FE 401 FOOD TECHNOLOGY

LEGUMES/PULSES PROCESSING TECHNOLOGY

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LEGUMES X CEREALS

• Legumes absorb Nitrogen (fertilizer) from air, and release to soil ➔ Lentils, soybean, peanut

• Cereals absorb nitrogen from soil ➔ Wheat, corn, rice
Legumes X Pulses

===

Legumes: Botanic names only legumes plants
(Legumes → originally vegetable)
Pulses (commercial term, contains some cereals and legumes:Bakliyat)
## COMMON LEGUMES AND THEIR SCIENTIFIC NAMES

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peanut, ground-nut</td>
<td>Arachis hypogaea</td>
</tr>
<tr>
<td>Redgram, arhar</td>
<td>Cajanus cajan</td>
</tr>
<tr>
<td>Pigeon pea, yellow dhal, congo pea</td>
<td>Cajanus indicus</td>
</tr>
<tr>
<td>Chickpea, Bengal gram, garbanzo</td>
<td>Cicer arietinum</td>
</tr>
<tr>
<td>Horse gram</td>
<td>Dolichos biflorus</td>
</tr>
<tr>
<td>Lentil, masur dhal</td>
<td>Lens esculenta</td>
</tr>
<tr>
<td></td>
<td>Lens culinaris</td>
</tr>
<tr>
<td></td>
<td>Ervum lens</td>
</tr>
<tr>
<td>Broad bean, Windsor bean</td>
<td>Faba vulgaris</td>
</tr>
<tr>
<td>Soybean</td>
<td>Glycine hispida</td>
</tr>
<tr>
<td></td>
<td>Glycine max</td>
</tr>
<tr>
<td></td>
<td>Glycine soja</td>
</tr>
<tr>
<td>Lupin</td>
<td>Lupinus SPP</td>
</tr>
<tr>
<td>--------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Velvet bean</td>
<td>Mucuna pruriens</td>
</tr>
<tr>
<td>Mung bean, green gram,</td>
<td>Phaseolus aureus golden gram</td>
</tr>
<tr>
<td></td>
<td>Phaseolus radiatus</td>
</tr>
<tr>
<td></td>
<td>Vigna radiate</td>
</tr>
<tr>
<td>Lima bean</td>
<td>Phaseolus lunatus</td>
</tr>
<tr>
<td>Black gram, urd, mungo bean</td>
<td>Phaseolus mungo</td>
</tr>
<tr>
<td>Kidney bean, navy bean, pinto bean,</td>
<td></td>
</tr>
<tr>
<td>haricot bean, snap bean</td>
<td>Phaseolus vulgaris</td>
</tr>
<tr>
<td>Pea</td>
<td>Pisum sativum</td>
</tr>
<tr>
<td>Winged bean</td>
<td>Tetragonolobus purpureus</td>
</tr>
</tbody>
</table>
Adzuki bean, azuki bean, Adanka bean, danka bean (Vigna angularis, syn.: *Phaseolus angularis*)

Broad bean, fava bean, fava bean, bell bean, field bean, tic bean (*Vicia faba*)
(large-seeded broadbeans, windsorbeans- *V. faba* var. major)
(horsebeans- *V. faba*) var. major)
(small, round-oval seeded tickbean, pigeon bean- *V. faba* var. minor)
Vetch, common vetch (*Vicia sativa*)

Common bean, common field bean, kidney bean, navy, habichuela, snap bean (*Phaseolus vulgaris*)

Chick pea, Bengal gram, calvance pea, chestnut bean, chich, chich-pea, dwarf pea, garavance, garbanza, garbanzo bean, garbanzos, gram, gram pea, homes, hamaz, nohub, lablabi, shimbra, yellow gram (*Cicer arietinum*)
Cowpea, asparagus bean, black eyed pea, black eyed bean, crowder pea, field pea, southern pea, frijole, lobhia, kibal, nieve, paayap (*Vigna unguiculata*, syn.: *Vigna sinensis*)

Guar bean, cluster bean, gawaar, gwaar ki phalli (*Cyamopsis tetragonoloba*)

Hyacinth bean, bonavist, bataw, lablab (*Dolichos lablab*)

Lentil, black lentil, brown lentil, green lentil, green mungbean, large-seeded lentil, red mungbean, small-seeded lentil, wild lentil, yellow lentil, adas, mercimek, messer, masser, heramame (*Lens culinaris*)

Lima bean, butter bean, patani (*Phaseolus lunatus*)
Top World Producers of Some Grain Legumes, 2008 (FAOSTAT, 2010):

Beans, dry- Brazil
Broad beans, horse beans, dry- China
Chick peas- India
Cowpeas, dry- Nigeria
Lentils- Canada
Lupins- Chile
Peanuts (groundnut), with shell- China
Peas, dry- Canada
Pigeon peas- India
Soybeans- USA
Vetches- Ethiopia
Ash content analysis = Shows BRAN content (bran contains high amount of mineral (inorganic material))

Unsoluble ASH in 10% HCl sol’n: Shows silisium (sand, soil, stone) dirtiness of product (silisium is not soluble in HCl)

Bulk density $\uparrow$ (hectoliter-weight) = Shows kernel size $\uparrow$ (bran content $\downarrow$, yield $\downarrow$)
## Energy and Chemical Constituents in Food Legumes

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Energy (kj/100 g)</th>
<th>Protein*</th>
<th>Lipid</th>
<th>Starch</th>
<th>Sugars</th>
<th>Ash</th>
<th>Total Dietary Fiber</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proteinaceous Oilseeds</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peanut</td>
<td>2255</td>
<td>28</td>
<td>53</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>8</td>
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<tr>
<td>Soybean</td>
<td>1695</td>
<td>39</td>
<td>20</td>
<td>2</td>
<td>8</td>
<td>5</td>
<td>22</td>
</tr>
<tr>
<td>Lupin</td>
<td>1565</td>
<td>38</td>
<td>10</td>
<td>2</td>
<td>10</td>
<td>4</td>
<td>33</td>
</tr>
<tr>
<td><strong>Starchy Pulses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common bean</td>
<td>1468</td>
<td>24</td>
<td>2</td>
<td>42</td>
<td>5</td>
<td>4</td>
<td>21</td>
</tr>
<tr>
<td>Dry pea</td>
<td>1418</td>
<td>20</td>
<td>1</td>
<td>52</td>
<td>5</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>Chickpea</td>
<td>1520</td>
<td>19</td>
<td>6</td>
<td>50</td>
<td>7</td>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td>Faba bean</td>
<td>1430</td>
<td>28</td>
<td>2</td>
<td>45</td>
<td>4</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>Lentil</td>
<td>1442</td>
<td>24</td>
<td>1</td>
<td>52</td>
<td>6</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>Pigeon pea</td>
<td>1443</td>
<td>21</td>
<td>2</td>
<td>46</td>
<td>6</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td>Cowpea</td>
<td>1442</td>
<td>24</td>
<td>1</td>
<td>47</td>
<td>7</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>Mung bean</td>
<td>1445</td>
<td>25</td>
<td>1</td>
<td>47</td>
<td>4</td>
<td>4</td>
<td>23</td>
</tr>
<tr>
<td>Lima bean</td>
<td>1420</td>
<td>21</td>
<td>1</td>
<td>43</td>
<td>5</td>
<td>5</td>
<td>23</td>
</tr>
</tbody>
</table>

* N x 5.7.
Intestinal gas problem (Sugar)

Food legumes in general contain significant concentrations of free sugars (4–12%) (Table 18.2), which are composed of about 40% disaccharides (sucrose mainly) and 60% α-galactosides (raffinose, stachyose, and verbascose) (13). The latter group represents a problem for consumers since the human digestive system lacks the enzyme α-galactosidase. Thus this raffinose family of oligosaccharides passes into the large intestine where sugars are fermented anaerobically to produce gas.
Hardness (Hard cooking)

The hulls of pulses contain about 50% cellulose, 20% hemi-cellulose, 20% pectin-like and water-soluble carbohydrates, and 2–12% lignin, condensed tannins, and procyanidin. The hydroxyl groups of the latter compounds form cross-links with proteins to cause seed hardening during storage and decreased protein digestibility during cooking (5).
Safe storage condition

- m.c. <13%
- R.H.: <70%
- T<25 C
- Dry
- Prevent inside heat generation due to biological activity (kızışma), m.o., insect etc.
Processing

Legumes go through several primary processes-

1) Bean-Chickpea etc.

1- Pre-cleaning (sieving, destoner, foreign seed removing, sorting, dust removing)

2- Calibration

3- Packaging
EQUIPMENT

Cleaning screen (Posta eleği)

Triör-Intented cylinder
(to separate broken kernel and foreign seed)

Calibration screen

Destoner

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2) Dehulled/Splitted (lentils, soybean, pea etc.)

- hulling (husking),
- puffing,
- grinding,
- splitting, etc.-before they are used in different food preparations.
Conventional pulse milling
Wet pulse milling

Figure 1. Flow Chart of Wet Milling Grain Legumes
Dry pulse milling

Figure 2. Flow Chart of Dry Milling Process
Explaination of process steps for pulse milling

<table>
<thead>
<tr>
<th>Cleaning and grading</th>
<th>Raw pulses are cleaned by removing dust, dirt, foreign material, off-sized, immature and infested grains and graded. The dockage varies 2-5 percent. It depends on crop, season, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitting</td>
<td>Whole pulse grains after cleaning are passed through abrasive roller machine for scratching of seed coat to facilitate the entry of oil/water in the grain during pre-milling treatment. Two to 5 percent grain get de-husked during pitting</td>
</tr>
<tr>
<td>Oil and water treatment</td>
<td>Edible oil is applied to difficult to mill pulses for loosening of husk. The quantity of oil used varies from mill to mill and State to State and depends mainly on the type and size of the grains, variety, moisture content, etc. It is estimated that about seven million mt of pulses require oil treatment. The quantity of oil used is estimated to be 21,000 mt (300 gm/100 kg) worth Rs.630 million or US$14 million. Though a major part of this oil forms an edible portion of the product the actual oil consumption is not affected. Hence, saving of such oil by process modification/development is the only answer.</td>
</tr>
<tr>
<td>Water treatment, which varies with crop and place, is given to grains to achieve expansion for loosening of husk through drying when cotyledons shrink in size. More the water applied, longer would be the process/drying time and more energy requirement for drying. Some millers apply water and oil simultaneously. This reduces the total processing time.</td>
<td></td>
</tr>
<tr>
<td>Process</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Tempering</td>
<td>Treated grains are heaped and covered and left for 12-18 hours. It helps in penetration of oil/water into the cotyledons after oil/water mixing and equilibration of grain temperature after drying in the sun. At some places, wooden/cement tanks are used for tempering the treated grains.</td>
</tr>
<tr>
<td>Drying</td>
<td>Normally sun-drying is followed. Drying period varies from one day to five days depending upon weather conditions. Some dhal mills are equipped with dryers for continuous operation of the mill especially in the rainy season and/or unfavorable weather conditions.</td>
</tr>
<tr>
<td>De-husking and splitting</td>
<td>De-husking of pulse grains is a preparatory operation for splitting. In case of pulses (green gram, black gram, cowpea) having thin seed coat, there is a tendency to split them before de-husking. This needs many passes for complete de-husking and adds to breakage. De-husking is preferably achieved by subjecting the grains to abrasive force and splitting by attrition and/or impact. Generally 3-9 passes are required for milling of different pulses and this depends on the type of pulse crop, pre-milling treatment, grain size, variety, etc.</td>
</tr>
<tr>
<td>Process</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Husk separation and grading</td>
<td>Husk is separated with aspirator and sold as livestock feed. Some find broken go along with the husk and if separated, can yield extra quantity of dhal for human consumption. Grading adds to the quality of the product.</td>
</tr>
<tr>
<td>Polishing</td>
<td>Splits (cotyledons)/dhal and some of the pulse grains, namely black gram, green gram, lentil, and peas are polished to add luster and shine to the product. Dhal is polished in different ways such as nylon polish, oil/water polish, color polish, etc. Some consumers prefer unpolished dhal.</td>
</tr>
</tbody>
</table>
Processing for germination pulses (Pulse sprouts)

1. Bean
2. Clean and wash
3. Soak in water for six hours
4. Toss
5. Prepare germination box
6. Spread the soaked bean inside
7. Water it (three hours/day for three days), Scoop off the top layer and wash
8. Harvest
9. Bean sprouts

Figure 2. Processing of Bean Sprouts
Processing of Peanut (Groundnut)

Figure 5 Groundnut product system.

Groundnut plant

- grain (with shell)
  - direct human consumption
  - direct use as feed
  - industrial processing

- plant stem
  - fodder
  - other (not known)

(expeller process)

- oil
- oil cake

(solvent extraction)

- oil
- cake for feed

wastage (in the form of shell)

(uses not known)
Processing of Peanut butter

1. Bean (without coat)
2. Roast for one hour
3. Cool down
4. Remove the thin layer using “testa remover”
5. Chop coarsely using “disc mill”
6. Blend thoroughly using “colloid mill”
7. Shift to the container
8. Stir
9. Peanut butter
10. Fill in bottle and close
11. Keep at temperature 10°C for one hour
12. Label
13. Keep at room temperature

Salt and glycercyl monostearate
Oil – “palm stearin”

Figure 5. Processing of Peanut Butter
Processing of red lentils

Cleaning (sieving+destoning+aspiration etc.)

→ water addition (tempering) → dehulling or/and splitting → others
### Table 28. Soybean Food Potential and Options – Technology and the Products

<table>
<thead>
<tr>
<th>Soybean Form Used</th>
<th>Technology</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole soybean (direct use)</td>
<td>Separation, soaking, blanching, boiling, drying, size reduction, fermentation, extrusion, packaging, storage and marketing.</td>
<td>Full-fat soy flour, milk, paneer (tofu) curd, ice-cream, <em>tempeh</em>, sauce, sprouted and roasted snack, extruded snack foods, soy-fortified bakery and fermented foods.</td>
</tr>
<tr>
<td>Partially defatted soybean (oil and cake)</td>
<td>Mechanical expression, physical refining, enzyme, cooking, size reduction, packaging, storage and marketing.</td>
<td>Oil, margarine, medium fat soy flour, bakery foods, aqua and animal feeds.</td>
</tr>
<tr>
<td>Fully defatted soybean (oil and meal)</td>
<td>Solvent extraction, refining, hydrogenation, size reduction, separation and concentration, packaging, storage and marketing.</td>
<td>Oil, <em>vanaspati</em>, soy meal, defatted soy flour, lecithin, soy protein concentrate, isolates and hydrolysates, specialty and health foods.</td>
</tr>
<tr>
<td>Byproducts of soybean (hull, <em>okara</em> and whey)</td>
<td>Dehydration, size reduction, fermentation, separation, packaging, storage and marketing.</td>
<td>Dietary fiber, single cell proteins, citric acid, enzymes, alcohol.</td>
</tr>
</tbody>
</table>
Figure 4 Soybean product system.

- Soybean → Soy Milk → ISP → Oil → Protein Curd → Fiber
- Soybean → ISP
- Soybean → Granule
- Soybean → Textured
- Soybean → Powder
- Soybean → Fibrous
- Soybean → Peptide
- Soybean → Water soluble Fibers

- Soybean → Food
- Soybean → Oil
- Soybean → Meal

- Food
  - Fermented food
    - shoyu (soy sauce)
    - miso (soy paste)
    - sufu (soy cheese)
    - tempeh (soy cake)
    - natto (whole soybean)
  - Non-fermented food
    - soymilk
    - tofu (soymilk curd)
    - kori-tofu (dried tofu)
    - yuba (coagulant film of soymilk)
    - kinako (roasted soy powder)
    - moyashi (soybean sprout)

- Oil
  - Cooking oil
  - Industrial uses
  - Animal feed

- Meal
  - Water based alkyd coatings (plasticizer)
  - Oleochemicals
  - Fuel mixture
  - Printing inks
  - Defoaming agent
Varieties

Kernel

Paddy
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BASIC

Paddy = Çeltik

Cargo/Brown = Kargo

Husk/Hull = Kavuz

Bran
TYPES

- Depend on size of kernel

- Depend on starch/amlylose and amylopectin

\[
\text{Starch} \rightarrow \text{Amylose} + \text{Amylopectin}
\]

\[
\text{Kernel size} \downarrow \rightarrow \text{Amylopectin} \uparrow \rightarrow \text{Stickness} \uparrow
\]
TYPES

1- Long rice
   (low amylopectin-
    Not sticky property)
   Basmati (!)
   Jasmin
   (good pilaf)

2- Medium size rice
   Calrose
   Baldo
   Osmancık
   Good pilaf

3- Short rice
   (high level amylopectin)
   - Sticky
   - Asian food
   Sticky pilaf
Rice contains two types of starch: amylose and amylopectin. The amount of each starch, which is different for every type of rice, determines the texture of the cooked rice and whether it will be fluffy, creamy or sticky. As rice cooks, both the heat and liquid penetrate the grain and the starch molecules inside the grain break down. As the liquid is absorbed, each starch carries out a different task.

**Amylose** is a long, straight starch molecule that does not gelatinize during cooking. Grains with high amounts of amylose will be fully and separated once cooked. Long grain rice typically has high amounts of amylose (about 22%) and the least amount of amylopectin (ex., long grain varieties, Basmati and Jasmine).

**Amylopectin** is a highly branched starch molecule that is responsible for making rice gelatinous and sticky. Rice with a high amount of amylopectin will be very sticky once cooked. Short grain rice typically contains the lowest levels of amylose and the highest of amylopectin (ex., short grain, Asian-style types of rice). The characteristics of some medium grain rice tend to fall somewhere in between. They typically contain about 15-17% amylose and a good amount of amylopectin which results in a creamy consistency (Italian, Arborio, and paella-style types of rice).

**Sticky rice** (a.k.a., glutinous, waxy or sweet rice) is very sticky when cooked. It contains the highest amount of amylopectin and no amylose. It’s often used to make sweet dishes in Asia.
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Rice Processing Details

**STEP 1: PADDY CLEANING**

- RAW PADDY
- PADDY CLEANER
- CLEANED PADDY
- REJECTION

Diagram showing the steps involved in paddy cleaning:

1. **Paddy**
2. **Pre-Cleaner**
3. **Mist Polisher**
4. **Friction Whitener**
5. **Brewers Rice**
6. **Destoner**
7. **Abrasive Whitener**
8. **Barn**
9. **Rubber Roll Husker**
10. **Head Rice Bin**
11. **Paddy Separator**
12. **Brokens Bin**
13. **Husk Aspirator**
14. **Blending**
15. **Husks**
16. **Bagging**

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Step 6: Paddy Separating

Cleaned White Rice → Paddy Separator → Rice Without Paddy → Rejection

Diagram:
- Paddy → Pro-Cleaner → Destoner → Rubber Roll Husker → Husk Aspirator
- Stones → Paddy Separator
- Husks → Paddy Separator
- Mist Polisher → Friction Whitener
- Abrasive Whitener
- Paddy Separator
- Length Grader
- Brewster Rice
- Barn
- Head Rice Bin
- Brokens Bin
- Blending
- Bagging

Dr. Mt
STEP 3: WHITENING

Brown Rice → Whitener → White Rice

Diagram:
- Paddy
- Pre-Cleaner
- Destoner
- Rubber Roll Husker
- Husk Aspirator
- Mist Polisher
- Friction Whitener
- Abrasive Whitener
- Paddy Separator
- Stones
- Husks
- Length Grader
- Brewers Rice
- Barn
- Head Rice Bin
- Brokens Bin
- Blending
- Bagging

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**Step 8: Polishing**

**Unpolished Rice** → **Water Polisher** → **Polished Rice**

**Diagram Details**:
- **Key**:

**Flowchart**:
- **Paddy** → **Pre-Cleaner** → **Mist Polisher** → **Fricition Whitener** → **Brewers Rice**
- **Paddy** → **Destoner** → **Rubber Roll Husker** → **Husk Aspirator** → **Bagging**
- **Paddy** → **Abrasive Whitener** → **Paddy Separator** → **Brokens Bin**

**Used for paddy hulling and whitening.**

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**Step 7: Thickness Grading**

- Cleaned White Rice
- Thickness Grader
- Rice Without Immature Grains
- Rejection
- Sifted Rice
- Length Grader
- Graded Rice
- Broken Rice

---

**Diagram**

- Used for paddy grading and cleaning, hulled rice grading, and rice grading.

**Key**


---

**Flowchart**

- Paddy
  - Pro-Cleaner
    - Destoner
      - Stones
    - Rubber Roll Husker
      - Husks
    - Husk Aspirator
  - Mist Polisher
    - Friction Whitener
      - Brewers Rice
      - Barn
    - Abrasive Whitener
      - Barn
  - Head Rice Bin
  - Brokens Bin
  - Blending
  - Bagging

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**Text**

- ayram
Step 9: Sifting

Polished Rice → Sifter → Sifted Rice

Flowchart:

- Paddy
- Pre-Cleaner
- Destoner
- Rubber Roll Husker
- Husk Aspirator
- Mist Polisher
- Friction Whitener
- Abrasive Whitener
- Paddy Separator
- Length Grader

Branches:
- Barn
- Brewers Rice
- Head Rice Bin
- Brokens Bin
- Blending
- Bagging

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PARBOILED RICE

Basic

Raw paddy → Soaking in hot water → Steaming

Milling → Drying

Detailed

Threshing

Drying → Cleaning

Cleaning → Parboiling → Drying

Hulling

Cleaning → Paddy separation

Whitening

Bran separation

Polishing

Brokens separation

Grading

Brokens

Head rice

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FLAKED RICE

Raw paddy → Soaking in hot water → Steaming

Pre-cleaning → Shelling → Milling → Flaking

HTST treatment → Moistening → Drying

Flaked rice (ready to consume)