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Resurrecting Tilak Chandan:

The Fall and Future Rise of Local Rice Varieties in North India

Introduction:

Let us begin with a dish. Khichdi is a savoury porridge celebrated across India as a comfort or health food, uniquely appropriate for weaning babies and recovering from illness. With historical, social and cultural significance, it remains staple to the winter diet in the north Indian city of Rampur, located just over 100 miles northwest of Delhi in the Rohilkhand region. Rampur is now in the state of Uttar Pradesh, but, in the colonial era, it was a mid-ranked princely state within the system of subsidiary alliance ruled by a succession of nawabs identified with a refined Pathan culture (R Khan 2022). In its Rampur variety, khichdi is simple fare, made by boiling rice with urad dal – a split black lentil – and little spice beyond dried yellow chilies and slivers of ginger. Still, it is enjoyed by those of all social strata as a late morning or early afternoon meal – from the former nawabs to farmhands labouring in the local paddy fields. Depending on one's economic means, it is served with different condiments: til, or sesame, oil for the less affluent or the more expensive ghee, or clarified butter; freshly-prepared green and yellow chilli chutneys; and a radish pickle preserved well in advance to ensure its maturation. The tangy water from the radish pickle is often drunk alongside to aid digestion of a heavy meal.

Inviting friends and family for a khichdi dawat, or meal, is an important aspect of the living Rampur culture, or Rampuriyat, and a means of expressing various social subtexts. The shared meal indicates a certain degree of closeness or kinship, exemplified by a mixture of informality and hospitality. While khichdi is the main dish of the dawat, it is accompanied by complimentary meat curries, including a meat and cauliflower curry, meatballs in spinach and qorma. Historically, the method of eating – attributed to consumption cultures brought by Rohilla Pathans from Afghanistan to India – also underlined the social function. While Rampuris today eat off individual plates, previously khichdi was served on a large, round, clay dish placed on a dastarkhwan, or cloth spread on the floor. Three or four would gather to eat around a single dish, the ghee or til oil percolating to the edges, as the diners frenetically mixed the chutneys, pickles and other accompaniments into the porridge before it all turned cold. Because it is deemed to warm the body (*taseer*), khichdi is almost never eaten in summer in line with the humoral theories inherent to the indigenous medical system, unani tibb.

Until the 1990s, Rampuri khichdi was prepared with freshly-harvested rice of the tilak chandan variety. The small grains of this rice melded with the urad pulses, also freshly-harvested, to create a uniquely-textured khichdi with intense aromatic appeal. Local gazetteers show that, from at least the start of the twentieth century, agricultural practices in the region centred on this highly popular dish through the cultivation of tilak chandan and urad pulses alongside other crops (*Gazetteer* 1911 and 1931). An interdependent, thriving farming community was synchronised to the cultural ethos. Yet, from the 1960s, farming practice in the Rampur rice belt was increasingly impacted by India's Green Revolution with its investment in high-yield varieties (HYVs) and agricultural input, including fertilisers, pesticides and high dependence groundwater resources. The effect on rice yields was dramatic and impressive, with productivity across India increasing by around 50 per cent. The corollary was intense social and ecological change, the most damaging of which was an irreversible impact on agro-biodiversity. With the Indian government actively promoting HYVs, a country that had been home to over 100,000 rice varieties saw the numbers dwindle to a few thousand: HYVs now cover more than eighty per cent of India's rice acreage (Shiva 1991; Eliazer Nelson, Ravichandran and Anthony 2019; John and Babu 2021).

In more recent times, the impact of monoculture farming enabled by the Green Revolution has been compounded by global climate change – to the point that the intuitive wisdom and agro-ecology practiced by farming communities in harmony with the climatic conditions and foodways of a region in recent centuries has been destroyed. Rampuri khichdi continues to be prepared, but now it is with non-aromatic hybrid rice varieties of a very different size, look and feel. The heritage tilak chandan has disappeared from the local rice palette, meaning its distinct texture, aroma and flavour remain alive only as an intense gastronomic memory and deeply-felt cultural deprivation. This paper thus takes as its starting point the idea that foodways, in the form of prepared dishes and cuisines, are cultural devices with a deep impact on social identity and economic practices. In other words, food prepared with specific ingredients is more than the mere ingestion of calories: it can also represent a culinary celebration or a social bond with shared memories (Lupton 1994).

The broad brushstrokes of this story specific to Rampur, but also unfolding across India, inspired the project "Forgotten Food: Culinary Memory, Local Heritage and Lost Agricultural Varieties in India," funded by the Global Challenges Research Fund through the Arts & Humanities Research Council (2019-23). At its core was a question about the cultural and historic losses that accompany the depletion of agro-biodiversity justified by increased productivity. Was the longing for tilak chandan only culinary nostalgia or had something more tangible been lost in terms of food's aesthetic quality, nutrition and sustainability? Were there specific dishes, rituals and social subtexts that had disappeared along the way? And what did all this loss add up to in terms of local heritage today? This paper explores these eco-cultural tensions by charting the efforts of our interdisciplinary and international collaboration bringing together historians, plant scientists and farmers to resurrect tilak chandan in the Rampur rice belt. After contextualising the study in a broader discussion of Indian rice landraces, cultures and hybridization, it turns first to the changing agricultural and related cultural situation in Rampur and then the project's challenge of reviving heritage rice varieties.

Local Landraces, Cultural Contexts and Rice Hybridization in India

The domesticated Indian subspecies, *Oryza Sativa Indica*, has been identified as growing in the eastern Himalaya region approximately seven to nine thousand years ago (Huang et al 2012). From archaeological sites associated with the Harappan or Indus Valley civilisation, there is also indication of rice cultivation around six thousand years ago (Bates et al 2018). Early cultivators used a process identified by Charles Darwin as "artificial selection" to breed ancestral rice plants in a way that they could be adapted to local land and climatic conditions (Doebley 2006; Deb 2021a). Through this process, thousands of folk rice landraces were created. Though the exact numbers are not known before the Green Revolution, Bashar et al (2004) have estimated that around 15000 landraces were cultivated in undivided Bengal alone in the 1940s. Unpublished state records confirm that, until the late 1960s, farmers in West Bengal, the largest rice-producing state in independent India, grew around 5500 landraces (Deb 2005). Notably, Bengal farmers innovated several aromatic varieties, including kala jiro, khaksani and badshabhog, as well as many long, short and bold grain varieties, that have great cultural significance due to their use in local rituals and religious ceremonies (Deb 2005, 2021b).

Given its omnipresence in the Indian subcontinent, it is not surprising that rice finds mention in ancient Hindu and Buddhist texts, where it is often associated with specific gods and goddesses. An example is Dhanya Lakshmi, or "grain Lakshmi," one of the forms of the goddess Lakshmi, who is regularly depicted holding three sheaves of rice in one of her eight hands. The cultural context of rice is so tenacious that specific rituals and ceremonies are often associated with individual rice varieties. In Bengal, for instance, gobindbhog and mohanbhog are used to prepare sweet rice dishes for religious offerings, while a new bride is welcomed home with aman rice. The latter variety is considered so sacred that it often features as a part of votive offerings to deities. There are also specific festivals connected with the rice harvest, like Nabanna (literally, "new rice"), celebrated in Bangladesh, West Bengal, Tripura and parts of Assam, at which specific dishes are prepared to be enjoyed alongside music and dance (Deb 2021a).

Alongside their cultural significance, historic rice varieties have been shown to be rich in micronutrients, like beta-carotene, B vitamins, omega 3 fatty acids and antioxidants (Ray et al 2021; Kowsalya 2022; SubbuThavamurugan et al 2023). That the health properties of rice have long been appreciated in India is evident from oral traditions and indigenous medical knowledge. A landrace found in Tamil Nadu, black karuppu kavuni, also known as "emperor's rice" or "forbidden rice" (on the basis one needed the king's permission to consume it), has a black pigmentation possibly due to anthocyanins. A diet rich in these antioxidants has been shown to prevent inflammation and protect against certain illnesses – and oral history too recounts the importance of this rice to a long and disease-free life (Hema Malini et al 2018). The bran of garib-sal, congruently, contains silver nano-particles known to kill pathogenic microbes – which perhaps explains why, in indigenous medical practice, rice was used to cure stomach ailments (Sen Gupta et al 2017). Mapillai sambar rice, also grown in Tamil Nadu, and raktsal in north India is similarly purported to cure anaemia. In fact, eighty varieties of folk rice have been found to contain more than 20 mg of iron per kilogram, while jhuli, harin lajli and dudhe bolta have as much as 131 to 140 mg per kilogram. Perhaps for this reason dudhan was given to lactating mothers and parmai was said to help in child growth, while kelas and bhut moori were given to women during pregnancy and after childbirth to cure iron-deficiency (Deb et al 2015).

Inevitably, many of these social practices and cultural contexts have been lost or forgotten with the extinction of local and folk races accompanying the adaptation to hybrid varieties. As indicated in the paper's introduction, the Green Revolution in India was closely associated with the hybridization of rice varieties. Hybridization involved isolating the seeds of the next crop for the purpose of introgression such that desirable traits, like dwarfing, could be maintained. Once achieved, the new hybrids were semi-dwarf, fertilizer responsive and photoperiod insensitive with a shorter growth cycle. IR36, a hybrid basmati, for example, matures in 110 days as compared to traditional varieties (by which we refer to open-pollinated varieties more than fifteen years old) with a cycle of 180 days. The shorter growth cycle was beneficial as it allowed farmers to plant two rounds of crops in one season, while dwarf varieties also enabled fertilization without bolting and lodging. Moreover, hybrid varieties display uniformity in growth and resource needs, while landraces with non-uniform growth patterns and greater height are prone to lodging – especially during unseasonable storms that are reported to have become increasingly common with climate change.

Hybrid varieties have a distinct yield advantage over traditional varieties, but some studies have questioned if they remain less profitable due to the necessity for various inputs, including higher labour, irrigation, and pesticide and fertilizer costs (Janaiah and Hossain 2003; Janaiah and Xie 2010; Prakash et al 2017; Spielman, Kolady and Ward 2013). The necessary overuse of chemical fertilizers to maintain high yield has also been observed to have severe environmental consequences, specifically: 'physical and chemical degradation of the soil by altering the natural microflora and increasing the alkalinity and salinity of the soil' (Eliazer Nelson, Ravichandran and Anthony 2019; Singh 2000). Certainly, it is a major disadvantage that farmers must procure expensive hybrid seeds from seed companies on an annual basis. This reflects that hybrid vigour, or heterosis – the increase in yield or "vigour" of hybrid plants due to genetic contributions of crossing of distinct parental lines – declines after the first year. A large-scale survey of over thirty thousand farming households across India by the International Food Policy Research Institute (IFPRI) in 2020 found that modern hybrid varieties had been adopted by seventy-nine per cent of the surveyed farms – and that ninety per cent of the hybrid-growing farmers procured their seeds from private companies. Problems arise when resource-poor farmers either cannot afford the seeds or need to take out credit to purchase them or the necessary inputs (fertilizers, power and water, specifically, when grown in poor soils) (Negi et al 2020). This situation can create financial vulnerability that, as documented in the case of cotton farmers, has been associated with high rates of farmer suicides in India (Kannuri and Jadhav 2021).

Agricultural, Climatic and Cultural Change in Rampur

The northern and central states of Uttar Pradesh, Bengal, Jharkhand, Bihar, Chhattisgarh, Madhya Pradesh, Odisha, Gujarat and Haryana constitute eighty percent of the total area of India's hybrid rice cultivation. Uttar Pradesh, in which Rampur district is located, is the second highest producer of rice in India (after West Bengal) with 15.66 million tonnes in 2021-22 and a 12.8 per cent share of production (Economic Survey 2021-22). Rampur district itself is located in the terai region of the Himalayas – meaning that it is within a strip of marshy jungle between the lower foothills and the plains that, historically, grew aromatic rice varieties in rich, well-irrigated soils. The 1911 Rampur State gazetteer, compiled at the height of the princely era, noted that rice was one of the "main staples of the state," alongside maize and sugarcane in the kharif (or autumn) cropping and wheat, barley and gram in the rabi (or spring) cropping. It went on to explain that some rice plantations had converted to maize – not as a staple food, but for export – in the 1890s after drought had impacted the summer rains for autumn harvest. However, rice cultivation had increased again between 1901 and 1909 due to extensive work in canal irrigation and improved communication networks. Thus, between 1911 and 1931, rice and maize each covered around 46% of all cultivated land, or around 80-82,000 acres, during the kharif (*Gazetteers* 1911 and 1931: 22-24). Even when a "want of rain" caused "scarcity" in other parts of UP (as in 1906-7 and 1908), the network of canals reinforced by traditional wells and tanks was said to protect against it in Rampur (*Gazetteer* 1911: 27-30). The famines often impacting British India were thus averted in this princely state thanks to government investment and intervention in irrigation projects (for comparison, see Davis 2002: 332-40).

In terms of varieties, the state gazetteers noted: "It is almost impossible to enumerate the many species of rice here found." In support, they enumerated certain "better" quality rice varieties grown in Rampur's various *tehsil*, or administrative, divisions, including "*hansraj*, *banspati*, *sunkharcha*, *dalbadal*, *anjha*, *banki*, and *motha*," while also recording that certain "inferior-quality" rice varieties grew in "deep water" (*Gazetteers* 1911 and 1931: 24). Because Rampur received higher rainfall than neighbouring areas due to its geographical location, it was prone to floods (with the worst in 1907) that made low-lying areas especially suitable for small-grain varieties (*Gazetteer* 1911: 15). According to the 1911 gazetteer, "most villagers subsist chiefly on cheap rice," while, in the towns, a combination of rice and wheat was eaten (*Gazetteer* 1911: 56). It is worth noting that, throughout the princely period, Rampur's flourishing rice trade was not limited to rice only grown in the territory, but included varieties brought from Kumaon (now in Uttarakhand) and other places outside the state. Rice would be "seasoned and prepared" at a few centres and then carried to Delhi and beyond at a significant profit to local traders (*Gazetteer* 1911: 37-38). More than sixty years later, the 1975 Uttar Pradesh Gazetteer of Rampur gave the names of the "inferior quality rice used by common people" as tilak chandan, sendha, sathi and motichur (*Gazetteer* 1975).

The post-independence gazetteers for Rampur also point to shifts in cropping patterns, noting that, "in the last century," indigenous grains, like mandua (finger millet), lahi and til (sesame), had been replaced by maize, bajra (pearl millet) and pulses. A further change was the introduction of mentha for the menthol industries from the 1950s such that the "negligible" cultivation of sugarcane in the princely era – at just 4700 acres in 1909 – expanded to 20,994 acres in 1969 and 38,000 acres by 1971. Still, the total area under rice cultivation in Rampur district actually increased from 89,125 hectares in 1908 to 1,51,441 hectares in 1969, with the rise again attributed to better irrigation (*Gazetteer* 1975). By the 1970s, HYV seeds were starting to be made available to farmers in Rampur district through the National Seed Corporation, Uttar Pradesh's agricultural universities and the Terai Development Corporation based in Pantnagar. The new seeds associated with the early years of the Green Revolution enabled local farmers to start cultivating rice in two rounds: the kuari crop sown in June and early July for harvest in September and the jarhan crop sown subsequently for harvest in November. Between 1969 and 1971, the area under paddy cultivation increased by a staggering 41 per cent, making rice the most valuable kharif crop in Rampur district by 1975. According to the 1975 Gazetteer, a consequence was pressure on ground water resources since most growers were dependent on irrigating their farms through the existing system of canals, wells and rainwater (*Gazetteer* 1975).

Most of the rice varieties mentioned even in the 1975 Gazetteer are unfamiliar in Rampur now. However, three remained a fixture of urban grocery lists – in varying quantities across different income groups – until the 1990s: tilak chandan, hansraj and indrasan (T Khan 2023: 199). As indicated in the introduction, the small-grained, aromatic variety tilak chandan was especially popular in the terai region where it was eaten freshly harvested with urad lentils in the form of khichdi. The importance of this combination to the locale was reflected in that urad lentils appear to be the main pulses grown in the region across the twentieth century. The princely gazetteers noted urad as a crop (alongside arhar and moong), but they were unable to put a figure on its acreage on the basis that it was "sown mixed with other *kharif* crops" – in other words, interspersed with rice grown during the same autumn cropping (*Gazetteer* 1911: 26). The 1975 gazetteer, on the other hand, reported that the area under urad pulse cultivation was 148 hectares as compared to just 18 hectares for the combined cultivation of moong and moth pulses (*Gazetteer* 1975). Hence, while khichdi is prepared with moong, chana or arhar pulses in most parts of India, the winter dish of tilak chandan and urad dal khichdi emerges as inherent to Rohilla Pathan cultures centred on the cities of Moradabad, Rampur, Bareilly and Shahjahanpur.

Beyond the gazetteers, another source for understanding Rampur's evolving culinary culture are a set of Persian and Urdu manuscripts at the Rampur Raza Library that were collected and commissioned by the Nawabs of Rampur from the nineteenth century (see, as example, *Ḵẖẉān e ne'mat* n.d. and *Nusḵẖā hai ta'ām* n.d.). These capture the huge variety of dishes available for preparation at the royal court, including several elaborate versions of khichdi. Among the dishes mentioned is a khichdi pulao in which meat boiled with spices (yakhni) was merged with a moong dal khichdi. Other recipes for dhuli khichdi and muqasshar khichdi combined moong pulses, rice and meat cooked with ghee and spices. A Khichdi Daud Khani – named after the Mughal nobleman who originally acted as patron to this dish (Vermani 2023: 1181) – similarly featured mincemeat, spinach and eggs alongside moong dal and rice. There are also meatless khichdis described as Gujarati khichdi and bhuni khichdi. Most of these recipes, it should be underscored, contained moong dal, rather than the urad dal used in the quintessential Rampur khichdi. This reflects that many of the cookbooks, like *Ḵẖẉān e ne'mat*, reproduced recipes from the Mughal's imperial kitchens, while also introducing newer dishes and ingredients (Vermani 2023: 1183fn46). Very often, courtly chefs drew inspiration from more refined Awadhi and Mughal cuisines when gracing royal tables. Indeed, the archived cookbooks contain no reference at all to the urad dal khichdi that came to rule gastronomic spreads in Rampur by the late twentieth century.

We may conjecture that urad dal khichdi was too simple or too common to be included in the court's cookbook manuscripts. Still, oral history is replete with stories illustrating the devotion of the Nawabs of Rampur and his subjects to the dish. According to one historic account, Nawab Hamid Ali (ruled 1889-30), was so fond of urad dal khichdi that he rewarded an able cook of it from his royal kitchen by sponsoring three of the cook's four sons to attend the prestigious Aligarh Muslim University, while keeping the fourth at home to learn his father's skill (Shadani 2006: 180-81). In oral interviews undertaken for the project too (see https://player.sheffield.ac.uk/series/forgotten-food-culinary-memory-local-heritage-and-lost-agricultural-varieties-india for a selection), Rampuri elders from the royal line and other socio-economic groupings lamented that the fragrance of tilak chandan no longer drifts through neighbourhoods to announce that khichdi made with the new harvest was on the boil. That this rice variety, with its historic, cultural and social associations, still inspires yearning among the people of Rampur was the main impetus to the project's efforts to resurrect and revive lost local varieties.

The Case of Benazir Farm

The original aim of the Forgotten Food project was to grow two rice varieties of historical and socio-cultural importance in Rampur, tilak chandan and hansraj, in lab conditions at the University of Sheffield. Using Sheffield's state-of-the art LED growth chambers with bespoke food-drain irrigation for rice cultivation (Conviron, Canada), the project team would amplify seed reserves provided by local farmers and/or heritage seed banks in India to seed volumes sufficient for culinary use. With environment and flavour of cereal crops strongly correlated, light, humidity and temperature levels were to be set relative to historical records for rice cultivation periods in Rampur derived from three contiguous local weather stations. Though it may seem counterintuitive to bring rice seeds to the UK to grow and develop (when this process might have been done locally or in partnership with major centres of expertise in India), the decision was taken based on Sheffield's world-leading expertise and facilities. The university's controlled environments – or "virtual rice paddies" – would enable the process to occur not only rapidly (with rice reaching maturity at three-six months in optimal conditions), but also under the climatic conditions from the historical period in which they were used and at the necessary physical scale. Even the most advanced centres in India do not have this capacity; indeed, there are not many, if any, other places in the world that do.

The COVID-19 pandemic radically interrupted this intended plan in the spring of 2020 by making it difficult, if not impossible, to access seed from seed banks or export seed from India to the UK. Rather than abandon the project entirely, we took the opportunity to instead work with a local farmer, Mr Birendra Singh Sandhu, to grow heritage rice varieties at Benazir Farm in Rampur itself. This farm, near the Benazir Palace of the former Nawabs of Rampur, was acquired by the Sandhu family in the 1960s.

Formerly from east Punjab, they had migrated to the region during the 1947 Partition of the Indian subcontinent. When the family took over the 100-acre farm, rice was not the main crop; instead, it focused mainly on sugarcane, maize, bajra and jau (barley). The acreage under rice grew steadily from the 1970s, particularly with the conversion to rice hybrids noted in the previous section. When interviewed, Sandhu confirmed that, even at that time, the farm grew several traditional varieties, including Pakistani basmati, taraori basmati, tilak chandan, hansraj and indrasan. There was only one round of rice cultivation, with rice sown in June at the onset of the monsoon to be harvested in September. According to Sandhu: "We only used irrigation when we planted and after that the [monsoon] season used to take care [of it]."

Pesticides were not used on the plants on account of a robust eco-system – or what Sandhu himself called "the predator cycle." In his view, the use of pesticides had destroyed the ecosystem that ensured a healthy harvest: "The predator system was broken when we used pesticides… the ecosystem didn't work as well as it did before the pesticides." This agroecological approach to farming has been advocated by scientist-activists, like Debal Deb, who support a more complex plant-animal system to enable the return to an "original state of equilibrium" without the use of pesticides and weedicides (Shiburaj 2022). Sandhu opined too that traditional rice varieties were less susceptible to fungal infection because they grow in a scattered pattern, allowing sunlight to penetrate down the rice shaft – in comparison to the dwarf hybrid varieties that grow close together and thus are dependent on fungicides. Additionally, because the traditional varieties grow more slowly, they develop stronger stems. This quality contrasts with the hybrids which, with their growth supported by nitrogen, have softer stems and leaf tissue more prone to pest attack.

The advent of hybrid rice varieties in the 1970s was thus viewed as a mixed blessing with higher investment and higher input of natural resources balanced with higher yields. While hybrids influenced cropping patterns in Rampur, most farms, including Benazir Farm, continued to grow both traditional and hybrid varieties through to the 1990s and, in some cases, beyond. The major shift came, according to Sandhu, when Pusa 1121 hybrid Basmati was innovated by the Indian Agricultural Research Institute

(IARI), more commonly known as the Pusa Institute. Introduced in 2003, Pusa 1121 was a long-grain, aromatic Basmati with a grain length of 8.4 millimetres – in other words, the longest-ever known released cultivar in the world. It also had a high kernel elongation at two to two and half times of uncooked versus cooked grain length. In terms of productivity, Pusa 1121, at 19-20 quintals per acre, had a much higher yield than traditional basmati cultivars HBC-10 or taraori basmati at 9-10 quintals per acre or CSR-30, an improved selection, which yielded 14-15 quintals per acre. Though Pusa 1121 had a slightly lower yield over the earlier basmati hybrid Pusa Basmati 1, it scored over the latter in grain elongation, aroma and less chalky grain content (Singh et al 2018).

With the demand for rice exports to the Middle East and high prices in domestic markets too, Pusa 1121 became highly popular with Indian farmers. By 2013, Pusa 1121 Basmati dominated the growing areas in western Uttar Pradesh (at 78%), Punjab (at 84%), Haryana (at 68%), Uttarakhand (at 30%) and Jammu and Kashmir (at 8%); in Himachal Pradesh, it was growing in over a 1000-hectare area to become a leading export commodity (Malhotra, 2019). Sandhu confirmed that the popularity of Pusa 1121 and later Pusa 1509 hastened the conversion to hybrids among farmer communities of the terai and Rampur region too. Farmers were able to cultivate two rounds of crops on the same land, meaning that high expenditure on fertilizers and pesticides was offset by significantly higher productivity. Pusa 1509, introduced in 2013, had an even shorter cycle than Pusa 1121 by 35-30 days. A crop sown in late July when the monsoons were in full force could be grown in a mere 145 days, with groundwater used for puddling during transplantation. Due to the shorter cycle, Pusa 1509 utilized three-three per cent less water and 5-6 fewer rounds of irrigation. Moreover, it had non-shattering and non-lodging attributes (Singh 2014). These varieties thus had all the advantages of modern hybrids: dwarf stature, shorter duration, high productivity, high response to fertilisers, pest resistance and photo insensitivity.

With hybrid seeds available on semi-credit arrangements, the remaining traditional varieties were soon phased out. As Sandhu explained: "Almost everyone had converted to hybrids [by the early 2000s] because it was not viable [not to] anymore… the people, for their own use, kept on growing those traditional varieties for home use for some years, but ultimately they also [stopped doing that]."

With a twenty-five to thirty per cent lower yield than hybrids, tilak chandan and other traditional varieties became an indulgence, rather than a commercially viable venture. The shift to hybrid varieties in the region also represented a “democratisation” of finer rice varieties: less elite groups – who, as we saw in the previous section, were limited to “inferior” or “cheap” varieties in earlier times – gained access to choice long-grained Basmati as hybrid versions flooded the large wholesale markets, or *mandis*. Though Sandhu exported a traditional Basmati variety to a German chain of stories, Rapunzel, the contract was not renewed after 2014. Benazir Farm grew one last good harvest of traditional Basmati in 2016 after which it was not sown again for three years – by which time the seed would not germinate and the option to grow it again was lost.

Climate change patterns since the millennium have further enabled the extinction of traditional varieties, with their concomitant cultural and historic value. For tilak chandan, flooding is crucial at the time of flowering – and the necessary rainfall is no longer a reliable aspect of climate patterns. At the same time, climate change and the deterioration of natural resources has started to threaten food security by making sustainable development of agriculture untenable (Negi 2020). Though Rampur is nestled between the rivers Kosi and Ramganga, it is facing a depletion of the groundwater on which Pusa 1509 especially depends (Sinha 2021). In response, the local administration has begun encouraging the cultivation of pulses and oilseeds instead – an irony being that these were regular cultivars in the region historically – but, according to Sandhu, the farmers so far are continuing to favour rice cultivation since rice sells better. For our project team, the question arose as to whether lost heritage varieties could be revived in a way that would balance gastronomic appeal and cultural significance with ongoing needs for food security and the growing challenges of climate change.

The Challenge of Reviving Heritage Rice in Rampur

The project team took the decision to undertake a field trial of heritage rice varieties at Benazir Farm under the oversight of farmer Birendra Singh Sandhu at the start of UK and Indian national lockdowns in March 2020. We reasoned that, though the trials would not occur in the planned lab conditions recreating historic environments, they would still help understand the challenges of cultivating local traditional varieties, plus – if they were successful – produce a rice crop in sufficient volume for culinary usage. That would allow the project to still go ahead with blind taste tests planned to interrogate cultural loss by recovering participants' emotional responses to heritage rice varieties (in comparison with the high-yielding, long-grain varieties now prevalent) in terms of appearance, taste, texture and smell. With that data in hand, we could investigate the possibility of intervening in India's food production in a culturally-sensitive matter by going ahead with a possible democratisation of lost rice varieties from the Rampur rice belt through the introgression of certain desirable traits into the germplasm.

A first challenge for the field trial was recovering the seed itself. Before the pandemic outbreak, we had undertaken steps to source the two types, tilak chandan and hansraj, from Vrihi Seed Bank in Odisha where renowned ecologist Debal Deb has taken the lead in preserving around 1500 heritage rice varieties. Visits to local mandis near Rampur had turned up what was claimed to be tilak chandan, but it lacked the strength of emblematic aroma – and it was later revealed that traders mix a small quantity of aromatic rice into hybrid rice in order to sell it at a premium price. Similarly, we had procured a rice claiming to be hansraj from a boutique farm near Bareilly (at the high price of 500 INR per kilogram) – but, when it was sent to Deb's labs in Kolkata, tests revealed that it was only 10% heritage variety and the rest a hybrid. Vrihi Seed Bank did hold tilak chandan seed, but their stock of hansraj had become contaminated. We were working out the logistics of procuring and transporting the available seeds to the specialized labs in Sheffield when the lockdowns brought the process to a halt.

At this point, Sandhu advised that he had, through farmers' networks, found tilak chandan seed at a farm in Bilaspur district in Chhattisgarh state, approximately 1000 km from Rampur. As it was impossible to send the seeds to the University of Sheffield for confirmatory tests in pandemic circumstances, we instead had to rely on photographic evidence in which the seeds were pictured against a scale. Plant scientist and co-author to this paper Duncan Cameron sought to ascertain if the seeds had the physical characteristics of tilak chandan as reported in earlier scientific papers on Indian rice varieties, from the high colonial periods onwards. Papers from 2010 and 2013 considered three lines of the variety tilak chandan (3048, 3048 and 3051). Aroma (attributable to the compound 2-acetyl-1-pyrroline), milling yield and length-wise elongation upon cooking were identified as desirable characteristics, as was low amylose content being that it correlates negatively with taste panel scores for "cohesiveness, tenderness, color and gloss" of cooked rice. Paddy length was recorded as ranging from 6.8 to 7.75 mm, while paddy breadth ranged from 2.3 to 2.7 mm (Bajpai and Singh 2010: 242-43; Singh 2013: 282).

For his analysis, Cameron selected twenty seeds at random, measuring the length and breadth with a micrometer. These values were then compared with those for tilak chandan and several varieties of Basmati taken from the existing literature using a T-test statistical analysis. As shown in fig. 1, the length of seeds was not significantly different from the published length for tilak chandan – and, as the length of this variety is unusually short, that makes a good diagnostic feature. For breadth, the outcome was less clear. Though the seeds appeared to be significantly wider, Cameron concluded that a shadow in the image could be making breadth measurement more difficult. Based on the historical scientific literature and these easements, he was confident enough to conjecture that they were the "right seeds." With the sowing season beginning, we took the decision to chance the seeds. An agreement was thus negotiated with Sandhu by which, to reduce his risk, he was guaranteed compensation to the level of a usual rice yield for Benazir Farm, even if the crop of tilak chandan failed.

The seeds were sown in a nursery on 24 May 2020. At the onset of the monsoons in Rampur on 27 June 2020, the plants were then transplanted on two *bighas* (approximately 1000 sq m) (see fig. 2).[1] The second challenge for the field trial was the difficulty of growing tilak chandan from this point. The longer growing cycle (see fig. 3), lasting from late May to harvest in late November (six months instead of four months for the hybrid varieties), meant higher exposure to pests and fungal infections. Though the plants had a healthy growth of over four feet, there was a minor infestation of rice bug *Leptocorisa oratorius F.* and *Leptocorisa acuta thunberg* (locally called Gundhi bug) and some fungal spots on the leaves were observed. To address the problem, a mixture of antifungal and pesticides – 2020 Adexar

(BASF) Fluxapyroxad with Epoxiconazole at 2 ml per litre and Actara (Syngenta) Thiamethoxam at 0.66 gm per litre – was sprayed on 10 September 2020 in line with the best practice in the region. On 14 October 2020, a second round of pesticide spray – Seltima (BASF) Pyraclostrobin at 2.5 ml per litre and Chess (Syngenta) Pymetrozine at 0.8 gm per litre – were administered. The farmer also laid down poison after a small number of rodents were identified in the field.

Notable was that the plants were much taller than the hybrids and displayed uneven growth (see fig. 4). Bajpai and Singh recorded 129.2 to 134.0 cm plant height for tilak chandan lines in their earlier study (2010: 244). The height of traditional varieties makes them prone to lodging, particularly with the vagaries of the weather brought by climate change. Traditional wisdom within farming communities about optimal timings for sowing has also been lost or forgotten with the exclusive transition to dwarf varieties. The region experienced unseasonal thunderstorms and high velocity winds on 17 November 2020, which had the effect of flattening a quarter of the plants. Fortunately, the following days were sunny and the remaining crop was able to dry out. Before any further weather misfortune, harvesting was undertaken by hand on 19 November 2020 – though, even on that day, some plants were slightly green (see fig. 5). The bundles were left in the field to dry out further. After about a week, the first round of threshing was done manually on 25 November 2020 (see fig. 6). Because the plants had still not dried out completely, threshing had to be suspended for completion on 7 December 2020. After another ten days of drying, the seeds were stored and, subsequently, shelled and polished at a village facility on 19 December 2020. Analysis showed that the length and breadth of the tilak chandan grains varied considerably from those of hybrid basmati, suggesting significant differences between the two cultivars (see. fig. 7)

The third challenge of the field trial was the output. The total output was ninety kilograms of paddy, with ten kilograms of seed given to the Bilaspur farmer in return for the five kilograms borrowed initially – in line with farming practice in the region – and five kilograms kept for the next sowing. This gross yield, when compared to the bumper rice yield for India as a whole in 2020, was abysmally low: 900 kg per hectare for tilak chandan against 4138 kg per hectare for all rice, as documented in the Food and Agriculture Organisation of the United Nations dataset (see fig. 8 and 9). After cleaning and shelling, the net yield for the crop was forty kilograms, for which the cost was 24000 INR – or 600 INR per kilogram. This pricing made the 2020 tilak chandan crop much more expensive than hybrid basmati, which sells at market prices from a minimum of 23 INR per kg (for short or long grain) to a maximum of 135 INR per kg (for medium grain) (see fig. 10). For comparison, it may be noted that an online shop was selling what it called tilak chandan from Godson Farms, located in Bareilly district, approximately sixty-five kilometres from Rampur, at 400 INR per kg at this time. Because of the longer growing cycle, the tilak chandan crop also required more natural resources, particularly water. The cost of other inputs, like pesticides and fungicides, was also high.

As soon as it became possible to again courier seed internationally, we sent examples of the tilak chandan seeds and grains – one kilogram of each – to the University of Sheffield for trials and tests. Possibly due to the fumigation process required for the phytosanitary certificate (which allows the export of plants and fresh produce by confirming that the shipment has been treated to be free of harmful pests and plant diseases), the seeds would not germinate in the lab facility. To ensure the precious seed was not again lost through disuse, Sandhu chose to sow a second crop of tilak chandan on a similar-sized area in 2021. To ensure the crops had adequate sunlight to dry near harvest, he transplanted the paddy to the field by late June. As previously, an infestation of rice bug *Leptocorisa oratorius F.* and *Leptocorisa acuta thunberg* was identified and pesticides administered on 17 October. Two days later, sudden heavy rains hit the region for three days, creating a flood-like situation with most farmlands submerged. In this circumstance, the tall tilak chandan plants collapsed, causing the entire harvest to be lost – though, notably, the dwarf hybrids were largely unaffected by the storms and flooding. Clearly, the unseasonable rains, attributable to climate change, had a greater effect on the traditional variety, with the plants' height and uneven growth making them more prone to lodging.

Despite this misfortune, Sandhu persisted in growing tilak chandan at Benazir Farm in 2022, primarily with the intention of using it for his own household use. For this third crop, the seeds were planted in the nursery even later, on 13 June 2022, before being transplanted to four bigha (approximately 2000 sq m) on 14-15 July 2022. As in previous years, there was an infestation of the colloquial Gundhi bug and fungal infection, but, on this occasion, Sandhu took the conscious decision to only apply one round of pesticide and fungicide – Pymetrozine 50% WG at 12 gm per acre and thifluzamide 24% SC at 150 ml per acre – in late September. He also applied less fertilizer. While he conjectured that the yield would have been higher if he used two rounds of spray, the plants appeared healthier from less fertilizer, with stronger stem structure making them less prone to lodging. Though there were unseasonable rains again (6-10 October 2022), as the crop was green and the stems more hardy, there was no collapse. A yield of 225 kg from twice the acreage was higher proportionately than in 2020 (at 1125 kg per hectare), meaning the rice could be sold at 400 INR per kg. While the price was still very high, it was in line with market values for advertised traditional rice varieties (see fig. 10).

In the same year, we were also able to pursue our original plan of growing a second traditional variety of interest to the project, hansraj, known locally in Rampur as *chhota*, or small, basmati. According to oral history interviews, this long-grained rice previously used for preparing pulaos was distinguished by an intense, lingering aroma and a higher elongation than the Pusa basmati varieties that had become ubiquitous. Finding the seed from seed banks proved particularly challenging, and the project team was near to giving up when Sandhu stepped in again: a search through his farming connections in the Jammu region turned up seeds in Chakroi village, just 300 metres from the highly-contested Indo-Pakistan border. With the project again subsuming the risk, he cultivated the variety on one acre (approximately 4000 sq m), sowing the seeds in the nursery on 13 June 2022 and transplanting them on 17 July 2022.

Since the farm had not used pesticides and fungicides on traditional basmati varieties when it grew them earlier, Sandhu did not treat a Gundhi bug infestation initially, but, as with that year's tilak chandan crop, he sprayed the plants once in late September to save the harvest. The October rains impacted the hansraj more than the tilak chandan, since the former plants had been transplanted a week earlier and thus were drier, making them more susceptible to losses due to lodging. Still, the remaining crop was harvested on 5 November and threshed on 12 November 2022, producing a gross yield of 235 kg, or 587.5 kg per hectare (compared with 4213.7 kg per hectare for all rice crops in India in 2021; figures are not yet available for 2022). The net yield (after shelling) was 100 kg of whole grains and 32 kg of broken grains, or, when taken as a total, 330 kg per hectare. This extremely low yield meant the crop was highly unprofitable: even if we count the broken grains (usually a cheaper grade) with the whole grains, the cost was a staggering 758 INR per kg (see fig. 10).

Ultimately, we purchased part of the third crop of tilak chandan for the project for use alongside the hansraj in public events in India and the UK in autumn 2022 and spring/summer 2023. These events included three taste-tests, in Delhi in India in October 2022, in Sheffield in the UK in November 2022 and in Rampur in India in March 2023, which we dubbed the "two khichdi experiment." As the name suggests, participants were invited to assess two separate versions of Rampuri khichdi: one made with the short-grained tilak chandan and the second, for comparison, prepared with a hybrid short-grain or a long-grain basmati. Audiences were mixed by gender, age and socio-economic status, but reflective of their locations – with Rampur representing a local audience, Delhi representing a general Indian audience and Sheffield representing an international audience. The main criteria for comparison, as identified in the original project plan, were appearance, aroma, texture and taste. Though the data requires more precise analysis in a dedicated paper, it was clear that tilak chandan's qualities made for a stickier, more textured khichdi with a "nutty" or "earthy" flavour and strong aroma, while the khichdi made with hybrid basmati was "softer" with the grains more separate and the aroma less pronounced. Nearly every participant could distinguish the traditional rice from the hybrid, but, after generations of basmati supremacy, their preference was more varied – except in Rampur itself where the local heritage rice was almost universally favoured.

The Impact of Revival and Future Pathways

The impact of the field trials of tilak chandan and hansraj on farming practices at Benazir Farm in Rampur is a thought-provoking and heartening case study. Farmer Birendra Singh Sandhu, who had completely given up growing traditional varieties after 2016, was inspired to join the quest to revive heritage varieties from the region. In a follow-up interview, he confirmed that, even if it was only for his own domestic use, he was determined to continue growing those types resurrected through the Forgotten Food project. With the higher yield for tilak chandan in 2022, he took the decision to sell some of his crop to local consumers at the market rate of 400 INR per kg. Showing admirable zeal, Sandhu has also located and sown another three near-extinct varieties of nutritional and cultural value in smaller areas on his farm for personal consumption and experimentation: a red rice rich in antioxidants known as nirvana, the raktali used to cure anaemia and sitabhog used for special festivals and religious offerings.

The yield of all these varieties was very low on first attempt, particularly as the sitabhog lodged completely and the nirvana was prone to pests. Nevertheless, Sandhu was clear that he valued the unique attributes of each variety, which underscored their high commercial value alongside a need for conservation. As he explained, “These varieties are thousands of years old and come from remote areas untouched by hybridization and should be preserved.” Increasing public awareness around the rich cultural and gastronomic heritage of the vanishing rice varieties could give impetus to demand and, in turn, encourage farmers to revive lost varieties. This point was confirmed at a public project event, the Jashn-e Rampur, held in Delhi in October 2022 at which Sandhu spoke eloquently alongside academic leads about his experience of growing, abandoning and later resurrecting traditional rice varieties. Afterwards, he was thronged by audience members asking to purchase his heritage crops. At public tasting and storytelling events for Forgotten Food in Sheffield in November 2022 and June 2023, too, local audiences followed up by asking where tilak chandan could be purchased.

Old and new yearnings for these traditional varieties could facilitate a possible niche market opportunity – by which comparatively expensive products are sold to more elite consumers in India and internationally based on their historic, cultural or medicinal credentials.[2] At the heart of the Forgotten Food project, however, was a more democratic premise: that the specific qualities of lost rice varieties made them culturally and historically meaningful to a broader swathe of Indian society. Some scientists in India are sympathetic to this position, arguing that the scientific community has a duty to promote traditional rice varieties, including tilak chandan and hansraj, to more farmers and traders. Then, consumers will be able to access “better aromatic rice at lower cost,” while also protecting India’s “non basmati aromatic rice germplasm” – though it is recognized that, without “strong research policy”, marketing support and perhaps a special categorisation for “traditional food products of India,” this endeavour has little chance of success (Singh 2013: 284-85; Eliazer Nelson, Ravichandran and Anthony 2019). Scientists at G.P. Pant University in Pantnagar are taking steps in this direction through their field experiments investigating the effects of organic cultivation on the growth and productivity of traditional scented rice varieties, including tilak chandan (Supriya et al 2023a and 2023b).

For our own project, we hope to continue work with Benazir Farm on a marketing and demand creation exercise for tilak chandan and other heritage varieties that, in brand terms, would draw on the farm’s historic connection to the Nawabs of Rampur. Sandhu’s farm is, after all, connected to the Nawab’s former summer residence, the Benazir Palace (now derelict), that hosted an annual festival, or *jashn*, of music, arts and food in the late nineteenth century (see Mir Yar Ali “Jan Sahib” 2021). In the short term, we reason, this approach could lay the ground for a new income-steam to benefit local farmers and field labourers in the Rampur rice belt. A more ambitious next step would be to use modern scientific techniques to resurrect traditional landraces in a form that it is also high yielding, drought tolerant and pest resistant – in other words, able to balance the dramatic effects of the Green Revolution in the twentieth century and climate change in the twenty-first to bring Rampur’s farming and foodways back in harmony. To make that happen, scientists would need to isolate key traits that would make these older rice varieties more reliable in India’s current soil and climate conditions. Preferential characteristics, like aroma, taste, texture and potentially nutritional value, could be incorporated through selective breeding, the development of novel hybrids or even genetic modification. Whatever happens next, this study makes clear that our understanding of food needs to move from only filling the belly – as important as that is – to a broader notion of cultural heritage replete with unique sensory attributes.

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Research Ethics

Ethics approval for this project was granted by the University of Sheffield on 20 December 2019 (Reference Number 032012). Accordingly, the project abided by the University's Research Ethics Policy (https://www.sheffield.ac.uk/rs/ethicsandintegrity/ethicspolicy/approval-procedure) and also the University's Good Research & Innovation Practices Policy (https://www.sheffield.ac.uk/polopoly_fs/1.671066!/file/GRIPPolicy.pdf).

Tables and Figures

Figure 1. Comparative seed dimensions by length of tilak chandan sample, tilak chandan reference and commercial basmati. The difference between the tilak chandan sample and the tilak chandan reference was not significant. Error bars represent ± 1 standard error. Adjacent bars were analysed for significant difference by a T-test (N = 15, P<0.0001).

Figure 2. Transplanting tilak chandan seedlings at Benazir Farm, 27 June 2020.

Figure 3. Graphical representation of the experiment timeline for the 2020 field trials at Benazir Farm.

Figure 4. Uneven growth of tilak chandan in 2020 field trial, Benazir Farm, October 2020.

Figure 5. Harvesting of tilak chandan in 2020 field trial, Benazir Farm, 19 November 2020.

Figure 6. Threshing of tilak chandan in 2020 field trial, Benazir Farm, 25 November 2020.

Figure 7. (A) Photographic images of tilak chandan (top) and commercial basmati (bottom) Scale bar divisions = 7.5mm; (B) Comparative seed dimensions of tilak chandan and commercial basmati by length and breadth. Error bars represent ± 1 standard error. Adjacent bars were analysed for significant difference by a T-test. Both seed length and seed breadth were significantly different across the two cultivars (N = 15, P<0.0001).

Figure 8. Yield from the 2020 field trial compared to the country average yield for paddy rice from the 2020 FAO Stat dataset. Crops and livestocks products. License: CC BY-NC-SA 3.0 IGO. Extracted from https://www.fao.org/faostat/en/#data/QCL. Date of access: 10 Jul. 2023.

Figure 9. Field trial data for cultivation of tilak chandan and hansraj at Benazir Farm, Rampur, 2020-22.

Figure 10. Comparative prices of different classes of rice (INR per kg).

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Interviews

Interviews with Princess Nighat Abidi, Nawab Kazim Ali Khan, chef Suroor Khan and farmer Birendra Singh Sandhu are available at: https://player.sheffield.ac.uk/series/forgotten-food-culinary-memory-local-heritage-and-lost-agricultural-varieties-india

Notes

[1] A bigha is not a standardized measurement, but one that differs depending on location. In many Indian contexts, including parts of Uttar Pradesh, it equates to 0.2 to 0.25 of a hectare. However, Sandhu confirmed that, on his farm, two bighas is roughly 0.25 of an acre or 1000 sq m – which is the measurement used here.

[2] For an example, see how rakthashali is being marketed online as an “iron rich medicinal rice” at 785 INR per kg, as at July 2023. https://qidhan.com/products/rakthashali-full-bran-raw-rice