DIVINFOOD

Co-constructing interactive short and mid-tier food chains to value agrobiodiversity in healthy plant-based food

Deliverable D3.6

Repertoire of technical and organisational solutions for pre-processing stages

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Executive summary

Deliverable D3.6 "Repertoire of technical and organisational solutions for the pre-processing stages" aims to list and describe technical and organisational solutions adapted to the pre-processing of minor cereals and legumes, as examples of neglected and underutilised crops (NUCs), and to present avenues for co-development and mutualisation of equipment between farmers.

To achieve this, a documentary search was carried out to benchmark the pre-processing techniques and equipment generally used on farms for minor cereals or legumes. To complement this documentary search, interviews with experts and farmers conducted in the DIVINFOOD project to compile experience and data on NUCs performance were reviewed to highlight the pre-processing techniques and organisational solutions implemented in the DIVINFOOD Living Labs regions, and innovative solutions were described (mobile cleaning unit, self-build equipment). In addition, the partners were involved in experimenting with the co-development and sharing of pre-processing equipment between farmers in 3 of the project's living labs (Cer-Occ, Leg-Nord, Faba-Nord). This deliverable presents the results of these sub-tasks, both dedicated to supporting farmers using NUCs and to contributing to the setting up of territorial networks around agrobiodiversity.

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Introduction

The pre-processing step is the preliminary preparation of raw material for processing. It includes all the stages before processing from harvest to the first processing step, such as, for cereals and legumes, sorting, storage, or dehulling (see Figure 1).

In Europe, about 9% of food production is lost during the steps of postharvest (that includes all the steps after the harvest until the marketing of the final product) (FAO, 2021). In the world this number goes up to more than 13%. Regarding grain production (legumes and cereals), losses during pre-processing, transport and storage range from 10 to 15 % of the production (Mesterházy et al., 2020). These losses have a big impact on food security and on the economy. It is therefore essential to manage these stages properly to guarantee high quality products in sufficient quantity and avoid loss of income for farmers.

The objective of this deliverable is i) to benchmark the techniques, equipment and organisations which are adapted to pre-process minor cereals and legumes on the farm, and ii) to present the first stages of an experiment involving the co-development and mutualisation of pre-processing equipment between farmers, which has been implemented in 3 living labs of the DIVINFOOD project and contributed to the setting up of territorial networks around agrobiodiversity.

Most of the existing pre-processing techniques, equipment and organisational solutions are designed for the major crops cultivated in Europe, such as wheat for cereals or soybeans for legumes. Therefore, producers of neglected and underutilised crops (NUCs) often have to adapt these methods to their crops, invent their own equipment, or outsource/subcontract these steps to specialised companies. The importance of having adapted organisational and technical solutions for NUCs is crucial, particularly for short and mid-tier food chains where the products are not supposed to go through many stakeholders.

This deliverable will be structured in 3 sections: i) benchmark of pre-processing equipment and techniques used for minor cereals and legumes, from literature search; ii) overview of pre-processing technical and organisational solutions developed in DIVINFOOD's living labs regions, from data collected through surveys; iii) presentation of equipment co-development and mutualisation experiments in 3 living labs of the project, which contributed to the setting up of territorial networks around agrobiodiversity.

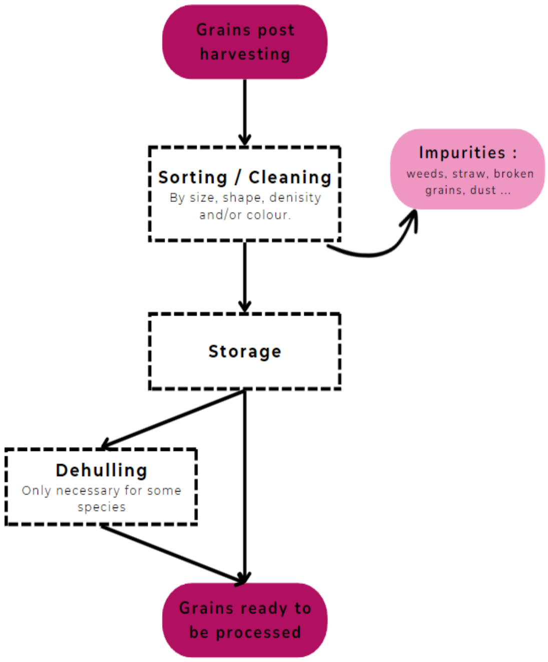

Figure 1. Diagram of the main pre-processing steps for legumes and cereals (adapted from FAO, 2007)

1. Benchmark of the main pre-processing equipment and techniques for minor cereals and legumes

References: *SEMAE, 2024; Solagro; ITAB et ARVALIS, 2006; Manandhar et al., 2018*

There are several stages in the pre-processing of legumes and minor cereals. First of all, the grains need to be sorted to remove any impurities, weeds and insects. Ventilation also helps to lower the temperature and humidity. Once the seeds have been sorted and cleaned, they can be stored. This stage is important to preserve the quality of the grain for as long as possible. Then, for certain species, it is necessary to remove the husk before starting to process the grain, so that only the edible part of the grain remains.

1.1 Sorting and cleaning the grain

The first pre-processing stage after harvesting involves cleaning and sorting the grains. This is a very important stage, as it removes all impurities, weeds, broken grains and even certain insects. This stage is also used to sort and separate two mixed crops when they are grown together. There are many different types of sorting equipment, and their choice depends on a number of parameters. The first is the type of sorting required (by shape, colour, size, density, etc.) (see Figure 2), which also depends on the quality required, and influences the cost of sorting. In addition, the quantity to be sorted influences the type of equipment to be used. All these criteria must be taken into account when choosing a sorting equipment. The most commonly used existing equipment, and the techniques for using it, are presented below, explaining their characteristics and their advantages and disadvantages.

Sorting criteria	Adapted equipment
Size	Separator or Screen grain cleaner (vertical or rotary)
	Drum rotatory cleaner
Dimension	Seed indented cylinder
Density	Gravity table
	Densiometric column
Shape	Propeller sorter
Colour	Optical sorter

Table 1. Adapted pre-processing equipments by sorting criteria

1.1.1 Sorting by size

- **Separator or Screen grain cleaner**

This type of separator uses screens in order to separate or clean the grains according to their size. The scalping screens remove the large impurities while the screening screens remove the small impurities. Grain cleaners can be classified into two distinct types: (i) **vibratory screen** (Figure 2), **(ii) rotary screen**, based on the movement of the screening surface.

The sieve cleaners use flat screens moving alternatively or vibrating and have two aspiration boxes, one in the grain input and a second one on the grain output. The upper screens are the scalping screens while the lower screens are the screening ones.

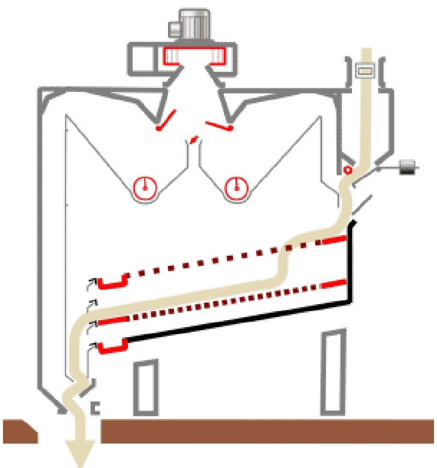

Figure 2. Scheme of a screen separator cleaner (www.denis.fr)

- **Drum separator or rotary cleaner**

The drum cleaners use screens around a rotating drum. They usually have only one aspiration box on the grain input (see Figure 3). In contrast to the screen cleaner, the first screen is the screening screen, while the others are scalping screens.

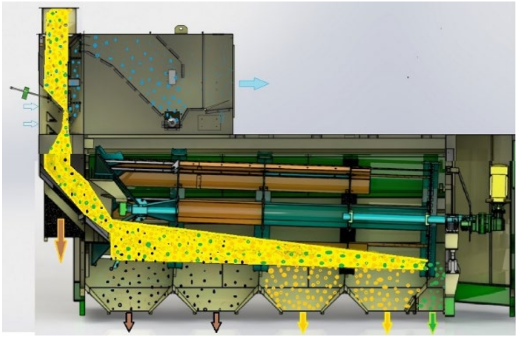

Figure 3. Scheme of a drum separator cleaner (www.cfcai.com)

Both types of cleaners can cover a wide range of grains and flow rates at an affordable price that makes them commonplace on farms.

1.1.2 Sorting by dimension

- **Seed indented cylinder separator**

This technique uses a horizontal cylinder that rotates. Thanks to centrifugal force, small particles remain trapped in the small slots on the cylinder (see Figure 4). Larger particles are discharged at the end of the cylinder. This technique can be used to sort all types of crop, provided that the sorting criterion is the shape of the grain.

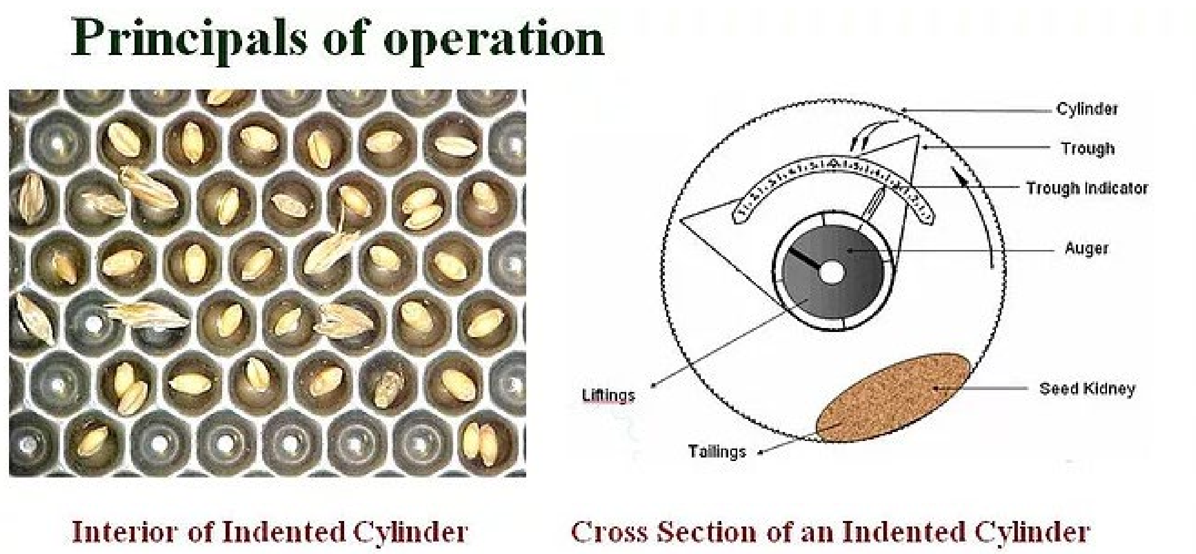

Figure 4. Scheme of an indented cylinder separator (www.arrowcorp.com)

The indented cylinder can be modified to match the size (mainly the length) of the grain. This is an efficient and cost-effective solution for separating grains of the same size but not the same length. It is often used on farms, as there were mainly small manufacturers of separators/cleaners between 1870 and 1970 (see Figure 5). These sorters are slow but very affordable. However, they must be powered by an electric motor.

Figure 5. Old indented cylinder separator (www.ferradosa.blogspot.com)

Modern indented cylinders are more efficient but much more expensive (see Figure 6).

Figure 6. Modern indented cylinder separator (www.indiamart.com)

1.1.3 Sorting by density

- **Gravity table**

The gravity table uses an air cushion and vibrations to select the grains according to their density. It is very accurate, but very delicate to adjust. It is mainly used for seeds intended for planting and for legumes. The gravity table is used for legumes because this technology can remove stones from lentils, for example, but also grains that have been affected by weevils.

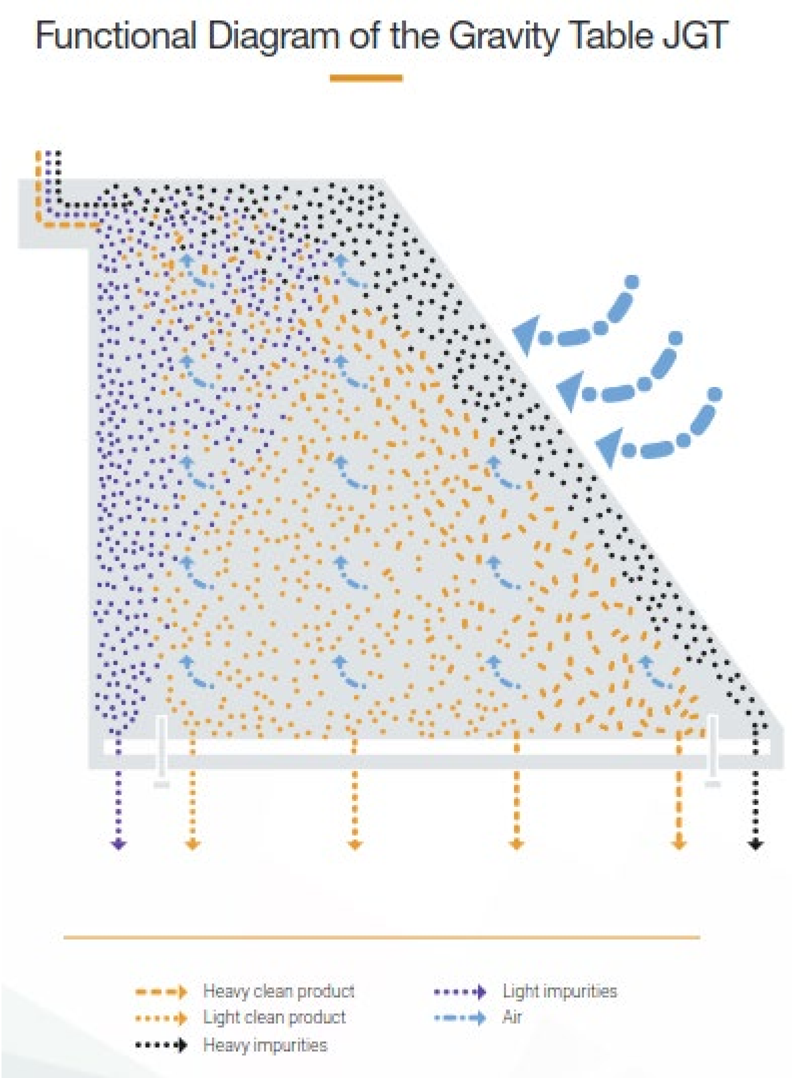

Figure 7. Scheme of a gravity table (https://jk-machinery.fr)

As this is a gravity sort, it is advisable to clean the grains using a sieve separator/cleaner before using the gravity table, as this equipment cannot sort small or large impurities with a density similar to that of the grains. A sieve separator can initially be used to separate by size and eliminate all small and large impurities.

- **Densitometric column**

As for the gravity table (Figure 7), the densitometric column is used to sort grains by weight. It works thanks to a column of air in which a flow goes up (Figure 8). The grains are introduced at the center of the column. The heavier grains move downwards, while the lighter particles move upwards in the column. This tool is mainly used for very precise sorting.

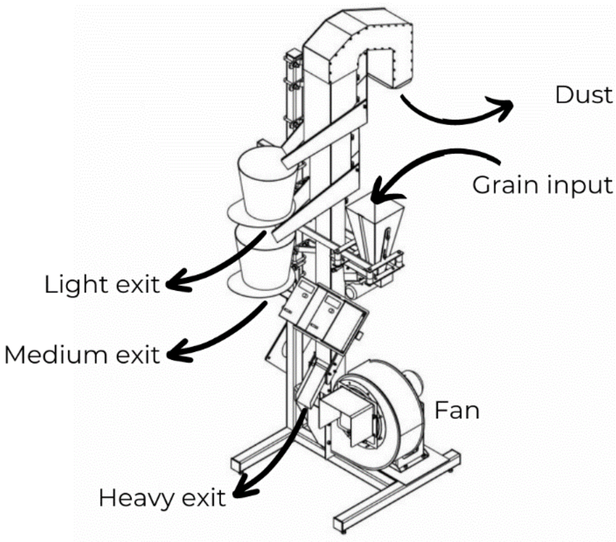

Figure 8. Scheme of a densitometric column

1.1.4 Sorting by shape

- **Propeller sorter**

This type of sorter is used to separate grains of different shapes. The grains move down the propeller and the more regular grains move faster (Figure 9). Thanks to centrifugal force, they pass outside the propeller, while grains with irregularities remain inside the propeller.

Figure 9. Scheme of propeller sorter (www.moulinsalmapro.fr)

1.1.5 Sorting by colour

- **Optical sorter**

Optical sorters use an infrared camera to sort grains by shape and colour (Figure 10). A series of valves placed above and below the grains eject unwanted grains. This equipment is very accurate, but it can also be very expensive and difficult to use, so very few farmers use it on their farms. However, small-scale colour sorters from China are available on the market at affordable prices. The grain to be sorted must first be cleaned by another separator, such as a sieve separator/cleaner. The new optical sorters are equipped with artificial intelligence and can sort according to grain shape. They can also be equipped with an infrared camera and sort according to parameters invisible to the naked eye.

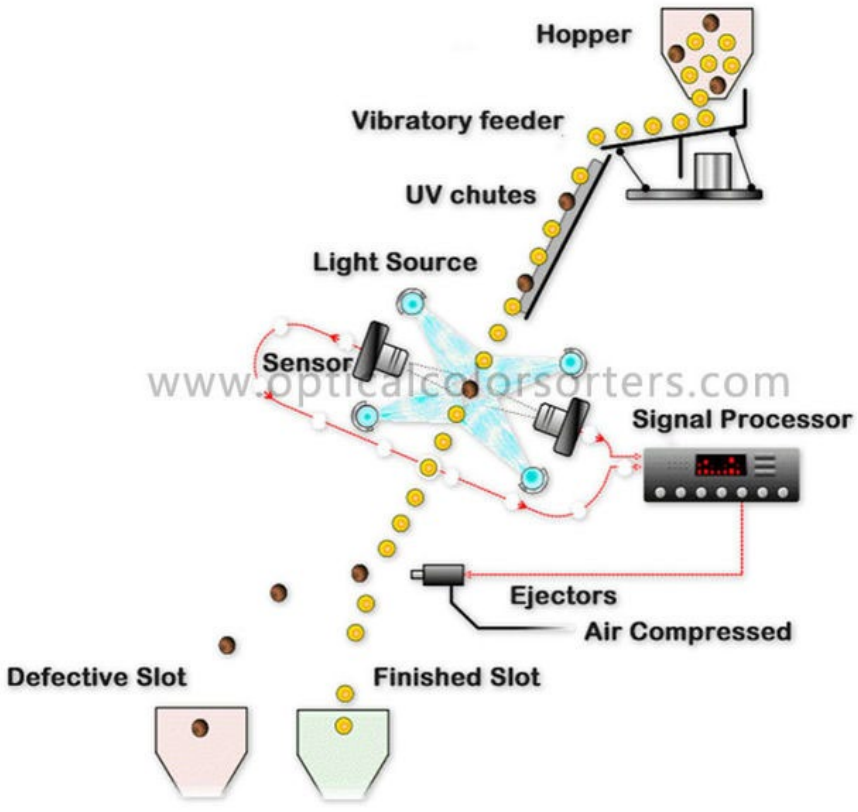

Figure 10. Scheme of an optical sorter (www.opticalcolorsorters.com)

There are other machines available, all of which can be adapted. Depending on the type of work to be carried out, these machines can or must be combined to sort more accurately or according to different parameters.

1.2 Storage

Once the grains have been sorted and cleaned, the next step is to store them. This is also a very critical and technical stage. There are several recommendations to follow before choosing the type of storage.

First of all, the location of the storage facilities has to be considered. It is very important to avoid any dampness, so the ground must be well drained or, if the products are stored in bags, they must be placed on a pallet. Storage on pallets is a solution to the problem of damp soil, but can pose a threat to rodents. To avoid dampness, it is also necessary to protect them from the elements (rain, temperature variations, etc.). The other threat to grain quality is the possible presence of parasites. To combat parasites, it is essential that all the facilities are cleaned before storage and that the equipment is easy to clean. It may also be useful to keep equipment away from fields or livestock areas to avoid contamination.

The other point to consider is proper preparation of the grain to be stored. Grains must be cleaned (using the techniques mentioned above) to avoid introducing pests into the storage facilities, and to remove weeds that could bring moisture and encourage the development of disease. The grains must also be dry when they enter the storage facilities to avoid the development of mycotoxins and diseases. If the grain is shelled, it may be worth keeping the hulls, which can protect the grain from disease. In addition, shelled grains are less demanding in terms of storage because they are less susceptible to pests than dehulled grains (White et al., 1999).

Humidity is a function of temperature, so it is very important to avoid any variation in temperature that could cause condensation and affect grain quality (Figure 11). The best way to combat parasites is also to regulate temperature by means of ventilation. It is advisable to reduce grain temperature gradually. There are three main stages in reducing grain temperature during storage:

1) A first stage at 20°C can and should be reached quickly after harvesting to increase the internal activity of the grains;

2) A second stage at less than 12°C, which stops insects developing;

3) A third stage at 5°C, which has an insecticidal effect.

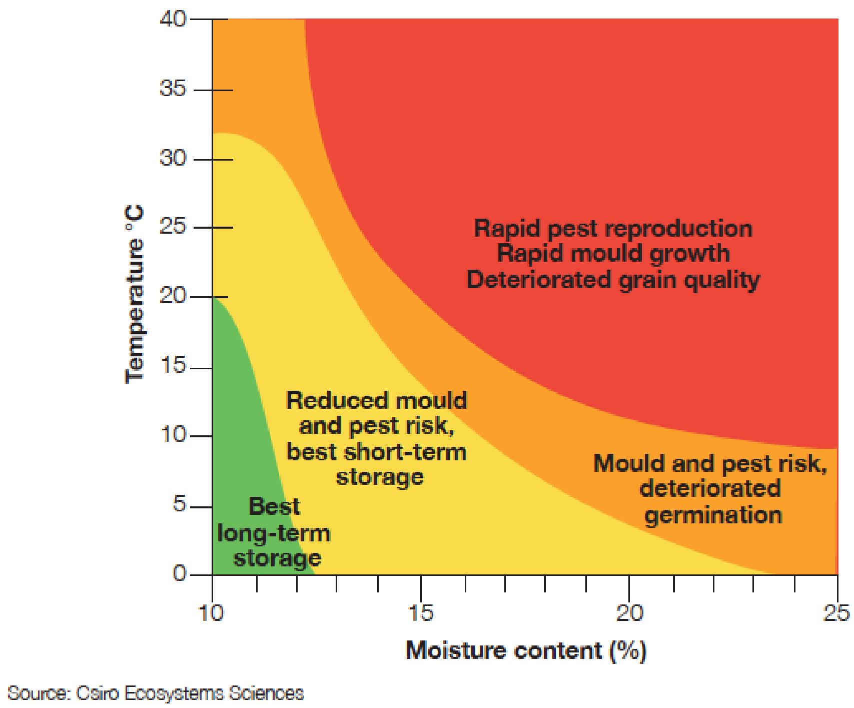

Figure 11. Effects of temperature and moisture on stored grain

The temperature difference between the storage unit and the outside must not exceed 10°C to avoid condensation. Ventilation is essential to reduce the temperature. It is also possible to control the air by using hermetically sealed silos. If the amount of air available is reduced or replaced by CO_2, it will be more difficult for insects to thrive in this anaerobic atmosphere. These are the main points that guarantee good grain quality after storage.

There are various storage techniques. They depend on how long the product is to be stored, the quantity of grain to be stored and the resources available. Grain can be stored on the farm or at a cooperative. Cereals can be stored in piles directly on the ground (flat storage) or in silos. Silos can be circular concrete silos or rectangular or circular metal silos (indoors or outdoors). Most large-scale storers use concrete silos, while small and medium-sized storers use circular metal silos (indoors or outdoors). Indoor metal silos are mainly used for small-scale storage on farms. Cereals can also be stored in big bags for small-scale, short-term storage.

1.3 Dehulling

Dehulling is a necessary step for many crops. For grain legumes, the need for dehulling depends on the subsequent use of the product. If the product is intended for human consumption, dehulling is more important than if it is intended for animal feed (although it can also be carried out for animal consumption). Dehulling legumes removes certain toxic substances that may be present in the seed coat. As far as cereals are concerned, only hulled cereals such as spelt, emmer and einkorn should be dehulled. This operation can be carried out after storage, as the husk surrounding the grain can help to make it more resistant to disease or mycotoxins. There are three main methods for dehulling grains: the first is impact, the second is friction and the third is compression between two cylinders. Impact and friction are the two most commonly used techniques. Impact dehulling (see Figure 12) is used for oats, spelt, wheat, sunflower, etc., while friction is used for buckwheat, millet, barley, legumes, etc.

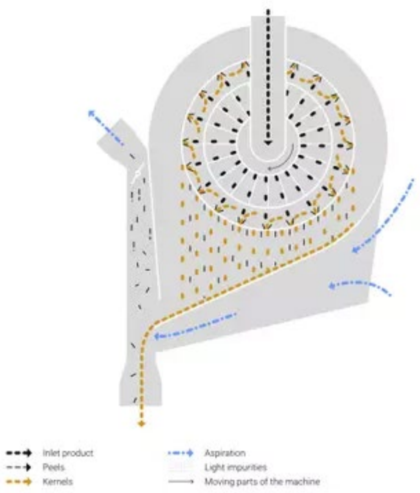

Figure 12. Scheme of an impact dehuller (www.jk-machinery.fr).

Some crops can be dehulled using different techniques, such as einkorn and spelt, which can be dehulled more or less successfully (from less than 50% of the hulled grain to more than 90% of the hulled grain) by impact, friction or cylinder, depending on the settings of the equipment and the quality of the grain (moisture, quality of cleaning, etc.).

2. Overview of pre-processing technical and organisational solutions used in DIVINFOOD living labs regions

2.1 Main pre-processing issues, equipment and organisation in the DIVINFOOD living labs regions

DIVINFOOD operates with nine living labs, each dedicated to the study of specific crops (see Table 2). Among these, two living labs focus on minor cereals, while the remaining seven focus on legumes. Some crops require specific stages of pre-processing.

Living Lab	Country	Crop	Specific stages of pre-processing
Bean-Lyon	France	Meat bean	
Bean-Cast	France	Lingot Bean	Soft grain transportation techniques (from the trucks to the storage facilities)
Cer-Occ	France	Rivet	
		Einkorn	Needs dehulling
Leg-ItSwitz	Italy and Switzerland	White Lupin	Needs to be tested for alkaloid content
GPea-Port	Portugal	Grass pea	
Leg-Nord	Denmark and Sweden	Blue Lupin	Needs to be tested for alkaloid content
		Grey pea	
		Lentils	
Faba-Nord	Denmark and Sweden	Faba bean	
Leg-Hung	Hungary	Dry or yellow pea	
		Lentil	
		Cowpea	
		Chickpea	
Cer-Hung	Hungary	Emmer	Needs dehulling
		Einkorn	Needs dehulling

Table 2. Crops studied in the DIVINFOOD living labs and their specific stages of pre-processing.

Interviews with farmers and experts conducted in the 9 LLs regions of DIVINFOOD (see Figure 13) explored the diversity of farming systems used on NUCs farms. In each LL region, several contrasting farms were interviewed to get a better representation of the type of farms and the type of agriculture being developed. Part of this study was to survey the most commonly used equipment and techniques in different countries, how farmers typically organise pre-processing stages according to their farm type as well as innovative solutions[1].

The study revealed that pre-processing techniques and organisation do not vary greatly across Europe. Generally speaking, small traditional and/or organic farms often carry out their own pre-processing, while large farms, whose production is too high for them to handle it themselves, outsource these stages to cooperatives or industries.

In the Hungarian living labs region (LL Leg-Hung and LL Cer-Hung), nevertheless, the organisational practices vary according to the crop. Cereal pre-processing can be divided into two main categories: small farmers who mostly carry out on-farm pre-processing and big farmers who do not. Among farmers who are doing pre-processing on farm some use their own low-budget equipment, often repurposing other equipment for dehulling and milling. For legumes only the drying and the storage of grains are commonly done on farm. The other stages are mostly done off-farm with a few exceptions of farmers who have invented their own innovative equipment (e.g. a machine to sort whole chickpeas from broken ones). This difference indicates a strong dependence on the type of crop. The difference between legumes and cereals may be due to the lack of adapted machines for farmers producing legumes. Additionally, there is a difference in the organisation of pre-processing. This can be explained by the recent privatisation of equipment that was previously shared by cereal-producing farmers. It was therefore easier to carry out on-farm pre-processing.

In the Leg-It-Switz LL region, where the focus is made on lupins, most farmers producing more than 3 tonnes sell the harvested crop before pre-processing, leaving these stages to collective cleaning, sorting, and storage centres. Farmers producing less than 2 tonnes often use low-cost and improvised equipment for on-farm pre-processing. The unique aspect of this Living Lab is the need to test lupins for alkaloids, which can be toxic in large quantities. If the alkaloid content is high, the crop is wasted. This testing step is costly, and if pre-processing is done on the farm, farmers may realise too late that the lupins are toxic. The result is time and money wasted on unnecessary pre-processing steps.

In the Leg-Nord LL and Faba-Nord LL regions in Denmark and Sweden, on-farm pre-processing steps are mainly carried out by small and/or organic farms, while larger conventional farms often rely on other companies for pre-processing. In Denmark, a company offers a mobile cleaning unit that goes to the farm and makes on-farm pre-processing easier. In Sweden, farmers sometimes dehull the crops of other farmers, a practice that reduces pre-processing costs and facilitates on-farm pre-processing. For faba beans, dehulling is mostly done off-farm.

In the GPea-Port LL region in Portugal, where the focus is on grass peas, the operational organisation is similar to other regions. As for Hungarian and Nordic living labs regions, some

[1] For a presentation of the survey methodology, see the Deliverable 3.1 of the DIVINFOOD project: Szira F., Fekete K. A., Fehér J., 2024. *Deliverable 3.1 – Repertoire of local farms and farming systems using NUCs in agroecology*. DIVINFOOD H2020 Research project, report, 77 p. Zenodo. https://doi.org/10.5281/zenodo.10869858.

farmers involved in on-farm pre-processing share equipment to reduce costs. The only major difference is that many small farms sort Grass-Pea by hand.

Finally, in France, in the 3 living labs regions (LL Bean-Lyon, LL Bean-Cast, LL Cer-Occ), there are various techniques and organisations for crop pre-processing. In the LL Bean-Lyon region, most pre-processing is done collectively, with farmers sharing equipment. However, some techniques are too expensive and challenging for on-farm use, such as optical sorters. In Occitanie, for legumes and cereals, farmers use three options for pre-processing: doing it on-farm, using collective equipment or using the services of a company.

In conclusion, while most farmers in the living labs regions operate in a similar way in terms of pre-processing techniques and organisation, there are some organisational and technical approaches that stand out and could be valuable for implementation in other regions. These solutions, both organisational and technical, have the potential to improve the quality of these processes and simplify the lives of farmers. This would not only rationalise the use of NUCs, but also contribute to their overall development. An innovative solution for cleaning was highlighted by the survey, with two different options depending on the region.

Figure 13. Map of the living labs in DIVINFOOD
(The dots on the map correspond to the players surveyed for the repertoire of farming systems, see Deliverable 3.1)

2.2. An innovative solution: mobile cleaning units in France and Denmark

Among all the DIVINFOOD living labs, one organisational solution stood out from the rest. In France and Denmark, mobile cleaning units are being used to enable farmers to clean their produce and reduce costs at the same time.

In France, the mobile unit is shared by a group of farmers organised in a CUMA (Coopérative d'Utilisation de Matériel Agricole). A CUMA is a French organisation that allows farms to easily share equipment or employees. To join a CUMA, a farmer must subscribe to shares in the CUMA. The equipment belonging to the CUMA is then shared equally between all the farmers. Fees for using the equipment may vary depending on the equipment and the CUMA.

In a CUMA in the French department of Tarn, farmers decided to buy a mobile cleaning unit to share. The initial motivation for this purchase was to enable organic farmers to add value to their produce through on-farm cleaning, while limiting investment costs.

The equipment purchased is a rotary drum sorter, which cost the CUMA €100,000. Around thirty different sized screens are available to the farmers, allowing them to adapt to a wide range of crops. Farmers have to pay €110 per hour to use it. With a grain flow of 3 to 5 tonnes per hour, the cost is between €22 and €37 per tonne.

The data for the mobile cleaning unit in Denmark was collected by ICOEL. The system used is different and involves a company that owns several lorries that drive from farm to farm. They do the following:

- Cleaning of seeds or sowing
- Cleaning of seeds for milling quality
- Milling
- Dehulling of oat
- Sorting of cereals (e.g. wheat for bread and barley for beer)

The company's trucks are equipped with complete processing lines for the different tasks. In addition to the mobile units, the company processes smaller batches on site and works with farmers who grow minor products such as lentils, broad beans and peas for human consumption.

Unlike the French mobile cleaning unit, the Danish grain cleaning and processing unit consists of a sieve separator/cleaner, and not a drum separator/cleaner.

The cleaning unit and the milling unit are on different trucks. The process is:

- Cleaning
    - Screen cleaner / separator
    - Destoner
    - Wheat brush / scourer
    - Cyclonic air separator
- Milling
    - Stone grinder
    - Bolter
- Packing
    - Paperbags of 2, 5 and 10 kg
    - Labels

The costs to use the tools offered by this company vary and depends on:

- The start-up fees
- The hourly rate (from the moment the truck arrives on farm to the moment it leaves)

- Fixed amount per kg of seed (The bigger the quantity the cheaper it is)
- Consumption – e.g. bags

This shows that various initiatives can be implemented to help farmers perform pre-processing steps on the farm without adding too much financial burden. The cost of services can vary greatly depending on when they are carried out, the quantity to pre-process, etc. It is therefore difficult to compare them with private tools that can be owned or shared by farmers. The return on investment also depends on how long you will use the tool and for what quantity of grains. Each case is different and needs to be evaluated.

2.3 Another innovative solution: self-build equipment

The Atelier Paysan is a French self-build cooperative society founded in 2009, located in the Bean-Lyon living lab region but with a wider reach, which supports farmers in the manufacture of agricultural equipment through training courses and open licence plans.

Atelier Paysan's training courses take the form of several-day workshops, during which trainees work together to build a machine that meets their needs. Around 600 trainees took part in workshops in 2020. There is a charge for the courses, but some of the costs may be covered by funds for training living entrepreneurs. Farmers from other regions and countries are also welcome.

The plans for the main machines produced during the courses organised by the Atelier Paysan are published under an open licence and can be accessed free of charge on the Atelier Paysan website: https://www.latelierpaysan.org/.

The Atelier Paysan and its network of self-build farmers are currently developing a dehuller for einkorn. This dehuller gives good results. It can be easily modified to test with other types of grain (buckwheat, sunflower, etc.) and numerous settings are possible to optimise sorting of dehulled grain, broken grain, chaff and dust. The fan is included, but the cyclone must be ordered separately: https://www.latelierpaysan.org/Decortiqueur

Other initiatives may favour equipment self-building, as one identified in Southern Italy, for instance: https://www.salentokm0.com/en/macchine-agricole-no-oil. The DIVINFOOD project could provide an opportunity to identify such innovative solutions in the LL regions/countries, and to establish links between the living labs and the latter to encourage the self-build of equipment for NUCs.

2.4 Case study: the loss of yield during the pre-processing of Einkorn

For Einkorn varieties in the Cer-Occ LL, the harvest of 2023 was sorted to do processing trials and organoleptic evaluations. In the same time a study was conducted to analyse the yield loss during the sorting process.

Sorting was performed using a 3-sieve cleaner/separator followed by an indented cylinder separator, reflecting the techniques and equipment used by some farmers in the Cer-Occ LL. The equipment has different exits, as shown in the Figure 16.

Lighter particles were removed through ventilation, while the grains were passed through three sieves of different sizes. The first sieve separated large impurities over 6 mm, the second retained particles between 2.4 and 6 mm, and particles smaller than 0.9 mm were discarded through the last sieve. Grains between 0,9 and 2.4 mm were sent to the cylinder, where broken grains were removed.

All these categories were weighed and compared to the initial weight to calculate the percentage of yield loss during einkorn sorting. The diagram illustrates the results obtained from the 2023 harvest. On average, 36% of the harvest was lost during the sorting process. However, it is important to note that a significant proportion of the harvest fell into the 2.4 to 6 mm category (19%), which is considered waste, although many bags from this category were still usable and contained viable grains. Some bags had excessive losses due to grains entering the ventilation system.

It should also be acknowledged that the sorting was performed on different varieties, and the parameters used on the machine were the same for all varieties. This may lead to variations in results, as the optimum parameters may be different for certain varieties, potentially causing additional loss.

Therefore, these results are not entirely representative of reality, but they do provide a good indication of the potential loss during sorting. Losses can also be influenced by factors such as the uniformity of the harvest, harvesting methods, the type and adjustment of the equipment used, and the presence of weeds in the harvest. It's important to note that the calculated losses here are only during the sorting step, and that additional losses may occur during the dehulling and storage of einkorn.

The next step in this case study would be to test different sorting techniques to compare them and see which ones are more efficient. It would also be very interesting to try to adapt the machine each time the varieties change. This kind of data is very useful for farmers to have an idea of the average loss during sorting. If another study focuses on different equipment, it would also be interesting for farmers to decide which one they want to use.

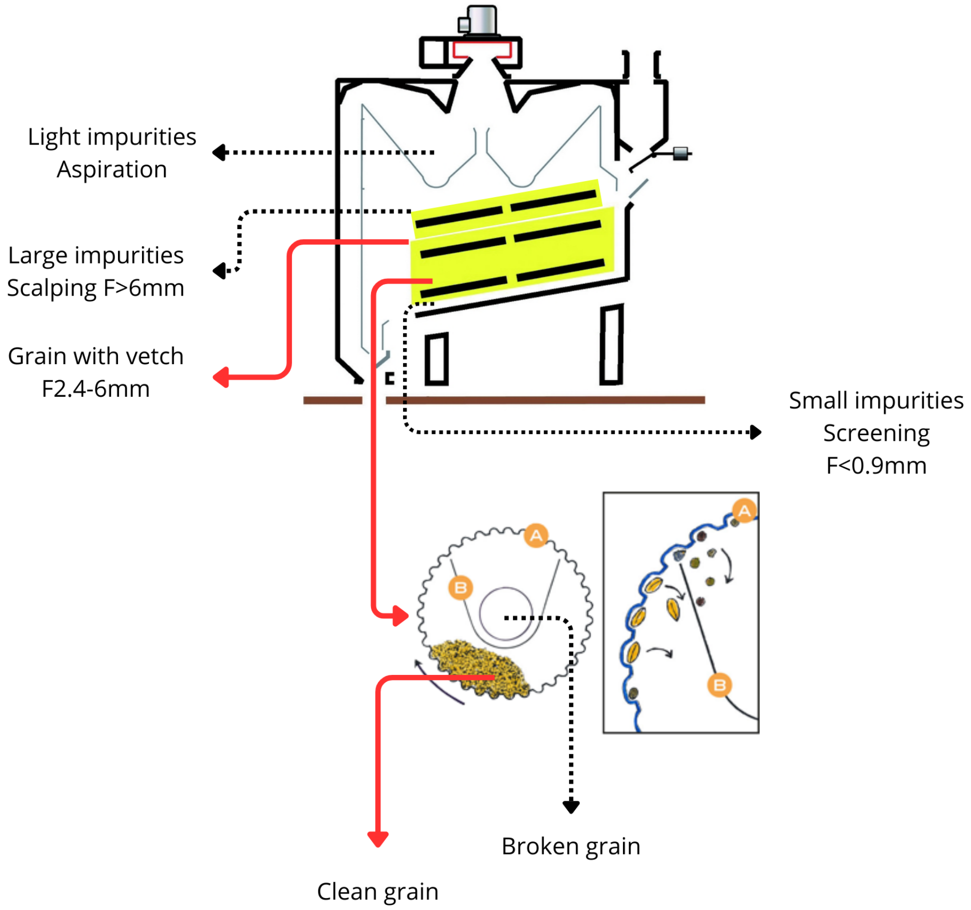

Figure 14. Scheme of the equipment used to analyse losses during einkorn sorting

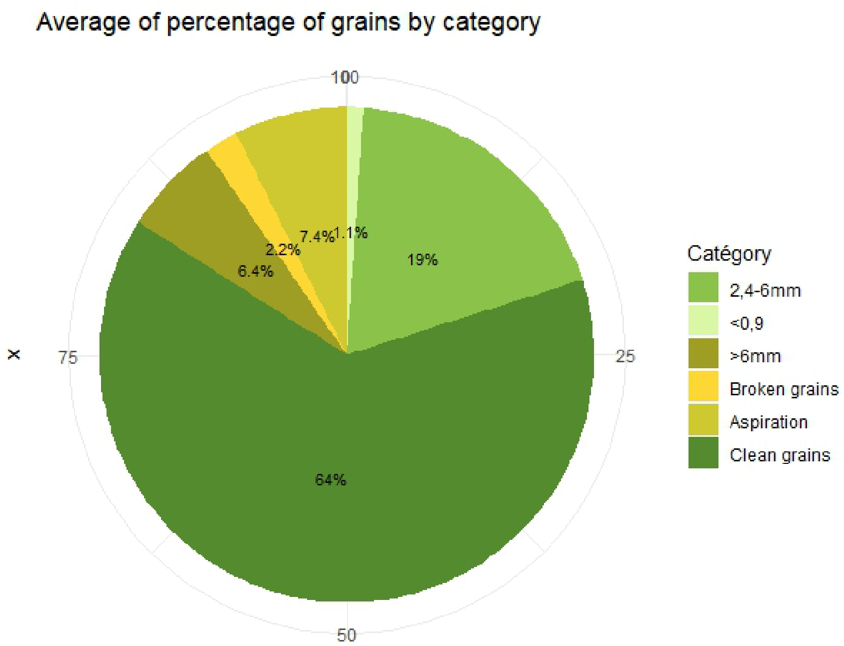

Figure 15. Average percentage of grains by size categories

3. Experimentation of equipment co-development and mutualisation between farmers

3.1 A previous experience of equipment mutualisation in the Cer-Occ Living Lab

In the Occitanie region (southern France), a number of farmers have come together to form a cooperative called SCIC Graines Equitables, which focuses on the production of certified organic cereals, pulses and quality fodder.

Since its creation in 2014 with 7 founders and 1,500 hectares, the cooperative has experienced remarkable growth, expanding to 16 farmers and 3,500 hectares in 2018, and reaching 37 members in 2019. It now has 70 members across the whole of Occitanie.

The cooperative has the capacity to collect and market a diverse range of crops, NUCs and forages, including ancient and modern varieties of wheat, rye, malting and feed barley, einkorn and spelt, buckwheat, yellow millet, oats, meslin, clover, lucerne, sainfoin seeds, vetches, white mustard, sunflower, camelina, hemp seeds, rape, brown and golden linseed, yellow and green peas, lentils, chickpeas and fodder peas. The cooperative also offers cereal mixtures suitable for green manuring vineyards and open fields.

Initially, the crops were cleaned and sorted by a specialist sorting company, then stored in a shed. As the quantities collected increased, the cooperative had to set up a more efficient system. Collectively, it decided to invest in a complete facility for storing, sorting, pre-processing and processing the crops. In 2021, a new sorting and storage facility was inaugurated, giving SCIC Graines Equitables a competitive tool for sorting agro-ecological seeds, meaning that the different mixtures are separated on arrival.

The sorting and storage process uses a combination of the equipment mentioned above. The sorting unit consists of a drum separator, a sieve separator, an indented cylinder sorter, a densitometric table, an optical sorter and a dehuller. For storage, the cooperative has seven 200-tonne units outside and three 400-tonne units inside the building. A unique feature is the storage of seeds in 14 concrete units of 20 tonnes each, converted from an old distillery. These concrete cells were originally used as storage tanks for liquid products and have been adapted to store cereals.

With 70 members today, the facility is operating at full capacity, prompting the founders to plan to double the sorting and storage capacity.

BioCivam 11 contributed to the creation of the SCIC Graines Equitables and actively monitored and supported the sharing of equipment, which was initially planned to be experimented in DIVINFOOD but was completed before the project was launched, thanks to funding and partnership opportunities.

The efficiency of the pre-processing now relies largely on the expertise and knowledge of its employees. The sorting of each crop mixture and each crop requires constant improvement. Each new crop tested requires various trials and tests on the tools in order to guarantee the best possible quality in the end, even if this sometimes takes a long time.

3.2 Co-development of pre-processing equipment mutualisation in the Cer-Occ LL

3.2.1 Co-developing another collective mobile cleaning unit

As explained in section 2.2, a mobile collective cleaning unit was developed prior to the project in the department of Tarn, in the south of France, to be shared by farmers and farmer-processors from the CUMA du Tarn. The attractiveness and key success factors of this organisational solution were assessed through an experiment involving stakeholders from Bean-Cast LL and Cer-Occ LL.

The aims of the experiment were to identify the key success factors for collective organisation around pre-processing, to assess the attractiveness of the mobile cleaning unit, to test the unit on different cereals for cleaning or separating intercrops, and to initiate the same type of collective organisation around another mobile cleaning unit or pre-processing equipment, in other areas of the Cer-Occ LL region and in the Bean-Cast LL.

The first step was to test the transport of the mobile cleaning unit. A crucial success factor for this organisational solution is to enable as many users as possible to use the unit on their own farms. The cleaning unit is mounted on a trailer with a total weight of just under 3.5 tonnes, which is the maximum weight for a trailer considered to be a light vehicle. Designing a unit on a light trailer is the first key to success, as it reduces costs and increases the number of potential users.

Two conditions must be met before it can be transported on public roads:

- A vehicle legally capable of towing a 3.5 tonne trailer, usually a pick-up, van or light truck.
- A driver with a licence to drive a trailer.

For short distances, the unit can be towed by a tractor without a licence if the driver is a member of a farm.

Another option, if the members of the collective are close, is to install the cleaning unit on a farm trailer, which makes for a larger unit, but only tractors can tow these trailers.

A demonstration/test of the mobile cleaning unit took place on 17 October 2022. Farmers were invited to see the mobile cleaning unit in action and to bring their grain to be sorted and observe the results on their own produce.

The experiment was attended by 90 participants, demonstrating considerable success. Six different batches were tested, resulting in the cleaning of almost 5 tonnes of grain. Participants identified the ability to operate the unit on its own as a key success factor, allowing farmers to use it independently on the farm. They also noted that, ideally, two lifts are needed, but that the unit can be operated with just one, bearing in mind that the need to use two lifts could reduce interest in the mobile unit.

In terms of sorting performance, participants rated the quality as sufficient for conservation, farm-saved seed or processing, with the test on batch 4 (pea/triticale) demonstrating the unit's ability to separate intercrops with good quality.

This simple experiment demonstrated that it is possible to share such equipment, and farmers and CUMA managers showed significant interest in this organisational solution, prompting discussions on the subject between farmers and CUMAs in the neighbouring department of Aude.

3.2.2 Experimenting traditional underground storage: Locastock

A second experiment of equipment sharing has been co-developed in the Cer-Occ LL, in connection with another project, about the storage of grains. The aim of the experiment was to co-design local, resilient, and low-carbon pre-processing innovations by valuing ancestral techniques, farmer know-how, and collective intelligence.

The experiment on traditional underground storage has been carried out with the participation of farmers, in the agricultural high school of Carcassonne. The challenge was to try to replicate the techniques traditionally used to store cereal grains and to see if they can be adapted to modern agriculture and environmental conditions. If so, it will allow to use low-carbon techniques to store grains. Similar trials have also been implemented in farms.

These techniques were used during the Middle Ages in Occitanie but they are still used in some parts of the world in Asia and Africa.

The technique is the following:

- An underground hole is dug (capacity around 600 and 800 litres) in the shape of a vase. It is important to dig the silos deep enough to avoid temperature variations that could damage the grain.
- Straw is placed on the walls of the silos to protect the grain, then the grain is placed inside the silo (Figure 16 and Figure 17).
- Closing the silo is a very important step. It's the stage that makes the silo airtight, so that water, moisture and parasites can't get inside. To achieve this, a layer of straw is first placed over the grain, then a mixture of damp earth and dry straw is placed over the straw. This mixture is sprayed over the top of the hole to seal it (Figure 18, Figure 19, Figure 20).

Archaeologist from INRAP (French National institute for preventive archaeological research) have been working on these silos and tested different parameters to try to have the most efficient silos as possible (Figure 21).

The aim of the experiment set up at the agricultural high school of Carcassonne is to see whether the grains will still be of good quality in a few years' time. Several tests are planned to analyse the organoleptic and sanitary quality.

Figure 16. Straw is placed on the wall of the silo

Figure 17. The silo is filled with grains

Figure 18. The grains are covered by a layer of dry straw

Figure 19. A mixture of straw and humid soil is placed above

Figure 20. The silo is sealed

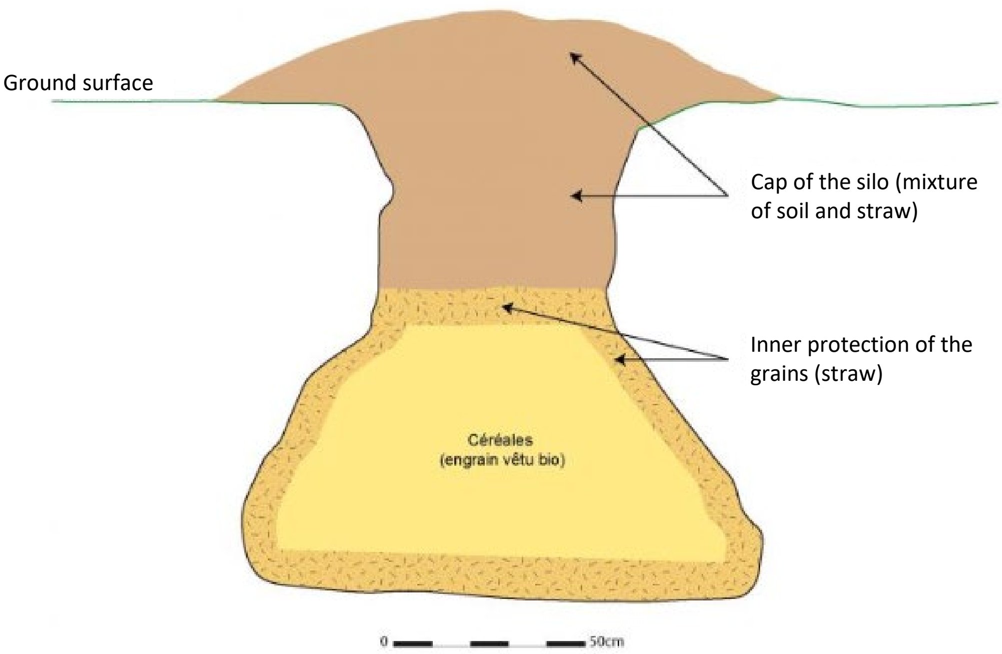

Figure 211. Tranversal view of a silo

3.3 Co-development of pre-processing equipment mutualisation in the Nordic LLs

3.3.1 Co-developing collective solutions

ICOEL worked with a group of Danish producers and processors to identify the challenges they faced in matter of pre-processing. A meeting was held in January 2023, attended by both small and large farmers who were experiencing difficulties in sorting their produce. This meeting enabled the farmers to express their needs in terms of pre-processing in order to find solutions and possibly, experiment with sharing equipment.

The results of this meeting revealed that cleaning lentils was particularly difficult. This crop has only recently been introduced in Denmark, often in small quantities and at the same time as a co-crop. Separating these crops has proved very difficult, especially there is limited expertise in this area in Denmark. In the case of lupins, farmers have to carry out on-farm pre-processing. Companies are reluctant to work with this crop, because of the allergens involved.

Grey peas, on the other hand, do not pose any major problems in terms of pre-processing, so the discussions did not focus much on this crop. Finally, the main difficulty in pre-processing of faba beans is sorting the seeds eaten by bruchids.

Various solutions were discussed by the various stakeholders present. The main solution identified was the use of big bags with drying tubes. This allows easy mixing by simply changing the big bag, and is also suitable for delivery. Some farmers can also use the mobile cleaning unit described in section 2.2, as an indirect way of sharing pre-processing equipment.

Through interviews with experts and farmers, SLU has also gathered information highlighting the difficulties farmers face in sorting and cleaning mixed legumes in the Swedish part of the Nordic LLs. To solve this cleaning and sorting problem, tests will be carried out and shared, using different equipment and grain mixtures (legume-legume or legume-cereal combinations).

3.3.2 Collaborating through and with a food company as an alternative solution

The Nordic LLs illustrates another way for farmers to collaborate, through and with a food company. Nordvara is a key actor in organic legumes trading in the Nordic LLs region. The company works in close collaboration with farmers who produce the grains and can share issues and solutions through and with the company. In DIVINFOOD, Nordvara did experiments on drying, cleaning, and storage to ensure food grade quality. On-farm trials were carried out on ways to prevent pests, moisture, moth, etc. These experiments highlighted that on farm storage and in spaces that are not classified for food safety should only be temporary. They showed the interest, for farmers, to collaborate through and with an experienced food company in matter of pre-processing.

Conclusion

Pre-processing cereals and pulses is a crucial stage in producing quality raw materials. The pre-processing stages can be implemented in different ways, both in technical and organisational terms. It can take place on or off the farm, in cooperatives or in service or food companies. The key to selecting the right techniques and organisations for the farm is to understand its specific needs and assess the optimum solution. The DIVINFOOD survey of farmers and experts showed that small farms with low production levels often tend to carry out pre-processing on site, while larger farms prefer to delegate these tasks due to resource and time constraints. On-farm pre-processing allows farmers to add value to their crops and produce their own seeds for sowing the following year.

Collective solutions are emerging, such as a mobile cleaning unit run jointly by farmers or jointly developed open licence plans for self-build equipment, but there are still many innovations that could improve the activity of NUC farmers and reduce the costs of pre-processing.

The task partners have initiated new projects and initiatives to co-develop and experiment equipment mutualisation between farmers for the pre-processing of NUCs. The conclusion is that farmers are willing, but mutualisation takes time and needs to be well prepared, particularly if it involves employees, who need to be well trained and able to adapt to a diversity of crops. It may also be worthwhile to work with food companies that offer this service, in collaboration with the farmers who supply them with the raw materials.

The experiments have contributed to the development of territorial networks around agrobiodiversity in the LLs involved, by strengthening the relations between farmers and with agricultural high schools, service-providing and food companies as well as with researchers (archaeologists for storage using ancestral techniques, for example).

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