WHAT ARE PULSES?

- Pulses are edible seeds of legume family.
- The term "pulses" is limited to crops harvested solely as dry grains, which differentiates them from other vegetable crops that are harvested while still green
- Pulses include beans, lentils and peas. Also a cheap, low-fat source of protein, fibre, vitamins and minerals,
- It takes just 43 gallons(163 litres) of water to produce one pound (0.45kg) of pulses. They also contribute to soil quality by fixing nitrogen in the soil.
- Up to 25% = feeding (pigs and poultry)
- The United Nations Food and Agriculture Organization **(FAO)** recognizes **11 types** of pulses: **dry beans, dry broad beans, dry peas, chickpeas, cow peas, pigeon peas, lentils, Bambara beans, vetches, lupins and pulses nes**

STATUS OF PULSES IN INDIA

India - largest producer (25% world's production) importer (14%)and consumer (27%)of world's consumption)of pulses

- **Consumption rate** = 26MT annually (dehusked split form called dhal)
- **Global production & Global area** = 25% and 35%
- **Production** = 755 kg/ha
- **Climate** - semi-arid areas(Rabi and kharif season)
- **Water requirement** = 359 liter/ kg production
- **Major producers-** M.P (2.9 MT), U.P (2.76MT), Rajasthan, Maharashtra, karnataka , A.P
- **Major importers-** Canada, Australia, Myanmar, U.S ,Russia
- **Consumption** =75% of milled dhal
- **India's share in area** = (42.6%) and production (28.34%) of pulses globally.
- **Estimated Global market** = 143.7 M tons by 2025

PRODUCTION STATISTICS

- **India's share** (max) = pigeonpea (area) 73% and production 67%
- **chickpea** = 68% area and 66% production
- **Dry beans**= 37% area and 18% production
- **lentils** = 29% area and 18% production
- **Dry peas** =(12% area and 6% production
- **Other minor pulses-** horse gram, mothbean, lathyrus, cow pea, rajmash, fababean, ricebean,winged bean, cluster bean, hyacinth bean, jack bean,sword bean, zombi pea

Losses- 1) Storage = 7.5%
2) Processing= 1%
3) Threshing & transport =0.5%

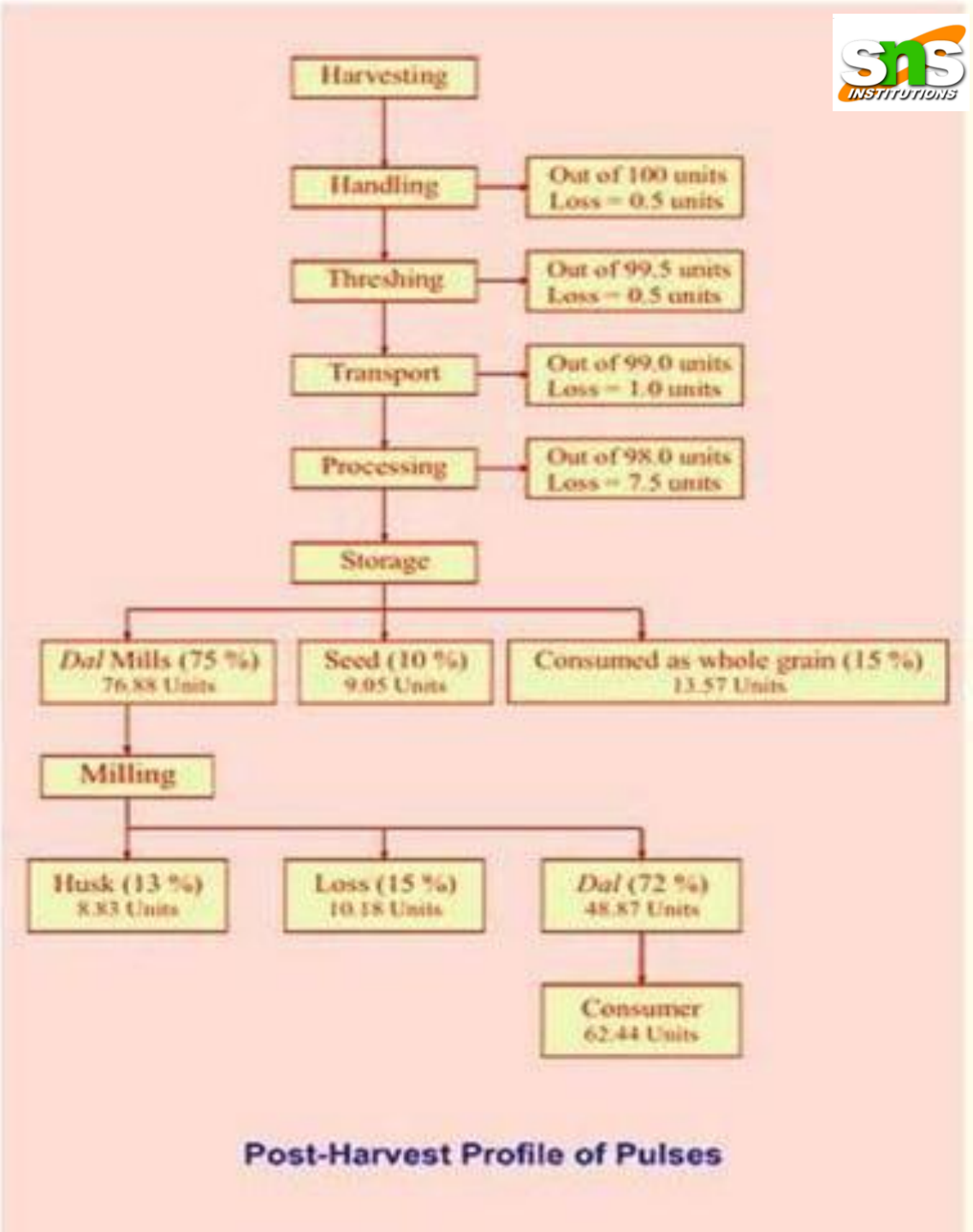
- **Rich in lysine (EAA)**

NUTRITIONAL COMPOSITION

- **ENERGY**- 1040 to 1430 kJ per 100 g
- **CARBOHYDRATE** - low glycemic index (57.6%)
  1) Insoluble fiber- bowel health
  2) Soluble fibre- lower blood cholestrol
  3) Resistant starch – high amylose content
  4) Oligosaccharide- raffinose (3-5%), stachyose and pentosans
- **PROTEINS** – 20-30g of protein peer 100g
  Methionine &cysteine- low
  Lysine- rich
- **FAT** =2-6% (PUFA)
- **VITAMINS**- vitamin B(thiamin, riboflavin, niacin, folate, vitamin B6 and pantothenic acid. Pulses contain more folate than grains.
  Vitamin E - the embryo of pulses contains vitamin E, a known antioxidant.
  Vitamin A
  Vitamin C - dried pulses contain vitamin C, (1 cup of bean sprouts contains 11 mg of vit c
- **MINERALS** (3.5%) – Potassium ,sodium,iron, zinc, magnesium and phosphorus, calcium, selenium manganese and copper
- **ANTINUTRIENTS**- Lectins, Phytic acid, Phenolic compound, Protease inhibitor, Saponins, Lathyrus
- **PHYTOCHEMICALS** - lignans & isoflavones, phenolic acid

HEALTH BENEFITS

- **High in dietary fibre** - healthy bowel function.
- **Soluble fibre** - lowers blood cholesterol.
- **Non digestible fibre**- anti proliferative activity(apoptosis)
- **low glycaemic index** or GI= (<55)
  - Low GI foods avoid hyperglycemia and/or increaseds in blood insulin levels - risk factors for cardiovascular disease, mortality, and type 2 diabetes.
- **Antioxidants** - vitamin E, selenium, phenolic acids, phytic acids, copper, zinc and manganese.
- **Phytoestrogens** - may help in the prevention of hormone-related cancers, such as breast and prostate cancer.
- **Folate** - prevention of diseases, such as heart disease, cancer. The B vitamin folic acid significantly also reduce the risk of neural tube defects (NTDs) like spina bifida in newborn babies.
- **saponins** - lower blood cholesterol(Chickpeas, faba beans, lentils)
- **Protein** = 21-25%
- **Gluten-free** - they offer a great variety for those on a gluten-free diet (eg for Celiac disease, a gastro-intestinal disorder).
- **Methionine and lysine**- esssential amino acids
- **Lignans& isofalvones-** possess anti-carcinogenic, antioxidant, oestrogenic properties
- **Protease inhibitor-** prevent cancer initiation
- **Lectins**- inhibit HIV-1 reverse transcriptase
- The World Food Programme **(WFP)** for instance includes **60 grams** of pulses in its typical food basket



Post-Harvest Profile of Pulses

POST HARVEST LOSSES

- LATE HARVEST: Shattering losses, losses due to attack of birds and other pests
- INSUFFICIENT DRYING: losses due to development of moulds and insects
- IMPROPER THRESHING : broken grains and threat of insect development at a later stage
- POOR STORAGE: losses caused by combined action of insects, moulds, rodents and other pests
- IMPROPER MILLING: broken and powdering loss
- TRANSPORT: quantitative loss
- DEFECTIVE PACKAGING: qualitative and quantitative loss

Stages	Losses (%)
Harvesting	1.0-3.0
Handling	1.0-7.0
Threshing	0.5-5.0
Drying	1.0-5.0
Transport	0.5
Primary Processing	1.0
Storage	5.0-10.0
Milling	15.0-20.0
Total	25.0-50.0

MILLING OF PULSES

DEFINITION: The process of removal of husk from the cotyledons is called dehusking and the entire process of dehusking and subsequent splitting of cotyledons, its cleaning, polishing and grading is known as milling.

- Losses may vary from 10-15% depending upon the type and quality of grain milled, the process and machinery used for milling.

Moisture content:

1) Harvesting time = 15-20%
2) Storage time = 12-14%

Milling of pulses involves two major steps:

- Loosening of husk
- Removal of husk and splitting into cotyledons with the help of suitable machine

TYPES OF MILLING

- Home scale milling
- Cottage scale milling
- Traditional milling
- Commercial scale milling

1) HOME SCALE MILLING

- **POUNDING OF GRAINS** - using a mortar and pestle after mixing with small quantity of water and drying in the sun for a few hours.
- **SUN DRYING** – helps to loosen the husk from the cotyledons.
- **DEHUSKING**- achieved due to shearing action between pestle and grains, and abrasive effect between the grains. pounding is done for several minutes, until husk gets detached from the grains.
- **WINNOWING**- separates husk and split cotyledons are separated from the whole dehusked and unhusked grains by manual sieving.
- The whole grains are again pounded for further dehusking and splitting.
- **SUITABILITY** : small quantity up to **5 kg** of pulses is to be dehusked.
- **YIELD** - **(50-60%)** due to breakage and chipping of the edges of cotyledons.
- Dehusking is also achieved by grinding in a hand operated **stone mill** (hand chakki)

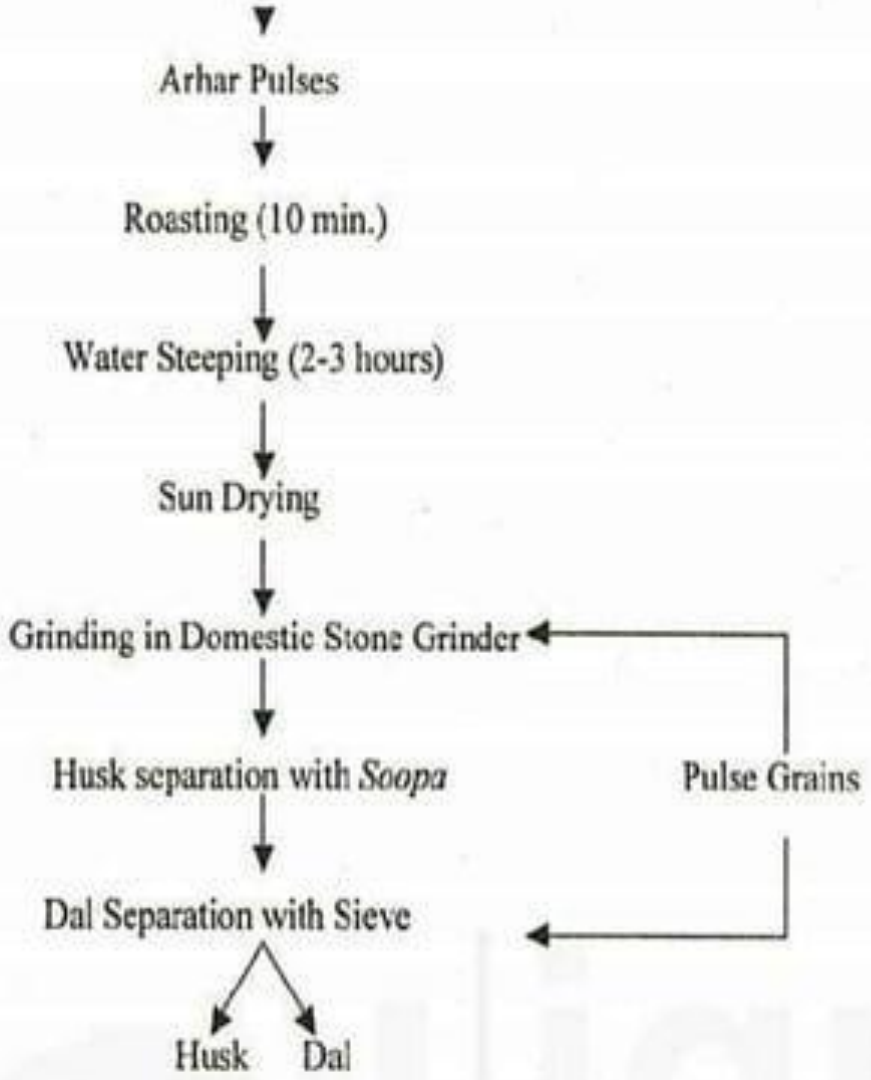


Fig. 3 : Home Scale Method of Arhar Milling in Uttar Pradesh Villages (Dal Recovery: 58-60%)

2) COTTAGE SCALE MILLING

DEHUSKING CAPACITY : **50 kg/hr**

- **PRE-CONDITIONING** : sun drying until the hulls are loosened or through application of water followed by several hours of sun drying and tempering.
- **HEATING**: of the grains in pan with or without sand along with vigorous stirring. The duration of treatment depends upon the variety of pulses to be milled.
- **MILLING** :1) hand operated wooden or stone chakki/ sheller (Traditional)
  2) Mechanized shellers & plate mills are used for custom milling of preconditioned pulses

❑ **YIELD** (head dal)= **55-70%** (depends upon the variety of pulse and pre-treatment used)

❑ **DISADVANTAGES** 1) Husk is not completely removed and breakage is also quite high.
2) Reduces the consumer appeal and value of the product

❖ There are no standard dehusking techniques at the cottage level.

MINI DALL MILL

❑ CONSTRUCTION

It consists of:

(1)Dehusking and splittting unit
(2)Aspirator
(3)Separator unit
(4) Polishing unit

❑ WORKING

Dehusking is achieved by abrasion of grains between the rotating emery coated cone and wire mesh cage. Aspirator separates the husk and broken.The dehusked and unhusked grains are collected at different points . The dehusked dal then passed through polisher and the output is polished dal.

CFTRI MINI DAL MILL

- **CAPACITY:** **100-150 kg** of pre-treated pulse/hr
- **COMPONENTS:** The mini dal mill consists to dehusking and splittting unit, aspirator and separator unit runs by **1 hp single-phase motor**, grader .
- **SUITABILITY:** Bold pulses (pigeonpea, chickpea, peas and soybean can be dehusked in this machine). Formungbean and urdbean, splitting of unhusked grains can also be achieved
- **YIELD: 77–80%**
- **DEHUSKING EFFICIENCY: 97-99%.**

ADVANTAGES

- Integrated unit
- Comes with a grader, which runs on 1/2 hp single phase motor and can grade 200-250 kg of soaked (wet) pulse per hour.
- Grains are dehusked and split simultaneously.
- higher yield and good quality dal at lower processing costs.
- low power consumption.
- Simple in design,easy to operate
- Repaired and maintained at rural level.

CFTRI Mini Dal Mill

3) TRADITIONAL PULSE MILLING PROCESS

Traditional methods of dehulling pigeonpea followed in various Indian states

4) COMMERCIAL SCALE MILLING

DEMAND: large quantities of pulses in plants of bigger capacities.

DEHUSKING CAPACITY: **98-99%**

DHAL YIELD: **77-80%**

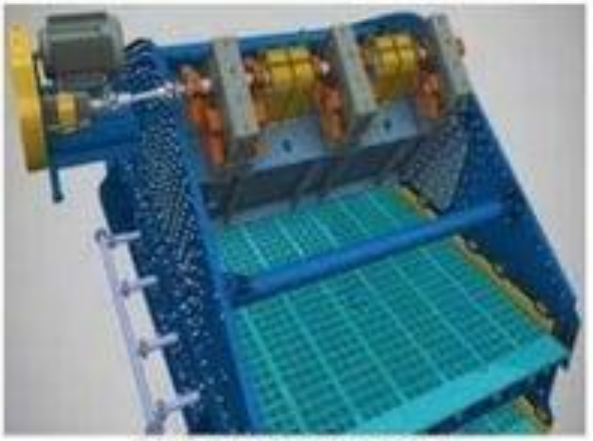
ADVANTAGES: 1) High capacity/efficiency
2) Free of dust pollution
3) Dhal yield is high
4) Integrated process
5) less time consuming
6) Less breakage/ wastage
7) Less power consumption
8) Independent of weather conditions.

STEPS INVOLVED IN COMMERCIAL MILLING

- CLEANING AND GRADING
- PITTING
- PRE –MILLING TREATMENT
- TEMPERING
- DRYING
- DEHUSKING AND SPLITTING
- POLISHING

1) CLEANING AND GRADING

- It involves removing dust, dirt, foreign material, off sized, immature and damaged grains and grading in two or more fractions.
- After every dehusking operation, the grain lot has to be subjected to sieving to separate out husk, brokens, splits, gota and whole (unhusked) pulses.
- Generally cleaners used are:
  1) **Reciprocating air-screen cleaners**
  2) **Reel screen cleaners.**



Use of Three Unbalance Exciters in Parallel

ADVANTAGES OF REEL CLEANERS

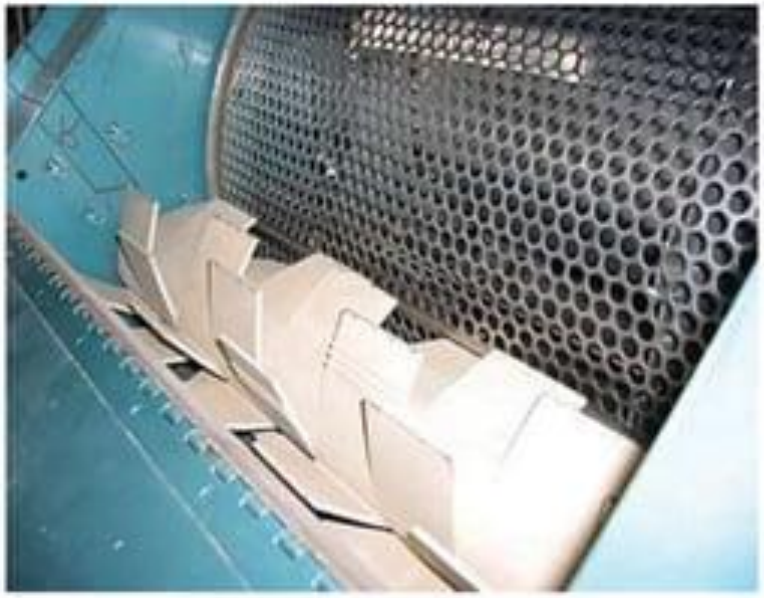
a) Operates at low noise levels.
b) It requires insignificant repair and maintenance expenditure.
c) Power requirement is almost half as compared to reciprocating cleaners.
d) It causes less dust pollution.

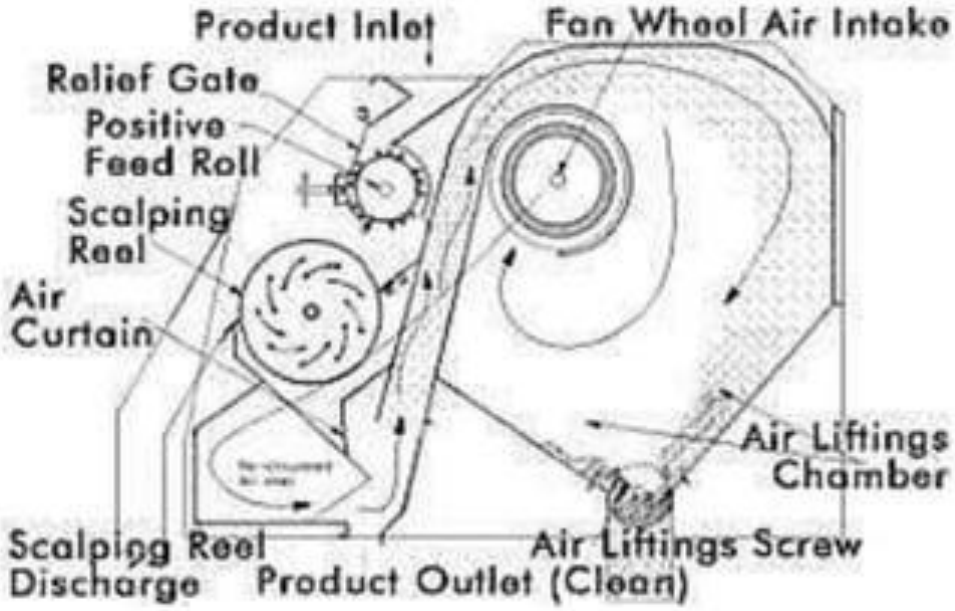
CONSTRUCTION OF REEL SCREEN CLEANER

- The reel screen cleaners mainly consist of **2-4** cylindrical compartments of different size perforation screens fitted on a **5-7.5 mm dia** shaft.
- The machine is fitted at an inclination of **2-3°**.
- The cylindrical screen drum rotates at a low speed of **15-35 rpm**. The frame of the machine is made of wooden or M.S. sheet

RECIPROCATING AIR SCREEN CLEANER

- It consist of **two** screens (sieves) and an aspirator air blower.
- The aspirator/ blower separates out the lighter material like **dust, stalk, dried leaves, husk** etc.
- The upper screen with larger perforations is called **Scalper**. It scalps out the larger size material while the smaller size material falls through the screen over second screen having smaller perfurations.
- The desired material bigger in size than perforation size moves over the screen and is collected in discharge trough fitted at its tail end.
- The smallest sized material passes through the screen and is collected through a trough.





(2) PITTING

Operation 'pitting' means producing scratches, dents and cracks on the hard seed coat by passing the pulses through Roller Dehusker.

NEED - easy migration, diffusion of oil & water in between the husk and cotyledons which weakens the gum bonding & thus loosens the husk adhering to the cotyledon

- **EQUIPMENT USED**: emery-coated roller (commercial dal mills)
- **MECHANISM** : abrasive or refractory action.
- **PROCESS**-The clean whole pulses are passed through an emery roller machine.
  - The husk is cracked and scratched(to facilitate the subsequent oil penetration process for the loosening of husk).
  - clearance between the emery roller and cage (housing) gradually narrows from inlet to outlet.
  - As the material is passed through the narrowing clearance mainly cracking and scratching of husk takes place by **friction between pulses and emery**.
  - Some of the pulses are dehusked and split during this operations which are then separated by sieving.

(3) PRE- MILLING TREATMENT

The treatment is given for loosening of husk from cotyledons, which is attached through a gum layer is called pre-milling treatment.

NEED : Loosening of Husk

Effectiveness of this operation decides the total recovery and quality of milled dal

EXAMPLE:

- ❑ Water soaking
- ❑ Oil and water application
- ❑ Mixing of sodium bi-carbonate solution and
- ❑ Thermal applications
- ❖ Commercial milling - oil and water treatment
- ❖ Household milling - water treatment

Pre-treatments can be broadly classified into:

i) wet treatment.

ii) Dry treatment.

(A) WET TREATMENT

ADVANTAGES: 1) facilitating dehusking and splitting the cotyledons,
2) Yield is also increased due to lesser breakage.
3) Dal produced by this method cooks better
4)helps to remove small patches of adhering husk due to its mild abrasive quality.

DISADVANTAGES: 1) lower deshusking percentage of grains
2)weather dependent and labour intensive.
3)Dal produced by this method takes longer time to cook.
due to longer periods of sun drying and affecting the cooking quality of dal,

METHOD: (Red earth treatment)

- The cleaned and graded pulses are steeped in water for **4-12 hours**
- Mixed with paste of red earth for **12-16 hours** and heaped
- Sun dried to keep the moisture at **10-12 %** by spreading in thin layer in drying yards for **2–4 days.**
- The grains are When dried, the red earth is removed by sieving
- The grains are then milled on power operated stone or emery coated vertical chakki to yield dal.

Treatment with red earth imparts **good yellow colour** to the finished product.

(A) WET TREATMENT OF PULSE MILLING

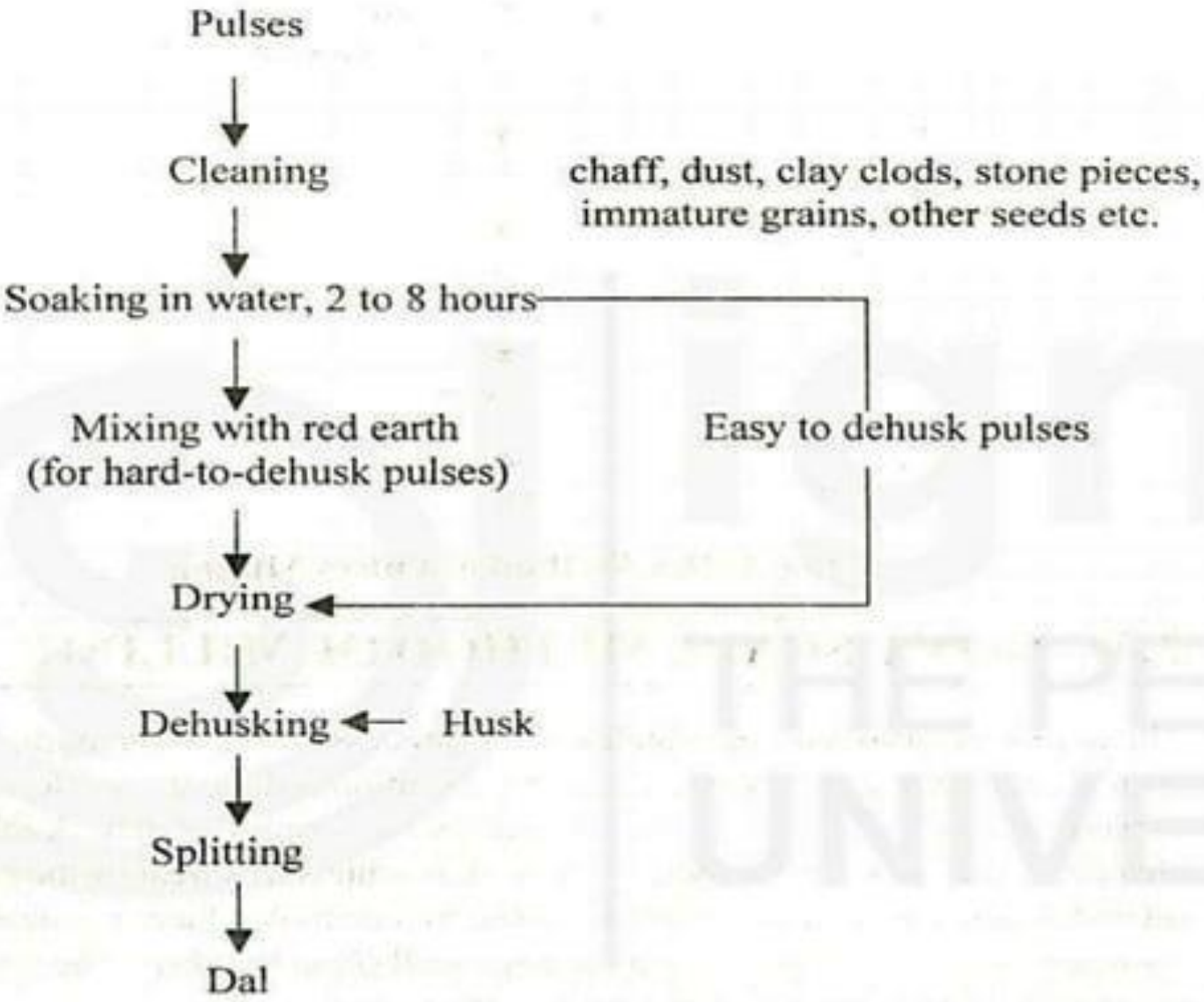


Fig. 1: Wet method of Pulses Milling

(B) DRY MILLING

Husk is loosened by oil smearing, water application, tempering and sun-drying.

ADVANTAGES

- Dry milling treatment is reported to produce dal that cooks faster

DISADVANTAGES

- Losses due to broken and powdering are high.

PROCESS

- Pitted pulses are smeared with **150-250/g** of linseed oil per quintal of pulses thoroughly and spread for sun drying in thin layer, for **2–3 days**. (During this period, oil diffuses in between the husk and cotyledon which loosens the husk)
- Mostly oils like **mustard, rapeseed, safflower, linseed, groundnut, cashew nut, husk oil, niger and soybean.** The rate of oil used varies for different pulses.
- Drying, **2-5%** of water is sprayed(2.5 to 3.5 kg of water per quintal of pulses) mixed thoroughly and tempered for overnight. sun-dried for **1-3 days** before subjecting to milling
- After drying and cooling Tempered grains are dehusked in roller machines to give dehusked grains or dal

DIFFICULTY FACED IN DEHUSKING

(i) **Hard to dehusk** - pulses namely arhar, urad and moong

(ii) **Easy to dehusk** - pulses namely channa (Bengal gram), masoor (Lentil) and field pea.

Husk and powder and later smeared with oil at the rate of **100-500 gram per quintal** manually or with auger mixer.

DRY METHOD OF PULSE MILLING

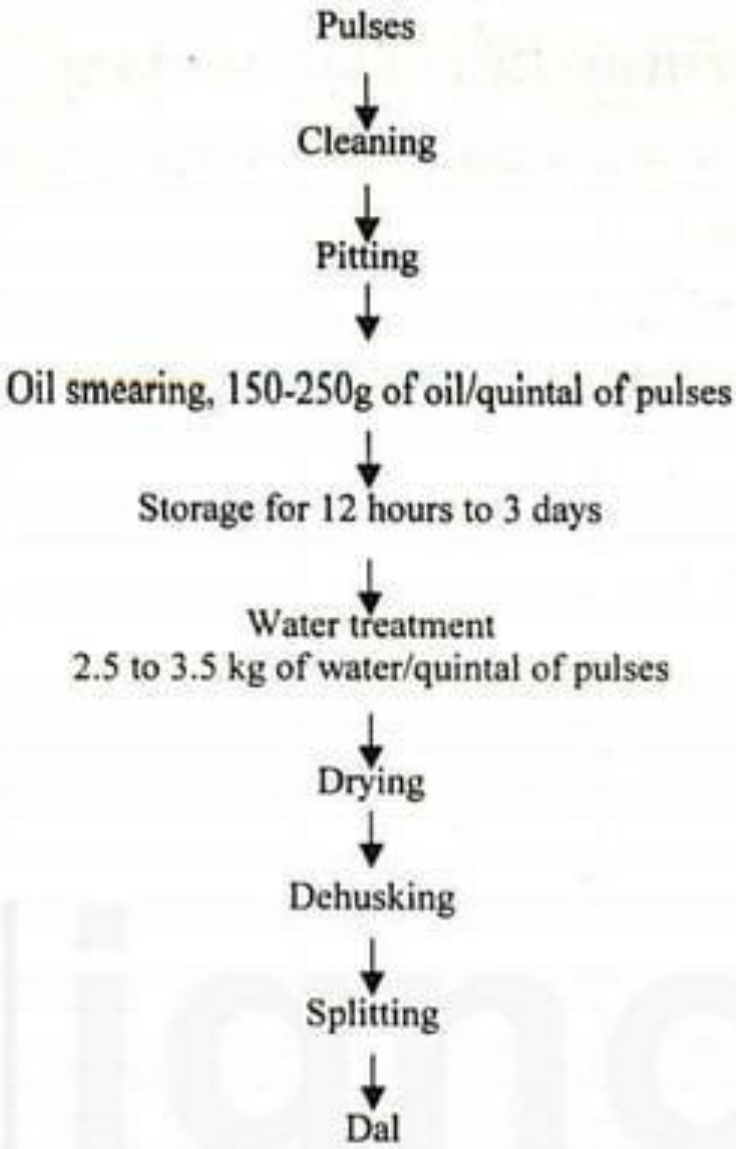


Fig. 2: Dry Method of Pulses Milling

(4) TEMPERING

Once the pre-milling treatment is given, conditioning is done to have uniformity of treatment throughout the grain mass. This process **gives time for better penetration of oil/water beneath the seed coat to dissolve gums.**

(5) DRYING

TYPES OF DRYING

SUN DRYING (Dry season)

cemented floor or roofs are used . Lifting the material to the roof is done by bucket elevators, while dried pulses are sent back to the desired point under gravity through metallic chutes. Drying is done for 1- 6 days as per the requirement. The pulses are spread over floor in 5 to 7.5 cm thick layer which are stirred manually with the help of rakes or turning by foot, in which four to five labours move side by side in straight row. At night, the drying pulses are collected in heaps and covered with canvas sheet to preserve the heat.

MECHANICAL DRYING (Rainy season)

These dryers are either batch type or continuous flow type. For heating air electricity, diesel, wood or coal fuel is used as per availability and economics. The temperature of heated air for drying varies from 60° to 120°C upto 10- 12% moisture.

ADVANCE TECHNOLOGY

- **Flash drying** is a continuous process where superhot steam (upto 300°C) is blown through the tempered/conditioned seeds causing rapid evaporation of seed moisture. It is exponentially faster than bin drying methods. An added benefit is that latent heat can be recovered by recompression leading to energy savings.
- **Dielectric drying** is a process whereby the tempered/conditioned seeds are dried by the absorption of electromagnetic radiation (radio waves, microwaves or infrared radiation).

(6) DEHULLING & SPLITTING

This operation comprises of two steps namely loosening the bond between the cotyledons and splitting.

- **DEHULLING**: is a removal of seed coat from pulse.
- **SPLITTING**: Dehulled seed can then be further processed to split the cotyledons to obtain a product that takes less time to cook.

DEHULLING MACHINES

ROLLER DEHUSKERS (large mills)

- Its roller is coated with carborandum (no. varies for different pulses)
- The Roller used In this machine are of two types, viz. cylindrical and tapered.

1)Tapered roller - foundation is horizontal. The diameter of roller increase from feeding side to discharge side. This is done to increase pressure gradually on the pulse grains .

2) Cylindrical roller- inclination of **10-15°** to help the forward movement of pulse grains inside the machine. Annular gap between the roller and the concave **(19-45 mm)**. The inlet and outlet of the roller machine can be adjusted for regulation of grain flow and retention time respectively.

RUN DISC SHELLERS (URD) OR BURR MILLS (Small mills)

- The yield of dal is lower by **5-10 %** besides getting inferior quality of dal.
- To remove the husk ,subjected to mild abrasion inside the roller machine, removing **10-25%** of husk in one pass.
- After passing the grains lot once or twice through the **roller machine**, the shelled husk, cotyledon powder, brokens and splits are separated out by **Air-screen cleaners**.
- The pulse grains are passed through Roller mill for **2-8 times**. Generally after every two passes, loosening of husk operation is repeated but at decreasing intensity.
- **Hard-to-dehusk** pulses = arhar, moong, urad, the number of passes through the roller machines vary between **4-8 times**. Recovery is between **70-75%**
- **Easy-to-dehusk** pulses = bengal gram, lentil, kesari and peas, the number of passes between **2 to 4.** Recovery is between **78- 85%**

COMMERCIAL MILLING MACHINES

1) ATTRITION MILLS (Dehulling + Splitting)

- The traditional stone chakki design was used as a template for these commercial-scale dehulling and splitting of pulses.
- The two-stone principle was retained and the much larger stones were rotated using the energy of harnessed animals (such as bullocks) or running water. Now, mills were adapted as electricity became an available power source, and automation increased.
- Nowadays, stones are artificial and coated with **carborundum** (derived from silicon carbide) of various abrasive grades (grit size). These new improved attrition-type mills are often called under runner disk shellers (URD Shellers).
- The orientation of the stones can be either horizontal (as in the original chakkis) or vertical, and the gap between the stones can be adjusted to the seed size to optimize dehulled seed and/or dhal yields

.

(2) EMERY ROLLERS (Dehulling + Splitting)

- Grain properties such as hardness, load deformation behaviour, shape, size density and variety of grain etc. have considerable effect on dal yield.
- The machine parameters such as roller speed, clearance, emery size etc have vital role to play on dal recovery.
- **Unhusked** and **dehusked whole grains**, **split cotyledons**, **broken**, **husk** and **powder** are obtained.
- SPEED = 850-900rpm
- RECOVERY = 74.75%
- OPERATION = Flat /V belt drive

Whole grains are passed again for further dehusking and/or splitting after water treatment. Husk and powder produced during milling is gen
feed.

(7) POLISHING

Glazing appearance is imparted to improve its consumer's acceptance and market value. Dal is polished in different ways, such as nylon polish, oil/water polish, leather and makhmal polish. Generally polishing is done using soap stone, oil or water or SELKHARI powder are applied to dal surface.

Polishing gives uniform look and shine to each grain.

- **REMOVAL OF POWDER DUST**: Cylindrical rollers mounted with the rubber mats or leather strips or cylindrical tapered emery rollers are used for the purpose. The dust particles sticking to dal surface are removed by gentle rubbing action on the roller surface. The speed and size of rolls is similar to Dehusking roller machines.

- **WATER POLISH**: used for urad, chana, masoor and arhar. In this 1- 1.5kg of water per quintal of dal is applied while passing it through anyone of the polishers mentioned above.

- **BUFF POLISH**: In this 2-2.5 kg of water along with 200-250g of oil per quintal of dal is applied with above polishers. This type of dal is preferred in Madhya Pradesh, Uttar Pradesh, Bihar, Maharashtra and Delhi.

- **NYLON POLISH**: soapstone powder or 'selkhari' powder (1-1.5 kg/q) is applied to the surface along with water (1-1.5 kg/q) by passing through the polishing machine. The flights and shafts are covered with nylon rope to impart gentle rubbing. This is used mainly for masoor, moong, tur and urad.

- **TELIYA DAL:** 2.5 to 3.0 kg of castor oil is mixed per quintal of arhar dal to make it look glossy. This is known as Teliya and the storage life of this dal is short.

Flow diagram of CFTRI method of pigeon pea

Raw Pulses (Pigeon pea)

⇩

Cleaning ⇨ Husk, chaff, powder and foreign matter

⇩

Grading

⇩

Graded pulses

⇩

Conditioning & Tempering (1st)

⇩

Husk & husk powder ⇦ Pearling, aspirating & grading ⇨ Dhal

Dhal ⇧ Polishing ⇧ Dhal (Grade I)

⇩

Pearled pulses

Water mixing ⇨ ⇩ ⇦ Lumped pulses – lump breaking

Conditioning in LSU dryer

⇩

Conditioned pulses

⇩

Splitting & sieve grading ⇨ Unsplit pulses

⇩

Dhal

CALCULATIONS

- **DEHULLING EFFICIENCY** : (degree of dehulling or dehulling index)

The yield of dehulled product material (dehulled whole seed and dhal) as a percentage of original seed weight

$$DE\ (\%) = (DWS + D) \times 100$$

where: DWS=mass of dehulled whole seeds

D=mass of dehulled dhal

Wt=original weight

- **SPLIT YIELD** : (dhal yield)

The yield of dehulled and split product material (dhal) as a percentage of original seed weight

$$SY\ (\%) = D \times 100 / Wt$$

where: D=mass of dehulled splits.

Wt=original weight

Milling efficiency

The overall efficiency of the pulse milling system can be estimated with the of the following equations.

1. $$E = \left(1 - \frac{M_{uh}}{M_t}\right)\left(1 - \frac{M_b}{M_t}\right) \times H_l \times 100$$

where, $$H_l = \frac{H_a}{M_t H_t}$$

E = milling efficiency

M_{uh} = mass of unhulled grains

M_t = mass of grains fed to the system

M_b = mass of brokens

H_a = actual mass of husk removed during milling

H_t = theoretical husk content of the grain

The theoretical husk content of common Indian legumes are given in Table

Table 5.12

Husk content of Indian legumes

Grain	*Husk Content,%*
pigeon pea	13.0–15.0
green gram	12.0
black gram	12.0
lentil	11.5
Bengal gram (chick pea)	11.5–13.0

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