Wheat debranning: industrial applications on durum wheat

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Presentation summary

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Debranning principle

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The debranning equipment

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Wheat’s structure

It contains the plant embryo, and thus provides the potential for the development of the kernel into a new plant.

This serves to protect the grain from its environment, including weather, insects, moulds, bacteria and other predators. It is the outer portion of the kernel that contains a large percentage of many functional, biological and active compounds.

Endosperm 82-85%

Bran 13-15%

Germ 2-3%

It is the most uniform of the three grain’s parts. It primarily contains a single cell type specialized in the starch storage.
Cereals debranning

The debranning is a well known technology, traditionally used in the transformation process of some hulled cereals (i.e. rice, barley, oat, spelt).

Based on the intensity of action applied is possible to detach only the external hulls from the grain's surface (i.e. dehulling) or to remove the outer layers of the kernel coat (i.e. pearling, peeling) up to uncover the endosperm (i.e. white rice, naked oat, pearled barley).
Debranning principle

During the process, two are the main effects acting on the kernel structure:

- The **friction** (kernel to kernel) – the movement of the grain through the machine structure causes the kernels to rub against each other;
- The **abrasion** (kernel to rough surface) – the tissues' removal is due to the kernel's contact with the abrasive parts/device of the machine.

The **friction** manly removes the outer kernel's layers (i.e. **pericarp**) while the **abrasion** the inner ones (i.e. **aleurone**).

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The debrannig of wheat is worked out by suitable equipments mainly derived from a modified rice polisher.

The debranning of wheat is a pre-milling treatment that allows a controlled and progressive removal of the grain's layers.

The success of the transfer of the debranning technology on durum wheat processing is due to the improvement on the debranning equipments and on the process:

- increase of the debranning machines models available on the market
- improvement on the efficiency of the abrasive material (effectiveness and endurance)
- improvement on the mechanical technologies
- reduction in the energy consumption
### Preliminary steps on wheat debranning - 2

<table>
<thead>
<tr>
<th>Year</th>
<th>Company</th>
<th>Process</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988 - 1995</td>
<td>Tkac &amp; Timm Enterprises Ltd.</td>
<td>Trigo Tec</td>
<td>The friction steps (# 2) followed by the abrasion ones (# 2). Bran removal ≈ 12 % (*)</td>
</tr>
<tr>
<td>1992 - 1993</td>
<td>ConAgra Inc.</td>
<td>Pearling</td>
<td>Two abrasion steps. Bran removal = 6 - 10 % (*)</td>
</tr>
<tr>
<td>1995 - 1998</td>
<td>Satake Corporation</td>
<td>PeniTec</td>
<td>First the abrasion (# 1) then the friction (# 1). Bran removal ≈ 10 % (*)</td>
</tr>
<tr>
<td>1995</td>
<td>Barilla Research Centre on durum wheat</td>
<td>Peeling + Pearling</td>
<td>Three abrasion steps. Bran removal = 10 - 12 % (*) Specifically for durum wheat</td>
</tr>
<tr>
<td>2005</td>
<td>Buhler A.G.</td>
<td>Peeling</td>
<td>Only friction. Bran removal = 4 % (*)</td>
</tr>
</tbody>
</table>


* = as % of grain by weight
Debranning approach on the durum wheat milling - 1

One of the main targets of the milling transformation is to maximize the separation of the starchy endosperm (semolina) from the other components, the bran and the germ (refinement).

**CONVENTIONAL**

- Breaking (roller mills)
- Separation according to size (plansichter)
- Cleaning of semolina

On the conventional milling, the grain is at first broken, the endosperm is gradually divided from bran and germ through a series of grindings with intermediate steps of separation by sifters and purifiers. The milling co-products like the bran and the germ are separated over the milling process.
Debranning approach on the durum wheat milling - 2

The debranning becomes the first step, before the B1 grinding. The almost part of the bran and of the germ is removed \textit{in advance} and only a residual amount - the bran located in the kernel's crease - will be separated during the following conventional milling steps.

The wheat debranning produces a significant modification in the physical composition of the grain before the milling; therefore the flow chart needs to be adapted to better exploit the benefits of this technology.
The progressive bran removal

As well reported by several tests and applications, the debranning can be applied in one or in multiple steps (i.e., sequence), with a degree of intensity ranging from 6% to 12% of the grain weight.

“Open Fields srl” advises a debranning application designed in 3 sequential steps:

<table>
<thead>
<tr>
<th>Step</th>
<th>Action Description</th>
<th>Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>first</td>
<td>the 2 - 3% of kernel weight is removed</td>
<td>1st</td>
</tr>
<tr>
<td>second</td>
<td>the 3 - 4% of kernel weight is removed</td>
<td>2nd</td>
</tr>
<tr>
<td>third</td>
<td>the 3 - 5% of kernel weight is removed</td>
<td>3rd</td>
</tr>
</tbody>
</table>

The bran layers are gradually taken off, reducing the risk to damage the endosperm (i.e. starch loss into the debranning fractions) until a total bran removal that can reach 12%.
The debranning equipment

In the durum wheat chain the debranning machine use may be recommended both for small and high capacity plants. Furthermore, this technology can be applied both in existing mills and new plants.

Durum wheat debranning equipment usually has a vertical configuration.

The main components are:
- the rotor
- the screen
- the wheat flow restrictors
- the fan
- the wheat feeder / unloader system
The rotor
The rotor, vertically placed in the middle of the debranner, is made by 6-8 abrasive rolls (grindstones), the first of which is beveled in order to ease the wheat flow entrance of the product and it is fastened onto supports containing bearings. The rotor’s motion (rotation) needs a 55 kW engine.

The screen
The rotor is surrender by a cylindrical screen slotted with of 0.6/1.2 x 20 mm holes size. The wheat is forced to move within the narrow space set by the abrasive rolls’ edge and the screen surface. The bran fractions formed by the abrasion/friction process are aspirated from the wheat mass through the screen’s holes.

The flow restrictors
Within the machine, there are two vertical adjustable bars, symmetrically placed to the rotor, in order to guarantee the control of the wheat refill.
The fan
In order to guarantee the cleaning of the perforated screening and the removal of the bran particles from the mass of wheat, an air flow is blown through an external fan and then drawn by the central aspirating stream.

The feeder / unloader system
The debranning intensity is also a consequence of the permanence of the kernels into the machine; this span of time can be set by a regulation loop through the amperage of the electric engine. Everything is handled by a PLC that could be placed on board of the machine, or by a PLC managed by the operators in the control room. Once defined the power absorption target (i.e. related to the debranning level needed to achieve the standard ash content in the semolina), the wheat unloading is adjusted through a shutter. The control of the shutter’s opening/closing state changes according to the set absorption.
Debranning Pros

- Increase of the milling yield. Depending on the starting yield, growth of 2-8% has been recorded according to the ashes in the finished product.
- Simplification of milling process (shorter flow mill compared to the conventional one) that is:
  - new mill → lower capital investment and more compact plant
  - existing mill → increase of the production capacity (more than 20% from the wheat silos)
- Thanks to a lowest quantity of bran in the milling phase, there's lower wear of the roll corrugation.

Economics

- Holding time reduction after the wheat conditioning
- Breaking rolls units reduction
- Better usage of the overall sifting capacity
- Removal of moulds/crusts in plansichter channels (B4, B5, B6)
- Thanks to the bran separation occurred in the cleaning phase, the milling process turns out to be more uniform (constant) and less susceptible to the atmospheric influences, reducing the mill’s stops.

Process

- Ash and bran specks reduction
- Protein increase
- Yellow colour increase
- Enzymes activity (α-amylase) decrease and reduction of susceptibility to heat damage (i.e. furosine) during the pasta drying cycle

Products quality

- Semolina:
  - Ash and bran specks reduction
  - Protein increase
  - Yellow colour increase
  - Enzymes activity (α-amylase) decrease and reduction of susceptibility to heat damage (i.e. furosine) during the pasta drying cycle

- Debrann. fractions:
  - High value added co-products (physicochemical and nutritional properties) as base of novel food ingredients

Food Safety

- Reduction on:
  - Chemicals residues
  - Mycotoxins (DON ≈ approx - 50%)
  - Heavy Metals (Pb, Hg ≈ until - 90%)
  - Bacteria and moulds contamination (= approx- 50%)
  - Insect fragments and impurities (Filth test)
Debranning Cons

**Economics**
- Capital investment increase
- Higher energy consumption
- Higher maintenance costs because of millstones (once every 1.0-1.5 years) and screenings (around 4/6 months) substitution
- The stop of the plant in order to modify the milling diagram (around 15-20 days) during the debranning machines setting up.

**Process**
- Increase of the number of machines between the cleaning and the milling phases
Estimation of the incidence of debranning technology in the Italian durum wheat mills (Sept. 2011)

- Mills with debranning with daily capacity > 200 t
- Mills with debranning with daily capacity < 200 t
### Durum wheat mills Italy on 2009. Estimation of debranning implementation and impact on 2011

<table>
<thead>
<tr>
<th>MILL CATEGORIES based on daily capacity</th>
<th>Nr.</th>
<th>%</th>
<th>DAILY CAPACITY (t)</th>
<th>%</th>
<th>MILL ADOPTING DEBRANNING (Nr)</th>
<th>% on total mills</th>
<th>DAILY CAPACITY (t)</th>
<th>% on total daily capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 t</td>
<td>35</td>
<td>26</td>
<td>15504</td>
<td>77</td>
<td>31</td>
<td>23</td>
<td>12870</td>
<td>83</td>
</tr>
<tr>
<td>&gt; 100 – 200 t</td>
<td>16</td>
<td>12</td>
<td>2482</td>
<td>12</td>
<td>4</td>
<td>3</td>
<td>650</td>
<td>26</td>
</tr>
<tr>
<td>&gt; 50 – 100 t</td>
<td>11</td>
<td>8</td>
<td>820</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>10 – 50 t</td>
<td>71</td>
<td>54</td>
<td>1444</td>
<td>7</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>TOTAL</td>
<td>133</td>
<td>100</td>
<td>20250</td>
<td>100</td>
<td>35</td>
<td>26</td>
<td>1320</td>
<td>67</td>
</tr>
</tbody>
</table>

Adapted from ITALMOPA statistics

After ten years of the first industrial implementation in a Barilla mill (2001), almost 70% of the durum wheat milled in Italy is currently processed with debranning technology.
Companies producing debranning machinery adopted by the Italian durum wheat mills

<table>
<thead>
<tr>
<th>COMPANY</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buhler</td>
<td>Switzerland</td>
</tr>
<tr>
<td>Delfino &amp; Giancaspro</td>
<td>Italy</td>
</tr>
<tr>
<td>Ocrim</td>
<td>Italy</td>
</tr>
<tr>
<td>Satake Europe</td>
<td>UK</td>
</tr>
<tr>
<td>Tae</td>
<td>Italy</td>
</tr>
<tr>
<td>Loporcaro</td>
<td>Italy</td>
</tr>
<tr>
<td>Schule</td>
<td>Germany</td>
</tr>
</tbody>
</table>

= Companies with the higher # of debranning machinery installed
References


Satake 1990. Debranning process is new approach to wheat milling. World grain 8(6), 28-31.


THANKS FOR YOUR ATTENTION