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

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# 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 recent philosophy of science, which has turned attention to the practice of science and the activities of scientists as a 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) 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 sociality than philosophers have yet to fully articulate”(169). Thin accounts of sociality 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 thicker notion of sociality. Her thick notion 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. In order to describe the mechanics of scientific knowledge production in a thickly social world, Longino includes in this discussion an outline of her account of the sociality of interaction.

We are broadly sympathetic to this view. However, in outlining her account of 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 a case study from agricultural science. We consider the cooperative system of *agricultural extension[[2]](#footnote-2)* and the knowledge-producing work generated 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. We show below that the success conditions of the production of extension knowledge are inherently, and deeply, social. Through a discussion of agricultural scientific research focusing on potatoes, we illustrate how the interactive sociality of extension generates

content-knowledge that is deeply intertwined with the knowledge of agricultural practices.

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, particularly in the case of potato development and production, illustrates how knowledge about agricultural experiment is made through social interaction and why such interaction is essential for epistemic content. “Knowledge co-production” in this context refers to both the institutionally structured framework of U.S. agricultural extension facilitating conversations between university extension researchers and farmers, as well as the reciprocal exchanges and generation of new knowledge through those conversations themselves. 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.

# Knowledge coproduction and Longino’s contributions to mainstreaming values in scientific epistemology

In *Science as 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 the sociality of interaction that should be a focus of philosophical discussion, we disagree with the underlying assumption that scientific 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.[[3]](#footnote-3) 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 to have epistemic content. What we propose is an admittedly extra-strong form of sociality where sociality is conceived of as constitutive of knowledge. This proposal effectively brings Longino’s (1990) earlier arguments for the ineliminability of the social aspect of epistemology to bear on her more recent non-reductionist claims (2022). In sound-bite form, our claim that sociality is constitutive of knowledge means that 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 object knowledge we turn to agricultural science, 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.

# Deep Sociality in Potato Research

To understand the interactivity of the practices productive of knowledge and the products of knowledge 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 object 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.

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.

What is the object of study in potato research? One response to the seemingly straightforward question would be that potato research is research on the plant species *solanum tuberosum*. We contend that this response is incomplete, occasionally inaccurate, and misleading. As objects of study in agricultural scientific research, potatoes are complex systems integrated with human interests from planting to storage and from research and development to consumption.

To see the ways in which the would-be straightforward answer fails to capture the object of potato research, consider the goals of agricultural-scientific research (ASR) on potatoes. The overarching goal of potato ASR is to improve potato production for commercial sale and human consumption.[[4]](#footnote-4) Individual research programs and projects develop a host of well-defined subgoals within this overarching goal. In the following subsections, we offer four vignettes of potato ASR in order to show a variety of interactions between potatoes, researchers, and growing and consuming communities, each of which shapes the contours of research programs and projects. Together, these illustrate the complex and interactively social constraints that define the content and subject of potato ASR.

## Cultivar Research: The Birth of the Yukon Gold

One clear way to understand why the answer mentioned above is incomplete lies in the centrality of the concept of ***cultivars*** within plant ASR. Cultivars are classificatory divisions of cultivated varieties of plants that are differentiated according to specific desirable characteristics. Most produce sold in grocery stores does not distinguish fruits and vegetables at the cultivar scale, though apples are a notable exception: “Honeycrisp”, “Gala”, “Red Delicious”, and “Cripps Pink Lady” all name apple cultivars.

Potatoes are not generally sold by cultivar in grocery stores in the U.S., although some specialty varieties may be distinguished at the cultivar scale. Most tablestock potatoes, that is, potatoes sold as whole tubers to consumers in grocery stores, are distinguished by cultivar group: both “Russet” and “Red” name cultivar groups, not individual cultivars. (Examples of Russet cultivars include Ranger Russet and Russet Burbank, and red cultivars include Red Norland and Red Pontiac.)

An exception is “Yukon Gold”, which names a cultivar developed at the University of Guelph in the 1960s. (“Yukon Gold Potato Celebrates 50th Anniversary” 2016) The story of the development of Yukon Gold potatoes illustrates some of the entanglements of persons and potatoes that characterize a majority of potato ASR. Yukon Golds are so named for their yellow flesh; this flesh color and texture was sought by potato farmers who had immigrated to North America from Europe in the mid-20th century, in the aftermath of World War II. These farmers found the starchy, white-fleshed North American potatoes foreign and more difficult to incorporate into their cooking and growing traditions.

At the time, North American potatoes were not bred or sold by cultivar group, let alone cultivar. In response to repeated inquiries for a yellow-fleshed potato from this new community, potato scientist Gary Johnston of the University of Guelph worked with a team of researchers to cross-breed varieties he could access until a consistent, yellow-fleshed cultivar that was growable in southern Ontario soil. A key step on the path to developing the Yukon Gold was the crossing of a USDA registered cultivar with a yellow-fleshed Andean varietal from the cultivar group *phureja*. (Johnston and Rowberry 1981)

The result, commercialized in 1981, was the first potato to be sold by cultivar in grocery stores. It took over 60 crosses to produce the first true Yukon Gold seed potato in 1966 and another 15 years to hit markets. Yukon Golds are a hallmark of consistency within the world of potato produce, and they are still often used as a standard against which to test newly-bred cultivars. They are considered excellent all-around potatoes, neither too starchy nor too waxy, and are often recommended in mashed potato recipes especially.

Notice the integration of human motivations and preferences, as well as politics and geography, with the story of crosses that led to the Yukon Gold. In the original publication announcing the cultivar, Johnston and his co-author note that they began pursuing the potato that would become Yukon Gold due to “continuous requests from the large European immigrant population of central Canada that such a potato be made available because of the perceived superiority of yellow flesh in terms of flavor and texture.” (Johnston and Rowberry 1981, 242) Cultural preference is not a feature of potatoes themselves, nor more generally are flavor and texture: these qualities are products of humans’ extended culinary interactions with potatoes.

Further, while it might be possible (and we remain skeptical even to the in-principle possibility!) to develop an analysis of flavor and texture qualities in terms of strictly biological features of a potato cultivar, such as sugar and starch content, the sought-after qualities that define cultivar research aims are delineated in terms of potatoes’ relationships to their human producers and consumers. For instance, Yukon Gold was not developed with the goal to have 16 to 18 percent starch by weight; however, this moderate starch content contributes to the qualities that make Yukon Gold the consistent, all-around cultivar it has become known to be, and part of the reason Yukon Golds are often described as having the appearance of being pre-buttered due to the yellow “buttery” flesh.

## Potatoes-in-Soil Research

Another dimension of potato ASR is research on the processual, dynamic relationship between potatoes and the ground in which they grow. Understanding how different soil systems can impact the growth of potatoes includes a host of research programs, such as:

* Studying when to plant and harvest in a given geographic location, considering both physical and socioeconomic geography (i.e. crop insurance dates and anticipated consumer demands),
* Investigating how physical flows of water and minerals through fields impact the nutrient uptake of plant systems,
* Investigating the biochemistry of soil systems as ecosystems supportive or inhibitive of pests and diseases of potatoes,
* Comparing different tillage, cover crop, and irrigation strategies for varying effects on carbon sequestration, plant productivity, soil fertility, cost-effectiveness, and more.

Some of these instances of potato-in-soil research might be able to be carried out under the strictly biological view of potatoes as plants in an ecosystem, but a majority rely on an implicit understanding of potatoes-in-soil as products of human intervention. This implicit understanding frames research in some important ways. Notably, by understanding the potato-in-soil system as a product of human intervention, both soil and potato are viewed as manipulable variables in an experimental system, rather than as a self-contained “natural” system.

Further, it is part of the framing of this research that the goal of manipulating variables in these systems is to improve aspects of potato *farming*, as opposed to the wild proliferation of potatoes. Tilling, disease management, carbon sequestration, and especially harvesting, are not aspects of potato-in-soil development that matter exclusively or even primarily to the potatoes nor to the potato-in-soil system. Instead, these activities matter because they are activities that make a difference to potatoes as products for human consumption, either by directly impacting the nutritive qualities of potatoes, the economic and labor efficiency of producing potatoes, or the sustainability of growing potatoes on a piece of land over time. This observation makes it evident how potato-in-soil systems, and knowledge about them, are products not just of human–potato interactions but also of human social interactions, between scientists and farmers, farmers and consumers, and so forth.

That this framing underlies potato-in-soil ASR is further evidence that the subject of such research is not merely the potato plant, nor the tuber, nor the full potato ecosystem. Instead, the subject of this research is *potatoes as agricultural objects*, where agricultural objects are definable only in relation to human communities of producers and consumers. As with the story of cultivar development, the object of research in this case is not separable from the user community whose interests define the goals and methods of research.

## Potato Storage and the Extension Bulletin

Research on potato storage proves to be one of the clearest ways to see how the subject of potato ASR is defined by human use communities. For much of their agricultural history, potatoes have been valued for their long shelf lives: they can be stored in cellars to get families and villages through long winters between growing seasons. And unlike other agronomic crops (e.g. wheat, rice, maize), they require minimal processing prior to storage.

However, potatoes in storage are not inert systems. Anyone who has bought potatoes and forgotten them for too long in the back of the pantry knows this: they can sprout, they can grow black spots, they can dry out, and they can rot. There are a host of pests and diseases of potatoes that only act on tubers out of the ground in storage, as opposed to acting on plants in the field. For centuries, farmers and researchers have studied and improved strategies for optimal potato storage.

The largest factor in optimizing potato storage is controlling the tubers’ climate: not too hot and not too cold (never in the fridge!), not too dry and not too moist, and minimal direct exposure to light. Centuries of cellar-building around the world has established these basics of climate conditioning for potato storage, but the 20th and 21st centuries have brought revolutions in both farming and building technology that have changed both farmers’ scale of harvest and the norms of storage.

This change occurred gradually, and often with the intervention of agricultural extension workers whose interests focused on potatoes. As discussed in Section 1 above, U.S. agricultural extension is an institutionalized system of largely informal education and research activities that bridge university- and government-sponsored research activities with the immediate felt needs of farming and consuming communities.

As early as 1930, extension workers in Michigan performed studies on potato cellar designs and shared their findings with regional communities through the mechanism of the extension bulletin. (See Figure 1.) Extension bulletins are publications—now frequently found exclusively online, and often open-access—that contain information derived from ASR results and shared in formats emphasizing immediate, use-related results for farming communities to implement, as opposed to formats emphasizing experimental methods and advance of the state of scientific knowledge. The bulletin in Figure 1 contains a study of four extent storage cellars in Michigan, commentary on benefits and drawbacks of their varying designs, and plans for building an optimized cellar according to the findings from the study (Figure 1B), including a materials list and notes on preparing the empty cellar for initial storage.

Note two features of this instance of potato ASR. First, similar to the case of potatoes-in-soil above, the question of optimizing storage does not matter *to the tubers*, but rather to the humans who intend to sell and consume them. The activity of storing potatoes is inherently human, and research on all aspects of potato storage can only be understood if potatoes are interpreted as agricultural, rather than merely biological, objects. To emphasize this point, consider that there is an entire field of potato ASR dedicated to understanding and mitigating potato storage diseases. This disease category simply would not exist for purely biological potatoes.

Second, the mechanism of communication of research results, the extension bulletin, differs significantly from the well-studied means of communicating scientific results previously analyzed by philosophers of science. These bulletins form a “recognized avenue for criticism” (Longino 1990) that incorporates direct response to, and feedback from, farming communities. This offers additional evidence that producers and consumers, alongside extension workers and researchers, co-produce the knowledge that defines potatoes as agricultural objects—and that they do so in a deeply social way.

Extension bulletins provide a vehicle of knowledge exchange from extension researchers to farmers, but also from farmers to extension workers, researchers, and other farmers, in response to the applicability or not of the experiments undertaken by extension workers for the purpose of improving potato growing, harvesting and storing conditions. In this way, extension bulletins facilitate two-way avenues of critical evaluation, to borrow Longino’s language here. Farmers may—and frequently do—criticize the results of agricultural experiments conducted at extension stations which have been explicitly designed to test techniques and applications of potential interest for the local potato growers and in response to local environmental and economic conditions. For instance, local farmers may criticize the results of experiments reported in extension bulletins that are intended for their use if the farmers relying on the disseminated information use the techniques employed in the agricultural experiments and find that they do not work in their field (e.g. due to that year’s heavier rainfall), or if the application suggested is too expensive for some farmers to adopt. In turn, agricultural extension researchers can adjust experiment design and techniques employed in light of local farmer feedback. This extends the useability of the experimental data as well as the means by which it can be assessed in ways that expand on Longino’s theory of objectivity through avenues of criticism (1990). This accunt also builds on her more recent notion of the sociality of interaction (2022) as it applies specifically to the agricultural extension system.

From the perspective of philosophy of science, ASR at large is unusual in that publication of research results in peer-reviewed journals is often an afterthought, if it is a thought at all. The information gleaned from research conducted by extension agronomists is more commonly disseminated to user communities through extension bulletins, field days, and on-site presentations, weekly crop-specific zoom seminars, 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 and further emphasizes the role of local communities in co-producing agricultural scientific knowledge. We suspect that this locality, too, carries important implications for an amended account of the sociality of interaction, especially as regards the effectiveness of social interaction in generating avenues for objectivity-building criticism. Interrogating this aspect of the view, though, will have to be yet another project for another day.



*Figure 1A: Cover page of Extension Bulletin article on potato cellar storage design. Jefferson and Moore, 1930.*



*Figure 1B: Plans for building a potato cellar distributed by Michigan Cooperative Extension Services. Jefferson and Moore, 1930.*

## Exceptions Prove the Rule: Wild Potato Genetic Studies

The cases so far suggest that 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. We hold that this is the primary way that all science conceives of potatoes. It is the case that 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. Potato research in this scenario is meant to exemplify the sort of sociality Longino has discussed from her 1990 work onwards, but also intends to build on this to identify how and in what ways sociality can be conceived of within agricultural extension and farmer networks as a particular instance of agricultural knowledge-generating enterprises.

# Integrating Sociality Across Agricultural Scientific Research: A case study of potato commercialization 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 growing or storing conditions, that is, something about their ecological or environmental

non-identity.

For example, naming the geographic origin of a potato invokes differences between Idaho soil and Michigan soil, or between Michigan weather and Idaho weather conditions. Potatoes sold as Idaho potatoes are not potatoes of a particular cultivar group, but potatoes federally registered and certified according to the Idaho Potato Commission. They are potatoes grown in Idaho soil, which, unlike Michigan soil, 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; and tinker with machinery to make a piece of equipment better suit their needs. Human management and products of social interaction such as planting strategies and customized equipment all impact the accompanying interactivity between potato plants, soil, storage, and climate systems. This is the deeply social story of 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, or swine, whose feces significantly impact soil over generations). They also depend on topography, presence of hedgerows, and irrigation systems. Knowledge of the soil can help farmers decide their crop rotation and which mix of species to use for their cover crops. These interactions 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 to manage and what kinds of potatoes to plant. 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 soil heath following a soil’s nutrient analysis, the farmer may adopt different soil management practices.[[5]](#footnote-5) For instance, the farmer might adopt the practice of cover-cropping to manage soil fertility or to 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 the authors of the present discussion 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. It is worth noting that these data collection methods themselves fall under the umbrella of the sociality of interaction, suggesting that philosophy of science may integrate with scientific sociality in the co-production of future knowledges.

One of our interviews produced information about a Michigan-based program in potato variety breeding.[[6]](#footnote-6) 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:
	1. **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.
	2. **Cultivating seed potatoes** from 12 varieties of potato, which consists of in-lab and in-ground testing of seed varieties.
	3. **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.
	4. **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.
	5. **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 (tubers, leaves, stems, and roots) are sampled from breeding-line plants 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***. As suggested above (Section 3.3), 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.

In our view, this mechanism of change illustrates the extra-strong sociality of interaction that forms and constrains the growth of scientific knowledge about potatoes. 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 and through means implemented by scientifically and commercially interested members of the potato production community.

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 are 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 knowledge-making and includes both agricultural extension workers as well as farmers, and which 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. As such, and to emphasize the friendly spirit in which our amendment is intended, we believe this metaphysical conclusion could be understood to be a social-ontological extension of Longino’s social epistemology.

# The intertwining of potatoes, people, knowledge, and standards

Throughout our study of potato ASR, we have emphasized the intertwining of practice and content in the shaping of experiment, 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 science and the public mean by “potato.” By way of conclusion, 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. Longino also refers to standards in considering values and the grounds for objectivity. It is, therefore important to explain the difference as well as potential interplay of regulative potato standards and Longino’s conception of shared standards (1990, 77­–78).

Potato standards can be understood as those agricultural standards that shape how potatoes are identified as saleable, affect harvesting practices employed by growers, and in doing so shape values associated with what is good potato growing practice and what is a good potato. In this way, potato standards can shape the sorts of shared value standards Longino discusses. They define the object of investigation, the expectations of research and development, and the testability, reproducibility and reliability expected of agricultural experiments. Like Longino’s shared standards, potato standards function as public standards and criteria that community members (whether scientists or potato growers) feel obliged to respect. Growing and selling potatoes requires potato standards. However, potato standards are very unlike Longino’s shared standards. They are not standards that allow for pluralism of opinion. Potato standards must be abided by agronomists, farmers, and sellers of potatoes, and they are implemented not directly by these groups but rather by governing bodies comprised of representatives from these and other interested groups.

So what does it mean for agrotechnological standards to define the object of investigation as well as the standards for research and development and implementation? 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.[[7]](#footnote-7)

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, growers, 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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2. 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. [↑](#footnote-ref-2)
3. 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. [↑](#footnote-ref-3)
4. Unlike other major agronomic crops of U.S. ASR–wheat, maize, rice, alfalfa, cotton, and so forth–potatoes are rarely raised for the purpose of non-human consumption, e.g. as forage for livestock or as fuel or fiber for processing. This relatively straightforward relationship between production and consumption makes potatoes a less complex “base case” for studying the interrelations between people and products in ASR than other agronomic crops whose relationship to human consumption can be more complex. [↑](#footnote-ref-4)
5. For a discussion of how soil health is normatively assessed and how these assessments are shaped by different place-specific social ontologies of soil management practices, see Kendig 2024. [↑](#footnote-ref-5)
6. Additional discussion of these interviews is available in McCoy 2024. [↑](#footnote-ref-6)
7. Additional discussion of agricultural standards may be found in Kendig 2023. [↑](#footnote-ref-7)