculture.
5. ***Storage trials***. Storage trials are perhaps more specific to potatoes than other crops. They consist of testing how well potato tubers last through weeks and months of storage in a variety of human-made conditions, including box bins, modern warehouses with up-to-date ventilation and climate control facilities, and in less controlled environments such as farm sheds and homes. Storage trials are an important part of testing potato

varieties in Michigan specifically because Michigan is the country's largest storer of potatoes, due to its higher-humidity climate relative to other high-potato growth regions (e.g. Idaho). This means both that it is important to assess potato storage in Michigan climates and that potato varieties that will be stored in Michigan must be resistant to high-humidity vectors of disease and decay. Storage resilience is tested through sampling of stored potatoes for sugar and starch content and for disease and decay over regular time intervals.

6. ***Promotion and Commercial Seed Increase.*** A highlighted stage of variety trial testing in this Michigan program is the promotion of successful new varieties and increase of seed potato biomass from these varieties in Michigan and regional markets. Promotion occurs through word of mouth, advertising in seed catalogs, demonstrations, and similar marketing strategies. Commercial seed increase, intended to increase the supply to meet promotion's increased demand, occurs through agreements with seed potato growers to grow the identified novel varieties rather than others.

At the completion of this process, it will be the case that what varieties of potatoes are grown in Michigan has changed. This change occurs through a complex of changes in human social behavior in concert with biology, soil science, genetic, and conceptual engineering.

Perhaps you might be thinking, what does the above list of variety trials and testing scenarios have to do with the sociality of interaction in the content and practices in potato science that produce scientific knowledge? These trials are knowledge-producing through social interaction only in virtue of human-influenced genomic, ecological, geological and environmental research causes that are goal-directed. Trials can be performed only in virtue of these community-identified goals.

Community-identified goals define appropriate research hypotheses, determine experimental set up conditions, and set the rules of assessment for the success or failure of the trials. To put it strongly, knowing-and-cultivating potatoes is an inextricable and socially ineliminable set of intertwined processes. This is because potato knowledge is the result of human-facilitated causes that define what is planted, how, and for what purpose in test plots as well as the conditions for successful replicability of test results in farmers' fields. We believe this strengthened notion of interactive sociality and the inextricability of knowledge and practice better represents the nature of potato research and research communities than the epistemic privileging of practice knowledge over content knowledge suggested by Longino (2022). What we sketch here might be described as a 'normative agricultural metaphysics" (Kendig 2023) that structures agricultural knowlege-making and includes both agricultural extension workers as well as farmers and encompasses genomic as well as economic goals in evaluating future production strategies through practice-embedded conceptual commitments. This interactive normative metaphysics draws inspiration from Longino's (2002) arguments for the ineliminability of the social aspect of scientific knowledge and as such could be understood to be an social ontological extension of her social epistemology.

5. The intertwining of potatoes, people, knowledge, and standards

In the previous section, we emphasized the intertwining of practice and content in the shaping of experiment and research design and implementation. We hinted earlier at the ways in which our thesis extends even deeper into the root — or, shall we say, tuber — of what potatoes themselves are. It is the case that scientific knowledge about potatoes is inextricable from the interactively social research practices that produce that knowledge (performed by multiple diverse communities), and we hope to have shown this in sections 3 and 4. However, we also hold it to be the case that potatoes themselves are, in an important sense, socially constructed products of interactions. We do not mean this as mysterious metaphysics: it is simply the case that human intervention on the planting, growth, and cultivation of potatoes has touched a vast majority of the potato plant biomass presently on our planet. Wild potatoes are the significant minority by biomass, and this fact affects what the public and science mean by "potato." In this section, we consider what set of coincident properties and features define the majority, cultivated potato according to contemporary U.S. agricultural standards, to drive home this point.

Potato–people interactions are shaped in terms of how potatoes and people are defined according to agricultural standards. Agricultural standards for potatoes include requirements for minimum size and weight according to different designations, e.g. creamer, chef, small, medium, large (51.1545); skinning, e.g. whether the potato has suffered damage in harvest or storage that results in the potato.

For instance, if the potatoes are to be graded according to the standard of 'slightly skinned' then no more than 10 percent of the potatoes in the lot, having more than one-fourth of the skin missing (51.1549). The process of potato standardizing includes the engineering of the concept 'slightly skinned'. The engineered concept is the standard which is developed in consultation with potato growers, commissions, and governmental entities including the United States Department of Agriculture. Along with the engineering of the concept of 'slightly skinned', there is also the engineering of a classificatory ontology.

This classification specifies what sort of thing is conforming to the standard 'slightly skinned' and what it should be to meet the standard. The standard is the engineered concept and the entity or product which is the material entity or agricultural process to which the standard applies. Agrotechnological standards, like those for potatoes, do not just engineer the concepts and define the terms for potato standards and grades in use. Standard-making and standard-setting also brings into existence the product for which the standard is made–the potato–as an agricultural commodity.

Potato standards as normatively defined goals of a community do not just bring into existence the potato as an agricultural product that can be researched, cultivated, grown, stored, and shipped only according to standards defining them as qualifying as the agricultural product 'potato' for a particular community of researchers, growers, and eaters. They also constitute how potatoes are to be interacted with. For instance, they determine the nature of the activities and interactions that people have with potatoes, grower, potato researchers, extension workers, storers, and shippers.

These standards may be universally agreed upon or frequently revised. They may be state-led, national, the result of local potato commissions, or industry. While standard potato grades such as ‘slightly skinned’ appear to apply to potatoes as an acceptable agricultural foodstuff, their application in use depends upon the activities and interactions of people. The potato standard ‘slightly skinned’ implies a standard for a person working with potatoes. That means that standards for potatoes as agricultural products imply standards for all those handling potatoes or are in a position to protect the potato’s skin from damage–growers, storers, and shippers. Agricultural practices, research about how best to cultivate, keep and ship potatoes are intertwined epistemologically, ontologically, and metaphysically insofar as they are the result of interactive tripartite relationship of products-grower practices-knowledge.

The case studies of potato trials and USDA potato standards shows how agricultural interactions of products–grower practices–knowledge exemplify a situation where the existence of knowledge and the practices of its production are inherently and epistemologically, metaphysically, and ontologically inelimiably social.

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