

Dehulled grain legumes for food

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Split pea and red lentil are familiar examples of dehulled grain legumes. They cook faster, have slightly different flavour, and have a higher nutritional value than their whole-seed counterparts. The need for dehulling depends on the intended process and use, so both hulled and dehulled have their place in the market. For food uses, culinary quality is the main determinant of price, and is affected by traits such as the size and shape of the seed, the colour of the seed coat and kernel, the uniformity and purity of the batch, and the flavour of the product. Further traits contribute to the quality for industrial processing, such as ease and uniformity of dehulling and splitting, energy input for milling to flour, water uptake during cooking along with texture and viscosity after cooking, and of course flavour. Dehulling beans is a form of value-adding processing. This practice notes is focussed on grain legumes destined for the food market and demonstrates dehulling using faba bean as an example. Dehulling is

a simple process that involves removing the seed coat (testa) and splitting the cotyledons. Dehulling is usually part of a larger post-harvest line that also includes procedures such as cleaning and sorting.

Goal of dehulling

Is there a customer requirement for dehulling? Is there a strong market for dehulled seeds for food products and processing? If the answer is yes to any of the questions, then dehulling is something to consider.

The main processing goal is to remove the seedcoat or 'hull' of the grain legume seed. The dehulled seeds usually split into two, each half being a whole cotyledon or seed-leaf, and the product is often called "splits". The splits are an attractive yellow, green or red, depending on the cultivar and its pigments. The hulls are 90% lignocellulose, i.e., insoluble dietary fibre, but the



Figure 1. Dehulled and split faba beans. Photograph: Casimir Schauman





Figure 2. Cleaned and size sorted faba beans fed into silo. Photograph: Casimir Schauman

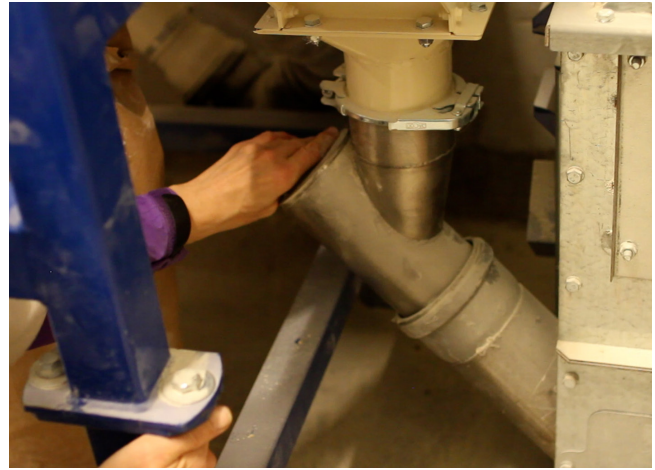


Figure 3. Magnet to remove metal debris. Photograph: Casimir Schauman

cotyledons have plenty of dietary fibre so the loss is not important in the food chain. The other important component of the hulls is tannins that have both positive and negative effects on the product. Tannins are useful antioxidants in the human diet and they add a distinctive flavour, but they are coloured, so they are not desirable in many wet processes, such as protein isolation or making tofu, where additional colours and flavours should be minimized. They cross-link with raw proteins and precipitate them, which is also enabled in a wet process. In a dry milling process such as flour production or dry fractionation, the hull particles form dark flecks in the light-coloured mass of flour.

Dehulled beans have a higher protein content than whole beans because of the low protein content of the hull.

The hull slows water intake into the intact seed, so a dehulled seed cooks more quickly. The hull keeps the seed in shape during cooking, whereas a dehulled split easily becomes a puree: both

are desirable depending on circumstances. Dehulling usually takes a small portion of the cotyledons with the hulls. The value of the fraction is, however, low and its particles are often dust-sized so its use is restricted.

The dehulling technique

Traditional dehulling methods involve thorough drying of the seeds. This is followed by rubbing or pounding with a simple mortar and pestle. In larger commercial units, abrasion is applied, using emery-coated rollers made from silicon carbide. Millstones are typically made of two burrstones with furrows or grooves. The gap between the stones is adjusted to remove the hull with minimal damage to the cotyledons. Uniformity of seed size is clearly important. The brittleness of the seeds needs to be taken into consideration as seed breakage is an issue regardless of the machinery used.

Newly harvested beans are harder to process if their moisture content is high. Drying to a

Table 1. Composition of whole and dehulled faba bean on a dry weight basis. Starred differences are statistically significant.

Samples	Protein	Fat %	Ash %	Carbohydrate %	Energy MJ/kg	Insoluble fibre %	Soluble fibre %	Total fibre %
Faba bean whole	31.2	2.1	3.4	63.3	16.85	22.7	2.0	24.7
faba bean dehulled & ground	35.5*	2.1	4.0*	58.5*	16.73	8.9*	1.3	10.2*

Note. Adapted from Mattila, P., Mäkinen, S., Eurola, M., Jalava, T., Pihlavan J-M., Hellström, J., Pihlanto, A., 2018. Nutritional Value of Commercial Protein-Rich Plant Products. *Plant Foods for Human Nutrition* 73, p. 110. CC BY 4.0.

moisture content under 14%, often around 12%, is usually needed before dehulling. Large seeds are often more economic to dehull than small ones because their lower surface to volume ratio means that losses are lower. This is considered good for the process as the machine adjustments can be kept the same. Shrivelled seeds do not dehull well because the wrinkles prevent removal of many parts of the hull. Other factors that make the cotyledons soft or fragile, such as altered starch composition, will make dehulling difficult. Ease of dehulling is an objective in several grain legume breeding programmes around the world, particularly for lentil, pea and chickpea. When the hull is firmly attached to the cotyledons, dehulling can be a time-consuming process.

Dehulling creates by-products such as seed coats, small particles and broken bits of legumes. These can be sold to livestock farmers or feed compounding companies. More recently, a small demand for faba bean seed coats has developed in the pet food industry.



Figure 4. Elevator and dust build up. Overall the entire process produces a lot of fine dust. Photograph: Casimir Schauman

The Arolan Tila processing plant in Finland

The Arola farm in southern Finland specializes in gluten-free and organic crop production. In addition, the farm operates a dehulling line for food-grade legumes.

This automated processing line, with sorting and dehulling stages, can process large quantities and achieve consistently high quality. The technology

Table 2. Processing stages

Operation	Process activity
Intake	Large container bags of 750 kg of whole beans are picked up with a forklift and poured into a small silo (Figure 2).
Destoning, initial cleaning	The beans are elevated into a destoning machine that removes the heavier material using density separation, discharging any stones into a separate chute. This step achieves a good level of a clean product before dehulling.
Dehulling	The beans are lifted into a dehulling machine that uses a cylindrical motion to rub the beans against the outer wall (made of stone) and grooves, splitting the seed and removing the hull. An integrated aspiration tunnel removes light impurities.
Air cleaning	About 95-97% of the light debris, such as flour and hulls, is separated by airflow and gravity using aspiration tunnels powered by a 4 kW motor. Cleaning light impurities by aspiration is integrated into the cleaning, peeling and sorting machine.
Sorting	A machine with two vibrating sieves helps to remove coarse impurities of different sizes. The splits pass through the upper sieve to the lower sieve. Small impurities such as fragments (2.5-3.5 mm in size) fall through the lower sieve, leaving the splits to pass through an integrated aspiration tunnel that removes light debris and a magnet that removes any metal debris (Figure 3). Unsuccessfully processed (unshelled or unsplit) beans are re-directed back into the peeler. This usually represents about 20% of the beans at this stage.
Final cleaning	The clean beans are elevated to the final cleaning step by a low-speed elevator with plastic cups. The remaining 1-3% impurities are removed by a final sorting machine. After this the splits are elevated into a raised square silo ready for bagging or colour sorting.
Colour sorting (optional)	To further increase the quality of the end product, colour sorting can be applied at the end, adding value by improving colour uniformity.
Packaging	The end product is a batch of faba bean splits (yellowish in colour) of uniform and pure quality (Figure 1). These are stored in big bags that are ready for delivery.



Figure 5. The processing line. Photograph: Casimir Schauman

removes impurities, stones and metal debris before dehulling and splitting of the beans.

First, the seeds are cleaned of debris, sieved to include seed sizes of 6 mm–10 mm, and poured into 750 kg container bags. Seeds that are too small or too large are not suitable for processing, mainly due to equipment limitations, and can be sent for livestock feed. The cleaned beans of the correct size are then put through the processing stages described in table 2.

Four machines are used to process the beans into clean splits. The colour sorter removes green, half-green or darkened cotyledons, which could be useful in the event of a poor quality harvest. Nevertheless, a colour sorter adds significantly to the capital cost. It is also possible to have fewer machines - one machine could do the job sufficiently but this increases the chances for impurities in the batch. The removal of dust or flour is an important part of improving the visual quality of the end product.

The processing capacity of this unit is roughly 5,000-6,000 kg a day. Cleaning the machinery between cultivars or species normally takes 3-4 hours. There is a wide range of machines on the market with varying dehulling capacities, with some having outputs as high as 6,000-10,000 kg per hour.

Storing the dehulled product

The dehulled beans are stored in bulk containers (big bags). Processing is done on order, so storage time is minimized. This reduces the exposure to air which starts a process of oxidation that reduces the shelf life of the splits.

Logistics

The beans are normally placed in flexible intermediate bulk containers - big bags (approved for food purposes) of approximately 750 kg or 1000 litres of material and transported on euro-pallets. Bagging systems can be flexible and are closely linked to customer requirements, as some consignments prefer sealed paper bags, e.g., canteens.

Key practice points

- Dehulled beans are used in the food and feed industry.
- Drying before dehulling improves results.
- Sorting and dehulling with specialized machinery saves time and ensures a good quality end-product.
- Processing on order reduces storage time and reduces risks of spoilage from oxidation.

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