No Small Potatoes: Patenting Spuds in an Era of Gene Silencing

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During a 1911 journey—in which he would discover Machu Picchu—Hiram Bingham's exploration party came across native Peruvians who "lived almost entirely on gruel made from *chuño*, frozen bitter potatoes. Little else than potatoes will grow at 14,000 feet above the sea."[1] For millennia, those living in the Andean highlands have cultivated over 3,000 varieties of potatoes—many of which remain unknown to our collective palates today.

Chuño is now prominently featured on the menu of the Central Restaurante in Lima. Chef Virgilio Martinez leaves the "potatoes in the snow overnight; by the time the sun comes up, the potatoes have dried out. 'When you see them, they look like white-peeled potatoes, like flour or something. They aren't heavy at all, either, because they lose their water,'" Martinez says, also noting they can be stored for up to 10 years.[2]

Like their Andean predecessors, modern day inventors continue to slice, dice, freeze, bake, dehydrate, fry—and now edit and silence—the characteristics of the humble potato in patentable ways. As with other formerly undifferentiated fruit and vegetable commodities, potatoes are morphing into branded, patentable varieties. The most recent variety to make news headlines is the Innate® potato, a genetically modified Russet Burbank potato.

This article focuses on the potato's history and patentable status in the United States. Recently issued patents are discussed, illustrating the trajectory of potato processing conundrums and innovations. The poor "market" reception potatoes received during the Columbian Exchange is compared to consumer angst associated with their genetic modification. The article closes with an altered paradigm for analyzing GMO food labeling issues through a more inclusive metric—*food satisfaction*.

New World "Patatas" Arrive in the Old World

Spanish conquistadors first encountered potatoes in 1532 and noted their importance to the Incan Empire. Early reports often confused potatoes (*patatas*) with sweet potatoes (*batatas*), even though they are from different plant families. Along with other New World foodstuffs—like cassava (also called manioc), tomatoes, and corn—potatoes made their way across the Atlantic to Europe during the Columbian Exchange.

Potatoes were not well received in Europe at first, but rather regarded with "suspicion, distaste and fear" and as unfit for human consumption.[3] Alan Davidson, a leading food historian, describes the probable Spanish reaction:

> The potato was the first vegetable of their acquaintance to be grown from tubers rather than from seed. Its appearance seemed as odd as its method of propagation, and under the prevailing Doctrine of Signatures, whereby a fruit or vegetable's appearance indicated what part of the body it would affect (hence walnuts being recommended for diseases of the brain and red beets for anemia), it was even thought that eating potatoes led to leprosy, for the tubers or flesh-colored underground nodules were likened to leprous growths. Moreover, the plant itself had a slightly sinister appearance, bearing a resemblance to deadly nightshade, a fellow member of the family Solanaceae.[4]

Potatoes eventually became a foundation of the Old World diet; many Irish people survived on milk and potatoes alone. The arc of potato acceptance can be summarized:

> Thus the general picture that emerges is that the potato required a catalyst to become popular. In particular, it tended to establish itself where food was short—often in the wake of a famine—because it produces so much in the way of calories, and so quickly too, from small plots of land. Wherever human exigencies have given it a chance to display its virtues, it has stayed on as a dietary staple.[5]

Monocultures and the Great Irish Potato Famine

When propagated through cuttings, the inherited strengths and weaknesses of the potatoes are passed down through generations. By the early nineteenth century, potatoes had all descended from a handful of varieties. The consequences of this inbreeding proved disastrous, leading to the "Great Famine" or the "Irish Potato Famine" from 1845 to 1852:

> The genetic aspects as we now understand them were not fully appreciated in the nineteenth century, but horticulturists did realize that the plants were inbred and therefore unable to resist disease. As the *Florist and Horticultural Journal* (1854, 163–66) editorialized on the degeneracy of the potato and the "disease of 1846," raising potatoes from tubers was unnatural because it bypassed the seed stage, thus perpetuating weaknesses and rendering them more "fixed and unchangeable." This realization brought about the Great Revival, as it was called, when old, deteriorating potato varieties were crossed with hardier wild varieties from Mexico and South America.[6]

Out of this potato revival, Luther Burbank—the "Wizard of Horticulture"—developed the Russet Burbank potato variety in 1870. That variety is the mainstay of McDonald's franchise empire.

The Legal Framework for Patenting Potatoes

Until the early twentieth century, plants were considered products of nature and therefore deemed unpatentable in the United States. The Plant Patent Act of 1930 (PPA) changed that legal dynamic. It sought to level the playing field between plant breeders and their mechanical and chemical inventor counterparts. Thomas Edison supported the legislation, hoping that it would "I am sure, give us many [Luther] Burbanks."[7]

Even had it been enacted during Luther Burbank's lifetime, the PPA would not have protected his potato cross-breeding efforts as it specifically excludes tuber-propagated plants:

> Whoever invents or discovers and asexually reproduces any distinct and new variety of plant, including cultivated sports, mutants, hybrids, and newly found seedlings, *other than a tuber propagated plant* or a plant found in an uncultivated state, may obtain a patent therefor, subject to the conditions and requirements of this title.[8]

In pushing for the PPA's enactment, the "demand for patent protection came primarily from rose and fruit tree breeders," as "only asexual reproduction is of commercial importance" in these fields.[9] Opposition came from farmers who propagate by seeding. Only "Irish" potatoes were being cultivated asexually.

Congress's compromise result excluded tuber-propagated plants. The legislative history justifies the exclusion by stating that "the only plants covered by the term 'tuber-propagated' would be the Irish potato and the Jerusalem artichoke. This exception is made because this group alone, among asexually reproduced plants, is propagated by the same part of the plant that is sold as food."[10]

Forty years later, perceived deficiencies in the PPA led to the enactment of the Plant Variety Protection Act of 1970 (PVPA).[11] The PVPA established patent-like rights for new varieties of seed-propagated plants. However, tuber-propagated plants were again excluded from PVPA coverage from 1970 until 1994, when the potato industry successfully lobbied for their inclusion by redefining the PVPA's term "seed" to include "the tuber or the part of the tuber used for propagation."[12]

By 1994, other patent law case developments had already paved the way for patenting potatoes under the U.S. utility patent provisions. In *Diamond v. Chakrabarty* (1980), the Supreme Court held that patent law covered microorganisms, rejecting an argument that patent law could not cover living things.[13] In *Ex parte Hibberd* (1985), the Board of Patent Appeals and Interferences adopted *Chakrabarty*'s reasoning and reversed a rejection of patent claims covering maize (corn) plant technology.[14]

The patenting circle would be complete in 2001 with the Supreme Court's *J.E.M. Ag Supply* holding that newly discovered plant breeds are patentable subject matter under general U.S. patent law, notwithstanding additional PPA or PVPA protections.[15]

The State of Potato Patenting Art

With the encouraging *Ex parte Hibberd* decision, the filing of utility patent applications directed to potatoes began slowly, and then accelerated. The first utility patent for a "novel potato cultivar" issued on September 29, 1987.[16]

Recently issued patents reveal what kind of potato processing innovations merit patent protection. While the dense text of patent specifications can be off-putting, their details often pinpoint and describe basic production problems confronting an industry or market segment.

Baked Potato Chunks

U.S. Patent No. 8,329,244 ('244 patent), issued December 11, 2012, is entitled "Friable, Baked Potato Pieces and Process." The inventors sought "a potato product that has baked as well as fried flavors," noting that no such potato product previously existed before their invention:

> [B]ite-sized pieces of optimally-baked potato [retain] the taste and texture of both the skin and pulp portions. The product exhibits a fully-baked potato flavor, texture and aroma, and it can be prepared simply for serving in any portion size with a minimum of effort. The texture of the product will include a characteristic dry, fluffy, mealy texture for the pulp on the interior of the potato and will have skin attached to unmashed pulp of the potato. The pulp will offer some resistance to the bite but will quickly become smooth like mashed potatoes when masticated.

In marketing language, the '244 patent's assignee touts its "Betty Crocker" branded product as bringing "you a family favorite—baked potatoes—in a fast, easily prepared, and delicious form. We start with only the finest potatoes, bake them, chop them into chunks, and finally quick-freeze them. Our 'Baked Potato Chunks' are fully cooked, ready to 'heat eat.'"[17]

Interestingly enough, the '244 patent's block diagram itself displays the many means of processing potatoes that find their historical roots in the Andean cultivation of potatoes.

'244 Patent's Preferred Processing Method

Sustainable Potato Products

Sustainability of food sources is a modern day mantra. Producing foodstuffs from less desirable potatoes is one means for achieving sustainability goals. An illustrative patent is U.S. Patent No. 8,440,251 ('251 patent), entitled "Doughs Containing Dehydrated Potato Products," issued May 14, 2013.

The invention of the '251 patent is a process for producing quality doughs and finished products from "non-ideal dehydrated potato products." The specification describes the problematic issue to be solved:

> For snacks, especially snacks made from sheeted doughs, the quality of the dough determines the efficiency and reliability of the production process, and the quality of the finished product. It is known that doughs comprising potato flakes, having from 40% to 60% broken cells and from 16% to 27% free amylose, process well and result in god [sic] quality finished products. Unfortunately, such dehydrated potato products typically command a premium price and, in many geographies, are in limited supply. *As a result, there have been attempts to produce doughs from non-ideal dehydrated potato products*.[18]

The inventors of the '251 patent discovered the "root causes" impeding the use of "non-ideal" dehydrated potato products. Product quality issues were related to the "amount and type of free starch, free cell wall components and starch-lipid complexes found in such non-ideal dehydrated potato products." Having identified these root causes, the inventors were then "able to identify materials that, when combined with non-ideal flakes, eliminate the root causes of said quality problems."

Novel Potato Chips

Who hasn't been put off by the unsatisfactory mouth feel and texture of baked potato chips? U.S. Patent No. 8,163,321 ('321 patent), entitled "Coated Potato Substrates Having Reduced Fat Content" and issued April 24, 2012, addresses the consumer desire for less fatty but crispy potato chips. Typically, when potato chips are fried by being submerged in hot oil, the "free" water in the chip is exchanged with the hot oil, resulting in a chip with higher fat content. Efforts to reduce this fat content by baking the potato chips have had less than desirable results:

> [L]ow fat baked potato chips, while achieving a lower fat content than traditional potato chips, are very dry and flinty in texture. Also, these traditional baked potato chips have a poor mouthfeel and do not taste much like a traditional fried potato chip because they do not contain the fat of traditional potato chips. Additionally, these traditional low fat baked potato chips break very easily during handling, for example, during packaging, distribution, and consumption. Upon opening a bag of traditional low fat baked potato chips, the consumer is generally dissatisfied with the number of broken potato chip pieces, commonly referred to as crumbs.

The '321 patent inventors solved this problem by first applying a coating composition (a "wet slurry") to the potato chip before frying. The coating sets quickly when fried and partially insulates the potato substrate from absorbing hot cooking oil. The coating is typically clear and substantially invisible to the consumer, and thus does not detract from the potato chip's appearance. Besides providing a better mouth feel and texture, the '321 patented process retards staleness. The coating also enhances the tensile strength of the potato chip, thereby increasing its resistance to breakage.

Social Controversy Surrounding Genetically Modified Potatoes

The most recent variety to make news headlines is the Innate® potato, a genetically modified Russet Burbank potato. In November 2014, the J.R. Simplot Company obtained a U.S. patent for its Innate potato. Claimed product advantages include:

- Reduced black spots from bruising results in potatoes that are less prone to pressure bruising during storage, a condition that eliminates many potatoes from going to market and costs growers millions of dollars every year.
- Reduced asparagine reduces the potential for the formation of acrylamide, a chemical compound that is created when potatoes, wheat, coffee, and other foods are cooked at high temperatures. (Acrylamide exposure may pose a risk for several types of cancer.[19])
- Reduced sugars that, under certain conditions, provide potatoes with a consistent golden color, providing ideal taste and texture qualities for consumers.[20]

The Innate potato achieves these beneficial results through the insertion of a DNA sequence (native to potatoes) into the genome of the potato that *silences* genes involved in the expression of black spot bruises, asparagine accumulation, and senescence sweetening.[21] This "gene silencing" form of genetic engineering is now being applied to alter the characteristics of any number of fruits and vegetables.[22]

A scientist who worked on the Innate potato's field trials describes its innovations in more general terms:

> "The Innate potato is the most promising advancement in the potato industry I've seen in my 30 years studying agriculture," said David S. Douches, Ph.D. at the Department of Crop and Soil Sciences at Michigan State University who has implemented field trials of Innate. "This potato delivers significant health and sustainability benefits, all by using the potato's own DNA. Such advancements haven't been possible using traditional breeding."
>
> Simplot used the techniques of modern biotechnology to accelerate the traditional breeding process and introduce new traits by triggering the potato's own RNA interference (RNAi) pathway. RNAi is a natural cellular process commonly used by plants and animals to modulate expression of certain genes, and has been used effectively in multiple commercial crops sold over the last decade. "Unlike traditional methods of breeding which introduce random mutations associated with dozens of genes, the method used to develop Innate potatoes is precise," said Douches.[23]

Despite the health and sustainability advantages associated with the Innate potato, its GMO status renders it a nonstarter for end-consumers. When news of the USDA's regulatory approval for the Innate potato made headlines, one blog post commentator cited McDonald's refusal to source GMO potatoes for the proposition that "not all 'taters' are created equal."[24]

The first wave of genetically engineered crops in the 1980s inserted new genes into plant cells. The second wave of genetic manipulation, in contrast, relies on gene editing and silencing. Using gene-editing technologies known by their acronyms as CRISPR and TALEN, plant scientists "can target a specific gene and deactivate it or replace it."[25] In a recent *Scientific American* article, "Editing the Mushroom," the author describes the tremendous impact of these new gene modification techniques:

> The CRISPR revolution may be having its most profound—and least publicized—effect in agriculture. By the fall of 2015 about 50 scientific papers had been published reporting uses of CRISPR in gene-edited plants, and there are preliminary signs that the U.S. Department of Agriculture . . .

> does not think all gene-edited crops require the same regulatory attention as "traditional" genetically modified organisms, or GMOs. With that regulatory door even slightly ajar, companies are racing to get gene-edited crops into the fields and, ultimately, into the food supply.[26]

Whether "transgene-free" plant modifications will alter the mindset of anti-GMO consumers remains to be seen. By way of comparison, Mendelian cross-breeding techniques do not provoke anti-GMO ire. Gene silencing—theoretically at least—could create consumer demand for certain fruits or vegetables by editing out plant "antinutritionals"—the "noxious, self-defense substances" produced by plants. For example, a gene-edited potato created by Calyxt "reduces a bitter taste trait associated with cold storage of the tubers."[27]

A New Paradigm of Food Satisfaction

The GMO food labeling debate tends to be shrill and demonizing. It often pits food producers seeking production efficiencies against consumers desiring pure food authenticity. GMO proponents will ridicule consumers seeking food labeling as intellectually challenged—e.g., "outraged Luddites will no doubt spin these positive [*Innate* potato] attributes into the very embodiment of evil."[28] What supporters of GMO food production fail to acknowledge is that consumer food choices reveal one's basic viewpoints about food.

In an age of relative plenty, what we choose to eat is a daily measure of our social status and ideals. Hunger strikes, eating disorders, and orthorexia—i.e., an obsessive compulsion about eating only foods that one considers healthy—all attest to the profound "control" aspects of food intake. Unlike the field of medicine—where we demand and expect new cures for afflictions—food ingestion relies on memory and nostalgia as appetite triggers or suppressants.

Emotional responses to food have been an object of psychological and sociological inquiry ever since Charles Darwin's *The Expression of the Emotions in Man and Animals* (1872). Out of this research a concept of "core disgust" emerged. It is defined as "revulsion at the prospect of oral incorporation of an offensive object."[29] This emotional food response draws its force from a primitive notion accepted in many traditional cultures: "you are what you eat."[30]

Food safety analyses ignore these harder-to-study emotional and social aspects of food consumption. The broader concept of *food satisfaction*—the real goal in feeding ourselves and our families—lies outside its analytical realm. A simple formulation unmasks this shortcoming by expanding the field of relevant food consumption considerations:

> *Perceived Food Quality + Consumption Setting + Food Safety = Food Satisfaction*

With *food satisfaction* as a primary metric for evaluating food intake issues, the fields of *psychology* (the perceived quality of food), *sociology* (the study of "subjective well-being") and the *hard sciences* (chemical and biological food safety) are all employed in assessing consumer choices. This paradigmatic equation lends itself to rigorous econometric testing of associated control variables. Measuring food satisfaction is akin to the American Customer Satisfaction Index (ACSI). Since 1994, the ACSI provides "information on satisfaction with the quality of products and services available to consumers. Before the ACSI, no national measure of quality from the perspective of the user was available."[31] Evaluating GMO food labeling concerns within the inclusive rubric of *food satisfaction* could alleviate the "talking-past-each-other" nature of the current, spirited debate.

Fifty Ways to Cook (and Patent) Spuds

At the Central Restaurante in Lima, Chef Martinez "and his team employ more than 50 different techniques to prepare spuds. They purée them, fry them, dry them, and make infusions, thickeners, and jellies. They also ferment the skins."[32] On the restaurant's dessert menu, *papas nativas* ("native potatoes") are prepared with cacao and *arcilla*, an edible, medicinal clay. While North American consumers may not be as adventurous in their potato recipes, a steady issuance of potato patents shows the central role this impressive tuber plays in feeding the maw of America. n

Endnotes

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