CASE STUDY

Microchips: from forest residues to a new versatile product

The term "Microchips" describes a very small (7 mm length) homogeneous wood chip product. Compared to other wood chip grades, microchips have the peculiar characteristic of a very small and even size. That confers many qualities to microchips, and especially a much better flowability compared to standard chips that are larger and much more variable in size. Such better flowability brings about dynamic and static benefits, and respectively a) easier automatic feeding (dynamic benefit) and b) homogeneous coverage when layered (static benefit). In turn, each of those two sides of the same quality reflects a specific innovative product, namely: pellet surrogate and mulch. The two value chains gathered under this case study exemplify those two products.

Figure 1. A classic example of microchips, produced here as a pellet surrogate to feed small-scale pellet stoves for residential use. This product must be very small (≤ 7 mm), very even and very dry (≤ 13% on a wet weight basis). Otherwise, the stove may malfunction...

KEY WORDS

Microchips, pellet surrogate, ecological mulch

COUNTRY

Italy

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Pellet surrogate

Microchips cannot match the quality of pellets in terms of high energy density, extremely low moisture content and even piece size: however, if properly dried, microchips have a low enough moisture content and a good enough flowability for feeding stoves that were originally designed for pellet fuel, and that are much cheaper to purchase compared with a classic chip boiler.

Today, many different entrepreneurs have endeavored into the production of fuel microchips, and several of them have gathered in a dedicated association, the Consorzio Forestale dei Produttori di Cippatino e delle Biomasse di Qualità (https://consorziocippatino.com/) based in northwestern Tuscany. However, the undisputed pioneer of microchips is Travaglini Bros., a family-owned farm business in the Chianti hills. As part of their thriving agroforestry business, Travaglini Bros. log their forests, grow agricultural crops and raise cattle - and this activity is successful enough to support the families of the three Travaglini brothers (now in their 70s) and of their sons - who live in the farm. Travaglini Bros. were among the first ones to acquire a chipper and install a chip-fed boiler, for heating the whole farm building complex. They also got into micro-chipping already 12 years ago, supplying a number of residential users in the surroundings. Eventually, Travaglini Bros. got into modifying commercial boilers and selling them to customers together with a guarantee of good functioning and fuel supply at an agreed price, competitive with that of conventional pellets.

Over the years, the process has evolved quite a bit, and today Travaglini have organized micro-chip production as follows:

1 - Storage and air drying of low-quality chestnut logs. These are the by-product of post and fencing assortment processing, which is done directly at the landing in the own forests. These logs are crooked, undersized or - most often - affected by ring-shake, all of which makes them unusable for the manufacturing and more valuable assortments. Reject wood is left piled at the landing or moved to the new satellite yard, where it sits for approximately one year, during which tannin is washed away and moisture is lost. Initial mean moisture content is 42%-w, and that will drop to 27% -w after one year-long storage in a ventilated position. Most of the wood they use for microchip production is their own, and it is difficult to calculate a price - but if they were to sell that wood on the market they would obtain a price of 30 € t-1 at the initial 42%-w moisture content.

2 - Chipping and screening. Logs are chipped by Travaglini, using their own Farmi 260 CH powered by a small 85 kW tractor. The tractor is fed with a loader mounted on a second farm tractor. The chipper is set to a cut length of 7 mm, and productivity is substantially reduced compared with the productivity obtain with the standard 20 mm cut length setting (3 t h-1 instead of 5 t h-1). Chips are blown directly into a bin trailer that is fitted with a self-constructed oscillating (reciprocating) screen. Basically, the screen consists of an iron wire net installed on 4 spring supports and shaken by a cam that is powered by a small hydraulic motor through the tractor's own circuit. Normally, 80% of the particle weight is micro-chip, 20% premium boiler chips.

Figure 2. Reject chestnut logs in the open-air storage. One can clearly see the central log as being affected by ring shake, which rules out its conversion into a high-value fencing product.

3 - Drying. Chips are dumped on a new solar drier just built on the satellite yard and consisting in a walled concrete pad sited on well-ventilated position for air drying. In summer, moisture content is reduced to 18% within 3 days, after stirring the chips with a front-end loader twice per day. The pad can process about twenty 30-t batches in a 2-month long hot and dry season. That limits production capacity to 600 t $year^{-1}$, but this figure is much below current production, so there is much room for further growth.

4 - Bagging. A bagging line for the microchips has been installed and fills standard 15 kg plastic bags, with thermo-sealing. The system is manual and requires that an operator attends to it. The investment cost for the bagging plant was 8000 €. Screen rejects are sold to local heating plants at 90 € t-1. Both stove-worthy microchips and boiler chips are sold directly to the final users, not to retailers: this way the intermediation cost is avoided. All microchip bags are stored under a roof until delivery, and can stay there for few months, because the process is completed within the end of the summer (early September) in order to obtain accelerated chip drying on the pad, while consumption occurs from October to March.

Like other forest entrepreneurs, Travaglini Bros. endeavoured into microchip production in order to find an outlet for their unutilized wood and to counter dwindling firewood demand. Among the main success factors, the most important is the ability to reach the final user, without intermediaries. Other significant success factors are the use of unutilized labour resources at marginal cost, control of the raw material supply, capture of opportunity wood and reduced investment cost. In fact, the cost for setting up this microchip operation was 38 000 € and represents about less than half that of setting up a comparable pellet-manufacturing operation. For Travaglini bros. this is a relatively small operation, with an estimated output of slightly over 100 t per year, but it is a very profitable one and it is strategic for optimizing the use of internal resources and for reaching new customers.

Ecological mulch

This alternative value chain was documented in the Pistoia mountains, in Western Tuscany. The landscape is more rugged than in the Chianti hills, and forestry dominates over agriculture. Again, microchips are produced mostly from chestnut residue. There are two main reasons why chestnut is specifically targeted for microchip mulch: first, chestnut firewood is the least valuable on the market. Therefore, turning residues into firewood is a tempting option when dealing with beech or oak, but not with chestnut. Second, chestnut wood is the richest in tannin, which makes the chip mulch especially durable – and that is definitely a desirable quality. In our example, chestnut-dominated coppice stands are harvested according to traditional uneven-aged coppice system in order to obtain several different products, and namely: chestnut timber (used for roofing), chestnut poles and fencing assortments, oak firewood and chestnut chips. The harvesting is performed by local small-scale logging companies, such as Santini Timber or Orlandini Agricola Forestale. Both are pioneers of cable yarding and normally resort to whole-tree harvesting.

Figure 3. One of the cable yarding operations common on the Pistoia mountains. A light tower yarder is used to bring whole trees to the roadside, where they are processed and loaded on trucks for subsequent transportation to the end user or to a centralized sort yard.

Santini also runs a small-scale processor, in order to speed up production and alleviate the burden on the chaser. After careful study, Santini selected the most suitable machine for the wood size and type available in the area. Their light Arbro stroke processor is mounted on a small, tracked excavator and can easily deal with the most branchy wood, while still being light and cheap enough to be within reach for most small-scale loggers. Its small size and light construction are not a synonym for poor durability, since the same machine has now been in operation for about a decade without suffering any major issues.

Figure 4 – The light stroke processor used by Santini Timber. The processor is installed on a mini-excavator and the whole machine is compact and light enough for easy relocation and trouble-free maneuvering even in constrained-space work sites. The machine is also cheap and reliable. It is now 10-years old, and it still runs

Such an affordable machine allows a small company to spare enough capital to purchase additional equipment and increase its task-versatility. Besides his tower yarder and processor, Santini also owns forwarding trailers, spare tractors, and a mobile chipper, for reaching those constrained landings that are outside the reach of a heavy industrial machine or completing those urgent jobs, when an industrial chipping contractor is not available.

The harvesting operation includes the following work steps:

1. Motor-manual felling by chainsaw
2. Dragging to the skyline corridor and extracting to the landing with a light tower yarder
3. Mechanized processing with a light excavator-based processor (or by a loader and a chainsaw assistant, in the case of Orlandini)

When the site is accessible by truck, logs are loaded directly at the yarder pad and taken to the mill. Otherwise, a farm tractor equipped with a forwarding trailer will move them from the yarder pad to a proper roadside landing. Below a simple graphical description of this system.

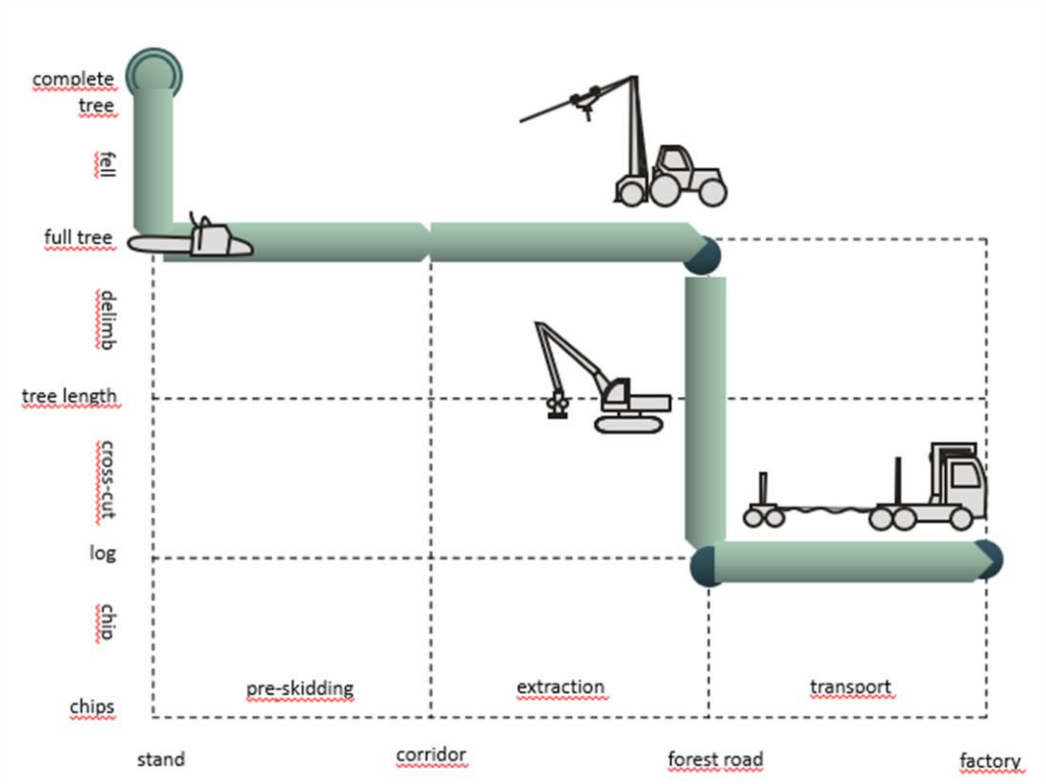

Figure 5 – Schematic description of the whole-tree yarding system common in the Pistoia mountains.

Yarding operations as those run by Orlandini or Santini are typical of the Tuscan mountain, where a dozen other yarding operators are also active. Those operations are quite different from the operations found in the Alps, because extraction distances are generally shorter, but tree size and removals are smaller, and the species are entirely different – being generally hardwood or young softwoods – not the large and valuable spruce trees one is yarding further North.

Operators have adapted and they have found the right equipment and methods for matching their own wood basket. Orlandini and Santini are leaders in this sector, as they pioneered yarders and processors, respectively. More contractors are following their example, to the benefit of increased financial, social, and environmental sustainability in forest operations.

Logs are taken to the sortyard owned and managed by Orlandini Agricola Forestale. This company was among the first to resort to whole-tree chipping, which has now grown into a very common business model all around Tuscany. As competition became fiercer, Orlandini realized that once again you have to start a new game if you want to stay ahead and changed its fuel chip business into an innovative microchip business, geared to offer a new product: ecological mulch. Being the first to offer such a product, Orlandini acquired the leading customer in the Province – Vannucci Piante - and they are once again showing the way ahead!

In Pontepetri is the largest of Orlandini's sort yards. While tops and branches are too bulky for efficient transportation and they are chipped at the forest landing whenever possible, logs are moved to the sort yard and chipped after air drying. Orlandini separates different log sorts by size and species, and they have their special recipes for mixing those woody ingredients to obtain the ideal product specifically suited to each individual user. By introducing chestnut in the mix, they increase the proportion of tannin in order to obtain better durability for their chip mulch. Conversely, they can reduce (or entirely remove) chestnut from the mix if the goal is obtaining hot-burning fuel chips.

The great thing about chip mulch is, that the only specification set by the customer is that of a durable even-sized chip, with a length below 2 cm. There is no strict moisture content specification, and therefore mulch chips can be produced simply by adjusting chipper cut length to the minimum setting and by installing a 3x3 cm or 3x2 cm mesh screen. There is no need for screening the chips after chipping nor for drying them to a very low moisture content (<20%), as is the case when producing microchips for use with pellet stoves.

All the microchip mulch produced by Orlandini Agricola Forestale goes to one single custmore: Vannucci Piante. Established in 1938 by Vannino Vannucci Sr. on a plot that measured less than a hectare, this nursery has become a global company that produces over 3000 plant varieties, for a total surface of 590 ha. Now in the capable hands of Vannino Vannucci Jr., the company remains a family-owned business, but its customers are spread over three continents, and range from the quality-minded home-owners purchasing a few ornamental plants for their gardens, to the Royal Gardeners of Buckingham Palace or of the Jordan Royal Residence.

Figure 6 – Microchip mulch freshly layered on garden plant pots at the Vannucci Piante nursery.

From the humblest to the loftiest, such clientele has a distinctive outlook on environmental and social sustainability. In order to resolve any concerns, Vannucci Piante operates under a double environmental and ethics certification scheme. That is quite important for nurseries, which are intensive operations and use significant amounts of water and chemicals. In fact, Vannucci Piante has endeavored into a very ambitious project: the Vannucci Zero project.

The project was launched in 2021 on a pilot site measuring 15 ha, located at La Ferruccia, just outside Pistoia. The innovation is radical: even if the new nursery is designed for potted-plant production, its surface has received minimum treatment to maximize water infiltration rate during rain events. Pots are lined on bands of permeable geotextile fabric, which only cover the area right under the potted-plant lines. Access and service roads are only metaled on the two 40 cm-wide strips corresponding to the vehicle wheel tracks. These measures maintain full soil permeability to the point where no surge ponds are necessary.

Furthermore, all plant supports are made of locally sourced chestnut posts, which receive no preservative treatment, given the high natural durability of untreated chestnut wood. Finally, all herbicide has been replaced with ecological mulch, supplied by Orlandini. Rather than spraying toxic chemicals, Vannucci Piante now applies a thick layer of microchips to the top of each pot, which constitutes a durable and effective mechanical barrier to weed growth. With that measure alone, herbicide use has been cut by over 50%, while creating a new market for local forest companies, such as Orlandini, who operates just few kilometers uphill. Vannucci Piante currently uses 8000 m3 of microchips per year, but that amount is rapidly expanding, as the new weed control technique becomes generalized: microchip is far superior in environmental, social, and financial terms.

Figure 7 – The Vannucci Zero project. Pots are placed on a permeable pavement (grass pad and geotextile cover) and the support structure for both the plants and the irrigation pipes is made by untreated chestnut wood poles.

Motivation for development

The reasons for implementation of both microchip solutions are multiple, and they all concur to their success. Those are:

1) Large availability of unused forest residue that cannot find a viable market. Alternative users offer a very low price that barely compensate production cost and is only accepted if the residue must be disposed of and cannot be left in the forest (e.g. fire prevention, amenity etc.);

2) Very high price of the surrogated industrial product. Pellet is sold at >5 € per 15 kg bag (>300 €/t) and herbicide is even more expensive. Furthermore, pellet availability and price are quite erratic: they may change abruptly with any disruption of the main supply channels, as it happened with the recent Ukrainian crisis, which caused an acute shortage of pellets with the resulting price spike (tripled within a week);

3) Regulations that are limiting or even banning the use of certain herbicides, as is the case for Glyphosate in Tuscany. Regional legislators placed a ban on the toxic herbicide few years ago, and that ban has impacted both food and non-food production, as in the case of ornamental nurseries.

Additional feedback received from the public attending the demonstrations concerned the following subjects:

- Several stakeholders found it very interesting to see such a large nursery (and the other nurseries around), which is a very important local employer and economy driver. They appreciated the direct connection between horticulture and forestry, which may help broadening one's mindset.
- Another subject of interest was the use of a yarder with relatively small trees, on a slope that could have been harvested with ground-based systems – although with some difficulty. The capacity to apply cable yarding to borderline conditions (for tree size and slope gradient) is crucial in minimizing site impacts.
- Some delegates also reported that microchips are occasionally used as mulch in their countries, but not on the industrial scale that was witnessed during the showcase day.

• Most appreciated the professional management of all the operations visited on occasion of the Showcase Day, as well as the strong experience of the operators. The use of low-cost machinery was also noted and favorably assessed, and so was the ability to maintain profitability when dealing with small sales and light removal, both of which represent severe challenges to financial sustainability.

Economic-, energy- and environmental perspectives

Both operations – PA #2 and PA # 55 – demonstrate successful value chains that are innovative, effective, and adapted to the local needs and potential. Starting from the same general conditions, they show two different ways to generate revenue from the same resource with the same level of affordable low-investment technology.

Due to their reliance on local raw materials, both value chains are resilient to global perturbations and can help mitigate their impacts. That was clearly the case of the pellet supply shortages derived from the Russo-Ukrainian conflict.

Furthermore, developing a local microchip business can boost the revenues obtained from low-value forest resources and support active forest management where it is most needed. Replacing imported industrial products with locally sourced domestic goods is also likely to increase energy efficiency, as well as GHG emission mitigation efficiency, due to the shorter transportation distance and the fewer processing steps. That is true for both imported pellet and herbicide – the former needing active drying and long-distance transportation, the latter requiring industrial processing and use of noxious chemicals.

Finally, evolving from firewood-production into microchip-production offers significant benefits for both producers and users. For producers, that means changing from labour-intensive and potentially hazardous semi-mechanized firewood processing to safer fully mechanized chipping; for users that means phasing out their old, inefficient and polluting firewood stoves and adopting newer, more comfortable and cleaner pellet stoves. In fact, firewood can be produced and used in modern and efficient ways, but the cost of converting an old firewood business (or firewood stove) into a modern and efficient firewood business (or firewood stove) is often higher than that of shifting to an entirely new product, such as microchips.

Figure 8 – Traditional semi-mechanized firewood processing is labour-intensive, costly and hazardous

Knowledge transfer potential to other regions

The main driver for establishing the microchip value chains described in this case study is the large availability of unutilized forest resources, which cannot find a viable market. Designing a new product is shown here as a successful solution, especially if such new product can replace another high-value product at competitive conditions. That is what PA #2 and PA #55 exemplify, as they show how forest residue can be processed into a competitive surrogate of expensive imported pellets or herbicide. Of course, the new product must be reliable, effective and consistent, and matching those specifications requires considerable skill and professionalism.

On the other hand, there is no need to commit large capitals into expensive and sophisticated machinery, nor to incur into large energy or material consumption, as when installing a small-scale pellet plant. The equipment required is that normally used for logging, which one expects to be already available to a professional logging enterprise. Only minor adaptations and/or additions are required.

The main barrier to a further development of microchips as a surrogate for pellets is legislation, or the lack thereof. At present there are no official quality standards defining microchips, although when microchips are quality certified, the certificate generally makes reference to chip quality Class A1+, according to standard UNI EN ISO 17225-1: 2015. However, most pellet stoves are only certified for use with pellets, not chips – regardless of quality. The result is that any malfunctions or non-compliance events eventually occurred when feeding those stoves with microchips are not covered by a manufacturer's warranty. In fact, a few manufacturers have now launched dedicated models that are certified for use with microchips, and they extend all their warranty conditions to that fuel, too. However, current public funding schemes do not include microchip stoves into the subsidized stove categories, and therefore a microchip stove may not benefit from the tax credit or subsidy granted by the regional legislator. Apparently, no such limitations are incurred by microchip mulch.

Concerning replication, installing a value chain for pellet surrogate requires that pellet is in large demand by residential users and that local production is limited. Such conditions are best met in relatively warm climates, where the utilization of heating plants is not extensive enough to justify the larger investment of a more efficient chip boiler. For the same power output, pellet stoves are simpler, cheaper and smaller than chip-fed boilers, while more convenient than firewood installations that cannot be automated. It is not by chance that Italy is the largest global consumer of pellets in residential heating applications, with an annual demand estimated at 1.4 million tons. This large demand is matched only in part by national production, quantified at 0.8 million t and largely supplemented by imports. Similar conditions are likely encountered in other Mediterranean and Southern European Countries, even if microchips could also be produced and used further north. The question is just about how competitive they can be against local industrial pellet and/or an intently used chip boiler, if heating requirements are large enough to justify its larger capital cost.

Figure 9 – Group photo from the Showcase Day devoted to the microchip mulch value chain (20/09/2023)

Summary

Low-value wood products and forest residues can be effectively converted into microchips, which are an emerging product with multiple applications. Among them, the two applications explored in the case study are: 1) a local surrogate to imported pellets and 2) an ecological substitute to toxic herbicides. Both applications rely on the excellent flowability of very small and even chips, which facilitates trouble-free automatic feeding (dynamic benefit) when used to replace industrial pellets in pellet stoves and guarantees homogeneous coverage when layered (static benefit), when used as a mulch to replace herbicide.

Microchips can be produced with a minimum of dedicated equipment (if any) and do not require revolutionizing one's production system. Most logging enterprises can adapt their operations to a collateral production of microchips with little modifications.

Microchip production has a very large potential for expansion and very few hurdles in its way. In turn, it replaces imported, carbon-inefficient and even toxic and polluting products with a locally produced, clean and ecological raw material. Microchips offer a clear improvement in terms of environmental, social, and financial sustainability.

ABOUT BRANCHES

BRANCHES is a H2020 "Coordination Support Action" project, that brings together 12 partners from 5 different countries. The overall objective of **BRANCHES** is to foster knowledge transfer and innovation in rural areas (agriculture and forestry), enhancing the viability and competitiveness of biomass supply chains and promoting innovative technologies, rural bioeconomy solutions and sustainable agricultural and forest management.

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