
UNIT 2 PROCESSING OF PULSES AND BY-PRODUCT UTILIZATION

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2.0 OBJECTIVES

After reading this unit you should be able to:

- know about pulses milling;
- learn various method's of pulses milling;
- know about drying operations in pulse milling;
- study different methods for manufacture of besan and papad; and
- learn various uses of chuni-bhusi a by product of milling.

2.1 INTRODUCION

Pulses are the major source of protein in Indian vegetarian diet. Their protein content varies between 19-25%. Generally, pulses are consumed in dehusked and split form which is termed as dal. The operation of dehusking and splitting pulses is termed as Dal milling. The hard seed coat remains tightly glued to kernel with a natural gum which makes it difficult to remove the seed coat. It is necessary to loosen this bondage before dehusking as otherwise the kernel may get damaged during milling resulting in reduced recovery of dal. There are several methods for loosening the seed coat which we will explain you in the coming text. However, it is easy to split the kernel in two halves after the removal of seed coat. When this kernel is spitted in two halves, the loosely attached embryo is detached and is lost along with the husk. There are several methods of dal milling which we are going to explain you in the following text.

2.2 METHODS OF PULSES MILLING

In home scale as well as commercial practice, there are two methods of milling:

1. Wet Method
2. Dry Method

Wet Method : In this method, pulses are soaked in water for 2 to 8 hours prior to drying. In different to dehusk pulses like arhar (pigeonpea, tur), urad (black gram) and moong (green gram), the soaked pulses are treated with red earth before it is dried. After drying, the pulses are subjected to dehusking and splitting which has been explained through flow diagram at Fig. 1

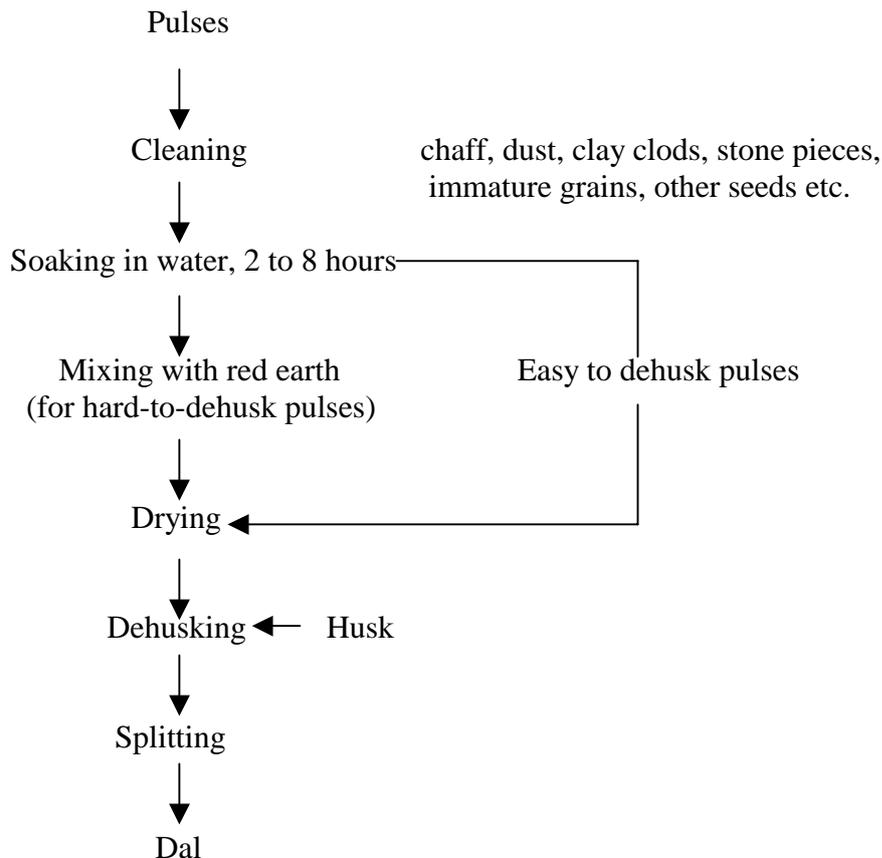


Fig. 1: Wet method of Pulses Milling

Dry Method : Here, after cleaning and grading, the pulses are subjected to pitting. Operation 'pitting' means producing scratches, dents and cracks on the hard seed coat by passing the pulses through Roller Dehusker. Now the pitted pulses are smeared with 150-250/g of oil per quintal of pulses, stored for 12 hours to 3 days. During this period, oil diffuses in between the husk and cotyledon which loosens the husk. To further loosen the seed coat, it is treated with 2.5 to 3.5 kg of water per quintal of pulses and stored overnight. Next day, after drying and cooling, it is subjected to dehusking and splitting as shown through flow diagram at Fig. 2.

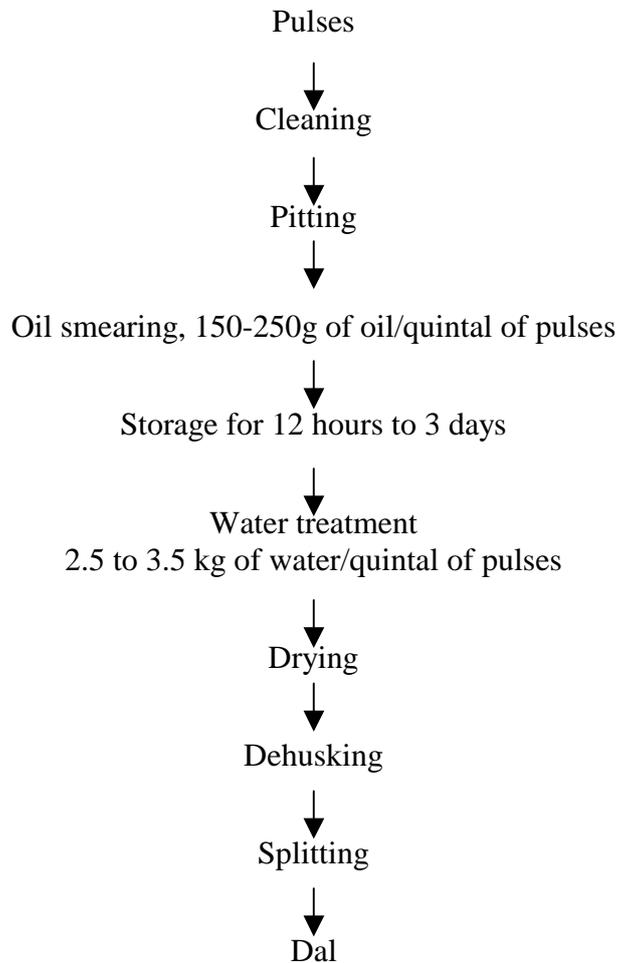


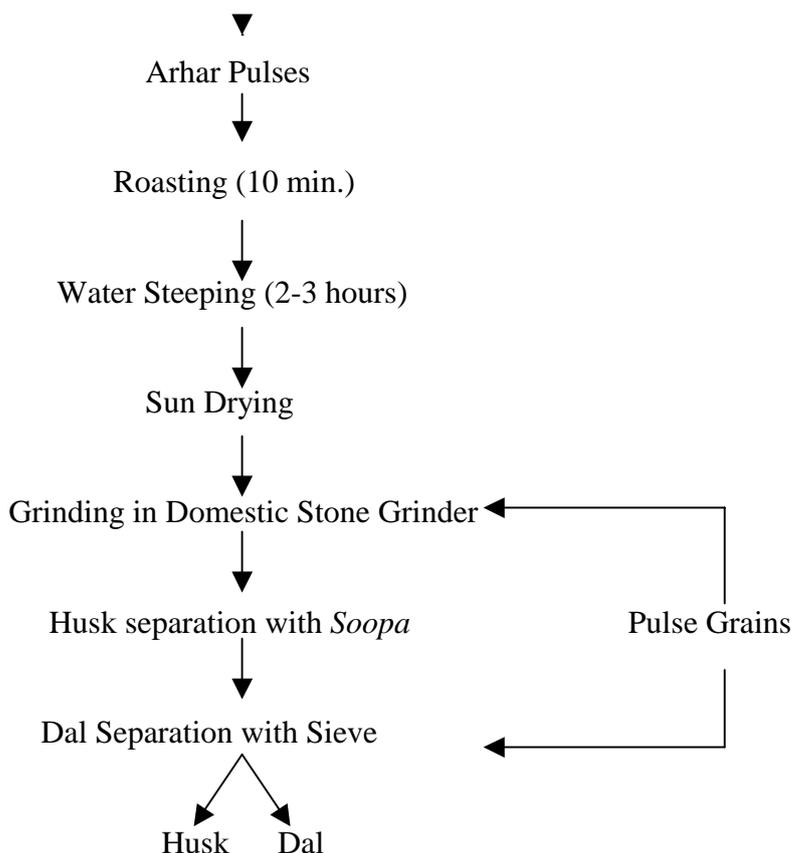
Fig. 2: Dry Method of Pulses Milling

2.3 HOME SCALE METHOD OF MILLING

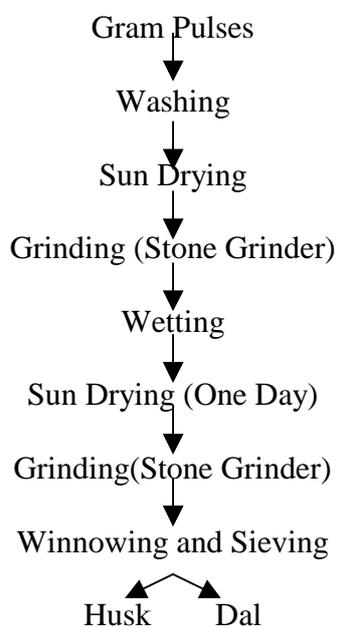
The oldest and most common technique of processing pulses on home scale is to pound it in a mortar and pestle. Here, the operation is done in two steps, firstly to loosen the husk by wet or dry method and secondly removal of husk followed by cleaning. The first step of loosening the husk is achieved by treating the pulses with oil and or water, storing over night followed by sun drying. Later it is dehusked in a mortar pestle or by a hand operated stone mill (*hand chakki*). The husk is then separated out by hand sieves and winnowing *soopa*.

The Home scale milling methods vary from region to region and (for different pulses). The general milling methods adopted for arhar and gram in Uttar Pradesh and Madhya Pradesh are explained through flow diagrams given at Fig. 3 and Fig. 4

In some regions, hard legumes like arhar, where husk is tightly attached to cotyledons, the soaked grains are treated with red earth paste, stored for some time and later sun dried. Dehusking on home scale process is accomplished by pounding the grains in mortar and pestle or grinding in a hand operated stone mill (*hand chakki*). The husk is separated out by hand sieving and winnowing while polishing is usually not carried out.



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



**Fig. 4: Home Scale Method of Milling Bengal Gram in Villages of M.P.
(Recovery of Dal: 60-65%)**

2.4 COMMERCIAL SCALE METHOD OF MILLING

Processing of pulses on medium and large scale is a commercial activity of millers. Though the basic principle for processing is same but the procedure for preconditioning treatment and dehusking varies. In general, the pulses have to undergo following unit operations for milling:

- i. Cleaning and grading
- ii. Drying
- iii. Loosening of husk
- iv. Dehusking
- v. Splitting
- vi. Polishing

i. Cleaning and Grading: This is an important unit operation in pulses milling industry. The raw pulses received by the plant needs to be cleaned and size graded for getting good quality dal and higher recovery. Also after every dehusking operation, the grain lot has to be subjected to sieving to separate out husk, brokens, splits, gota and whole (unhusked) pulses.

Normally two, types of cleaners are in use viz. Reciprocating air-screen cleaners and Reel screen cleaners. The Reel screens are better than reciprocating screen cleaners due to following reasons:

- a) Reel screen cleaners operate at low noise levels.
- b) It requires insignificant repair and maintenance expenditure.
- c) Its power requirement is almost half as compared to reciprocating cleaners.
- d) It causes less dust pollution.

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.

The reciprocating air screen cleaners 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 perforations. 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.

ii. Drying of Pulses: In pulse milling industry, drying of pulses is an important unit operation. The pulses received from farmers ‘mandis’ or traders generally have higher moisture and thus some degree of drying is essential before it is considered fit for storage and milling. Also during loosening of husk, the pulses need to be dried after it has been treated or steeped in water and stored overnight. For the splitting operation too, drying becomes essential to bring about the separation of cotyledons. Due to economical reasons, all the mills adopt sun drying during the dry season. For this, mills have cemented floor located generally at the backyards of the mill. At places where space is the limiting factor, roofs are used for the purpose. In such cases, 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. The sun 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 labourers move side by side in straight row. At night, the drying pulses are collected in heaps and covered with canvass sheet to preserve the heat.

In rainy season, generally dal mills remain closed for 3 to 4 months due to unpredictable sunshine. Lately with growing economic awareness, dal millers have started adopting mechanical heated air dryers. 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

iii. Loosening of Husk: This is the most important unit operation in pulses milling. Effectiveness of this operation decides the total recovery and quality of milled dal. In general, loosening of husk is done by two ways.

- a) Wet Method
- b) Dry Method

a) Wet Method: In this method, the cleaned and graded pulses are steeped in water for 4-12 hours, mixed with red earth for 12-16 hours and later sun dried to keep the moisture at 10-12 %. Steeping, facilitates easy dehusking and splitting. Longer the period of soaking, greater is the loosening of husk and caving in of the cotyledons on drying, which makes it easy to mill (dehusking and splitting). Yield is also increased due to lesser breakage. However the cooking quality of dal is adversely affected as it takes longer time to cook.

Treatment with red earth is said to impart a good yellow colour to the finished product. It also helps to remove small patches of adhering husk due to its mild abrasive quality. The wet method, being highly weather dependent due to longer periods of sun drying and affecting the cooking quality of dal, is practiced only in few pockets of south India.

b) Dry method: Dry method for loosening of husk is in vogue in most of dal mills of the country. In this method, husk is loosened by oil smearing, water application, tempering and sun-drying.

Pulses can be divided in to two general categories according to the difficulty faced in dehusking viz. (i) hard to dehusk pulses namely arhar, urad and moong and (ii) easy to dehusk pulses namely channa (Bengal gram), masoor (Lentil) and field pea.

In general, the cleaned and graded pulses are initially passed through the Roller mill (Roller Dehusker) to impart scratches, cracks and dents on its hard seed coat. This operation is termed as 'Pitting'. This facilitates the easy migration/diffusion of oil and water in between the husk and cotyledons which in turn weakens the gum bonding and thus loosens the husk adhering to the cotyledon.

The pitted pulse grains are passed through the sieve cleaner to separate out the splits, husk and powder and later smeared with oil at the rate of 100-500 gram per quintal manually or with auger mixer. Oil smeared grains are stored (tempered) for 1-5 days which permits the oil to diffuse in between the husk and cotyledons and thus weakens the bond thereby loosening the adhering husk. At the end of storage period, water is applied to the grains at the rate of 1-5 kg/q and stored for 12-14 h (overnight) and later sun-dried for 1-3 days before subjecting to milling.

The use of oil depends upon its availability and cost. The oils used are namely mustard, rapeseed, safflower, linseed, groundnut, cashew nut, husk oil, niger and soybean. The rate of oil used varies for different pulses. This has not been standardized so far. Similarly, quantity of water applied per quintal of pulse also varies from mill to mill.

- iv. **Dehusking :** Pulse grains are subjected to dehusking in Roller Dehuskers. Its roller is coated with carborandum. The carborandum number varies for different pulses. However, there is no standard fixed for any pulse grains.

The Roller used in this machine are of two types, viz. cylindrical and tapered. In case of tapered rollers, foundation is perfectly horizontal. The diameter of roller increase from feeding side to discharge side. This is done to increase pressure gradually on the pulse grains which helps in gradual dehusking. The cylindrical roller machines are installed at an inclination of 10-15° to help the forward movement of pulse grains inside the machine. Annular gap between the roller and the concave varies between ¾" to 1¾" (19-45 mm) depending upon the type of pulses being dehusked. The inlet and outlet of the roller machine can be adjusted for regulation of grain flow and retention time respectively. These rollers are available in different sizes from 250mm × 750mm to 350mm × 900 mm (10" × 30") to (14" × 36"). In case of tapered rollers, the roller dimension vary from (200 mm × 175 mm) × (8" × 7") × (24" to 14") × 300 × 900 mm) to (12" × 36") (1st dia × 2nd dia × length). The power requirement, capacity, roller size and speed of roller varies for different manufacturers.

In some small dal mills, Under Run Disc shellers (URD) or burr mills, are used for dehusking operation in place of Roller mills. However, here the yield of dal is lower by 5-10 per cent, besides getting inferior quality of dal.

To remove the husk with minimum scourage of cotyledon, the conditioned pulse grains are subjected to mild abrasion inside the roller machine, removing 10-25% of husk in one pass. Some of the cotyledon mass is also scoured resulting in loss of dal yield. After passing the grain lot once or twice through the roller machine, the shelled husk, cotyledon powder, brokens and splits are separated out by Air-screen cleaners. Depending upon the intensity of husk adhering to cotyledon, 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. For example, in case of arhar, 350g of oil and 3kg of water per quintal is applied in first round while it is reduced to 200 to 150g of oil and 2 to 1.5 kg of water in second and third pass respectively. In case of hard-to-dehusk pulses like arhar, moong, urad, the number of passes through the roller machines vary between 4-8 times. In easy-to-dehusk pulses like bengal gram, lentil, kesari and peas, the number of passes vary between 2 to 4. More the number of passes through Roller mills, more will be the loss in dal recovery. Due to this, in general, in hard-to-dehusk pulses, the recovery is between 70-75% while for easy-to-dehusk pulses, it varies in between 78-85%.

- v. **Splitting:** This operation comprises of two steps namely loosening the bond between the cotyledons and splitting. For loosening of bond between the two cotyledons, water at the rate of 1-5 kg/quintal is applied to dehusked pulse grain (gota) and is stored for 2-12 hours and later sun-dried for 4-8 hours. At this stage, gota when hit against hard surface, splits in two, thus giving an indication that the lot is ready for splitting. In Calcutta, use of water in some mills is totally avoided for arhar gota splitting. Here sun-drying at day and humid atmospheric exposure at night for 3-4 days helps in loosening the bond.

For splitting, several machines like under-run-disc sheller (URD), impact machine (Phatphatia), roller mill, and hitting the gota against the metal sheet at discharge side of bucket elevator are used. Carborundum number for URD sheller varies from pulse to pulse. In phatphatia machine, 8-12 M.S. flat bars (1"×1/8") welded to rotating shaft (300-600 rpm) split the gota moving inside the horizontal drum (18" dia×30" – 24" dia × 30" dia × length) by impact force. In case of bucket elevator, the discharge chute is fitted with an inclined M.S. flat sheet in such a way that the gota being discharged by centrifugal force, hits this flat and gets split. At many places, dropping the conditioned gota against cemented floor from a height of 3-4 meters (roof) splits the grains.

As such in this operation, there is no significant loss of cotyledons mass. However the embryo attached to two cotyledons breaks away, thereby, causing a loss in dal recovery by 1.5 to 2%.

- vi. Polishing:** This is the last operation before packaging. In this operation, dal is imparted with a glazing appearance to improve its consumer's acceptance and market value. Depending upon the need, different materials like water, oil, soapstone powder and 'SELKHARI' powder are applied to dal surface. In some cases, removal of sticking powder from dal surface is considered sufficient to improve its surface glaze.
- a) **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.
 - b) **Water Polish:** This is used for urad, chana, masoor and arhar. In this 1-1.5 kg of water per quintal of dal is applied while passing it through anyone of the polishers mentioned above.
 - c) **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.
 - d) **Nylon Polish:** In this, 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. In west Bengal, a set of screw conveyors arranged in a battery for repeated rubbings is used. The flights and shafts are covered with nylon rope to impart gentle rubbing. This is used mainly for masoor, moong, tur and urad. In Agra, field peas (without milling) are given polish with 'selkhari' powder (1.0-1.5 kg/q) by passing through Rubber Roll polisher. For polishing field peas, it is first cleaned and graded. The bigger size peas (60-65%) are subjected to powder polish while the smaller sized peas (35-40%) are split. In South India, similar polishing is given to whole moong and urad.
 - e) **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 is considered to be popular in Gujarat. The storage life of this dal is short.

2.5 MILLING OF INDIVIDUAL PULSES

To give further clear picture of commercial milling, a flow diagram of milling of two pulses namely arhar and bengal gram (channa) by dry method is shown at Fig.5 and Fig. 6 respectively.

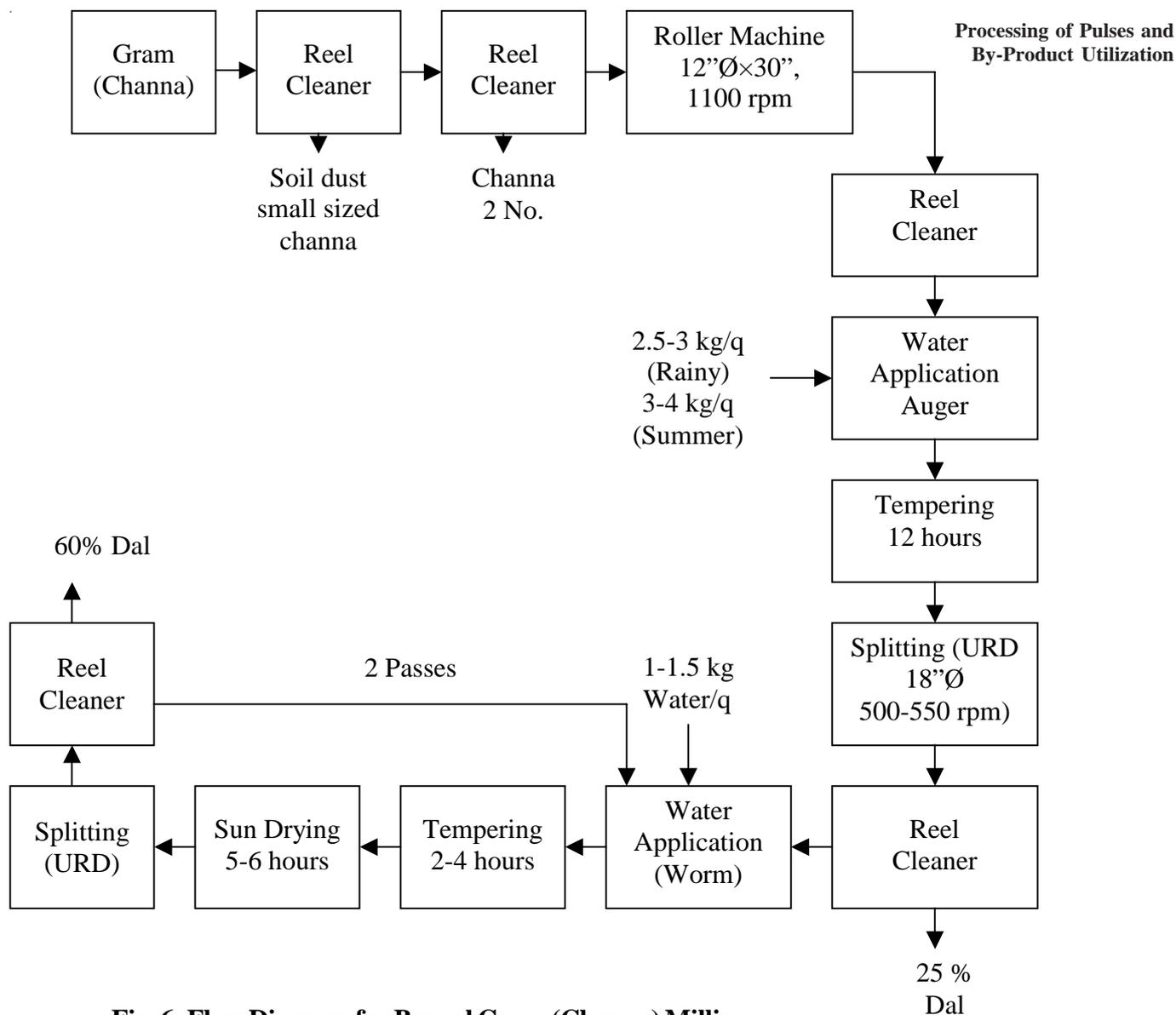


Fig. 6: Flow Diagram for Bengal Gram (Channa) Milling

2.6 CHUNI-BHUSI AS ANIMAL FEED

The chuni-bhusi is the mixture of broken dal and husk which is obtained during milling of pulses. As explained earlier, husk remains tightly glued to the kernel, in the pulse grain. If the husk is not properly loosened, the kernel is more abraded resulting in breakage of kernel in a form of small brokens and powder. It is mixed with husk and the mixture is termed as chuni-bhusi . As the mixture is not fit for human consumption, it is used as animal and poultry feed.

2.7 BESAN MANUFACTURE

Besan is made from chana dal (Bengal gram). It's production involves three major steps namely size reduction, sieving and packaging. Besan is made in rural areas and at home scale level in burr mills (*atta chakki*). Here, chana is ground to flour but size grading is not done. Capacities of such machines vary in between 50-100 kg per hour. Small dealers manufacturing 5-15 quintals of besan per day generally employ under-run disc shellers (30" dia disc, 275 rpm, 15 hp electric motor, 2 quintal/h capacity). Here too, size sieving is not considered necessary. Such dealers cater to the local requirement by supplying it directly to the retail shops in 20-50 kg bags.

Manufactures selling their besan under a particular brand at little higher cost generally employ Pulverizers (hammer mill) along with reel sieves. The reel sieve is generally fitted with a fine nylon cloth (112 mesh). It has a blower rotating on its axis at 350 rpm. This helps in blowing out the fine powder out of the reel which is collected at one end by auger. The coarse powder discharged at other end is fed back to hammer mill by a bucket elevator. A hammer mill running with a 5 horse power electric motor has an average capacity of 2 q/h which can be fitted in an area of 580 sq. m. Recovery of besan is 98% with 2% loss occurring due to burning in mill as well as getting lost in air in form of dust.

2.8 PUFFING OF PULSES

Puffing and toasting of pulses is practiced all over the country. These products are traditionally used as snacks. It makes dal lighter with porous structure making it soft to eat. The increase in size is 1.5 to 2 times of its original size.

Bengal gram and peas are best suitable for puffing. The grains are first soaked in water for short duration (1-3 minutes), mixed with sand heated to 250°C and toasted for 15-25 seconds with agitation. After sieving off the sand, the grains are dehusked between a hot plate and a fast rotating rough roller. The yield of puffed product is about 65-70% by weight.

In a cottage industry, water addition and roasting of grains with sand are done manually in shallow iron pans followed by dehusking and hand winnowing. In large commercial process, previously heated and cooled grains are taken in a perforated bucket, dipped in water and charged through a conveyor to a heated revolving drum containing heated sand (250-260°C). Conveyor helix are provided in the drum to take the mixture of sand and grain poured at a specific speed to allow enough time for roasting. The grain remains in the sand for 25-30 seconds till it reached the exit end of the drum where it is screened over a wire mesh and passed on to a fast rotating roller. The sand is conveyed back to the feeding end of the drum through an outer shell having a helix in the reverse direction while it gets heated up and used all over again and again. The roasted grains get dehusked with a mild impact between knurled roller (4-5 inches dia and 3000-4000 rpm) and a hot M.S. plate (heated by fire wood or any convenient fuel), placed parallel to Roller in an inclined position. Most of the grains get dehusked, puffed and split. The husk is aspirated off and the puffed grains size graded in suitable sieve.

2.9 PAPAD MANUFACTURE

As you know Papad is a thin round rolled sheet of dried papad flour. Papad flour is made by combining few pulses flours like urad, moong etc. In some papad flours, gram pulse is also added. Rolling papad is generally a manual operation done by women folks. The papad flour along with spices like black pepper, jeera, soda and salt is tightly kneaded with water and thus rolled tightly on——(*Chakla- belan*). A lady can roll about 2.5 to 4 kg of papad a day.

CFTRI has developed a papad mill where kneaded papad flour is pressed in round thin sheet by keeping the dough in between two polyethylene sheets and placing it in between two parallel discs. One disc is pressed against other with the help of foot through a lever. This way 2 to 3 inches papads are made. The capacity this machine is about 500 papad an hour.

There is another Rolling type machine available in the market. It is operated by a one horse power electric motor. It rotates one horizontal disc at about 350rpm.

Two pins mounted over a shaft can be pressed against this disc through foot . This way the dough placed in between two polyethylene sheets and kept in between this disc and two pins gets rolled in during diameter (4-8 inches) in 6-8 seconds when motor is operated and pins are gradually pressed down. This papad has a uniform thickness all throughout. By acquiring skill, one can make about 500 papad (5kg) in an hour.

Check Your Progress Exercise

Note: a) Use the spaces given below for your answers.

b) Check your answers with those given at the end of the unit.

1) What do you mean by pulse milling?

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2) Describe the methods of pulse milling.

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3) Describe Home Scale method of pulse milling

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4) Describe Commercial Scale methods of pulse milling

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5) Why loosening of pulse is essential in pulse milling?

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6) Which machines are used for dehusking at home scale and commercial scale of pulse milling?

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7) Why polishing of dal is done. Describe two methods of dal polishing?

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8) Describe arhar milling by dry method with the help of flow diagram.

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9) Describe Bengal gram milling with the help of flow diagram. How it is different from arhar milling.

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10) What is the by product of pulse milling, and its use?

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11) How is besan manufactured? Describe the process?

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12) What is puffing of pulses? Why it is done? Describe method of puffing of pulses

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13) Describe the machines used for rolling papad.

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14) Describe the papad rolling machine developed by CFTRI, Mysore.

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2.10 LET US SUM UP

In this unit , we have learnt about the methods of pulses milling viz. wet and dry method. In dry method, it is the oil which loosens husk while in wet method, it is water which dilutes gum in between husk and kernel which makes it easy to dehusk pulses. In wet method, the cooking quality of dal is affected. Due to this, the dry method of milling is mostly practiced in country.

In Home Scale method, pulses are milled by loosening the husk by water and oil and later dried in sun for one or two days. Later they are dehusked in hand operated stone mill. The husk is separated from dehusked dal by hand sieves and winnowing soopa. In commercial methods, home scale methods are adopted but at larger scale by using mechanical power. In general, pulse milling is done in three steps namely loosening of husk, dehusking and splitting of pulses. To improve the market value of dal, it is polished by various methods.

Besan a product of chana dal is manufactured by hammer mill. Puffing of pulses is done to make it soft to eat. It is done by water conditioning and roasting the pulses. In present days, papad is being manufactured at industrial level. In this, papad flour along with required spices is kneaded with electric motor operated kneading machine. The rolling of dough is done manually by female workers including other operations like sun drying and staking. The weighing and packaging is later done in industry premises. For papad rolling, two machines are also available viz. Press type and Rolling type papad machine.

2.11 KEY WORDS

Pulses : Grain legumes which are cultivated for their seeds and are called pulses. The seeds are used for human and animal consumption.

Puffing of pulses : In this process, grains are exposed to heat which causes the grains to burst open.

Pulses : Terminology

<u>English Name</u>	<u>Botanical Name</u>	<u>Hindi Name</u>
Bengal gram	Cicer arictinum	Channa
Black gram	vignamungo	Urad
Chicking vetch	Lathyrus sativus	Kesari
Green gram	Vigna radiate	Mung
Kidney bean	Vigna aconitifolia	Moth
Peas	Pisum sativum	Matar
	Vararvense	
Redgram (pigeon pea)	Cajanus cajan	Tur, Arhar
Soybean	Glucine wax	Soyabean

2.12 SOME USEFUL REFERENCES

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2.13 ANSWERS TO CHECK YOUR PROGRESS

1. Generally, pulses are consumed in dehusked and split form which is termed as dal. The operation of dehusking and splitting pulses is termed as Dal milling.
2. In home scale as well as commercial practice, there are two methods of milling:
 1. Wet Method
 2. Dry Method

Wet Method : Here pulses are soaked in water for 2 to 8 hours prior to drying. In hard to dehusk pulses like arhar (pigeonpea, tur), urad (black gram) and moong (green gram), the soaked pulses are treated with red earth before it is dried. After drying, the pulses are subjected to dehusking and splitting which has been explained through floor diagram at

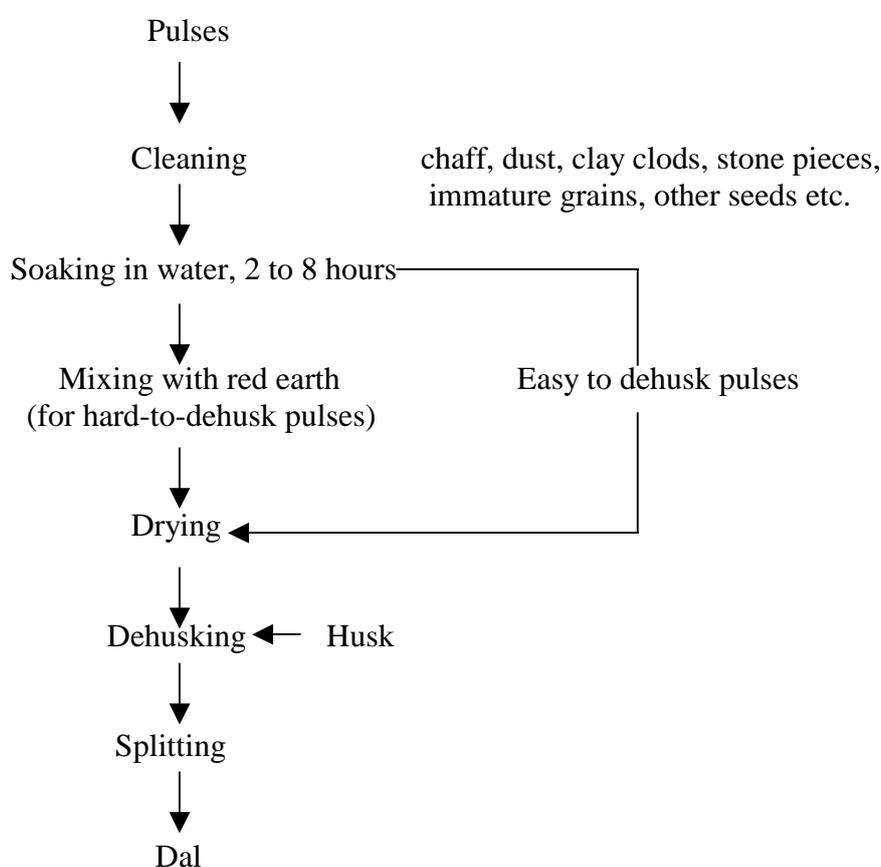


Fig. 1A: Wet Method of Pulses Milling

Dry Method : Here, after cleaning and grading, the pulses are subjected to pitting. Operation 'pitting' means producing scratches, dents and cracks on the hard seed coat by passing the pulses through Roller Dehusker. Now the pitted pulses are smeared with 150-250g of oil per quintal of pulses, stored for 12 hours to 3 days. During this period, oil diffuses in between the husk and cotyledon which loosens the husk. To further loosen the seed coat, it is treated with 2.5 to 3.5 kg of water per quintal of pulses and stored overnight. Next day, after drying and cooling, it is subjected to dehusking and splitting as shown through flow diagram at Fig. 2A.

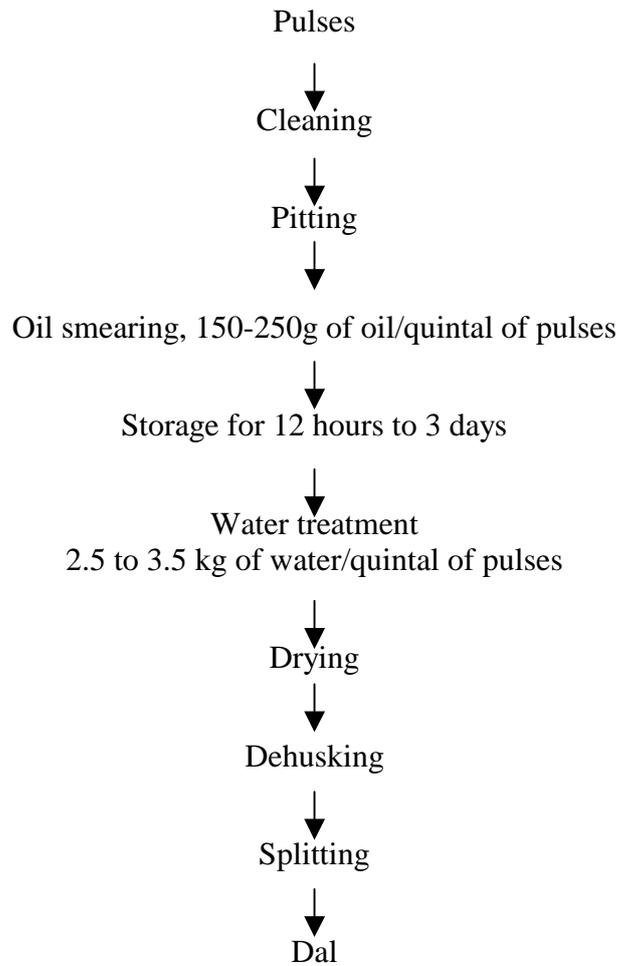
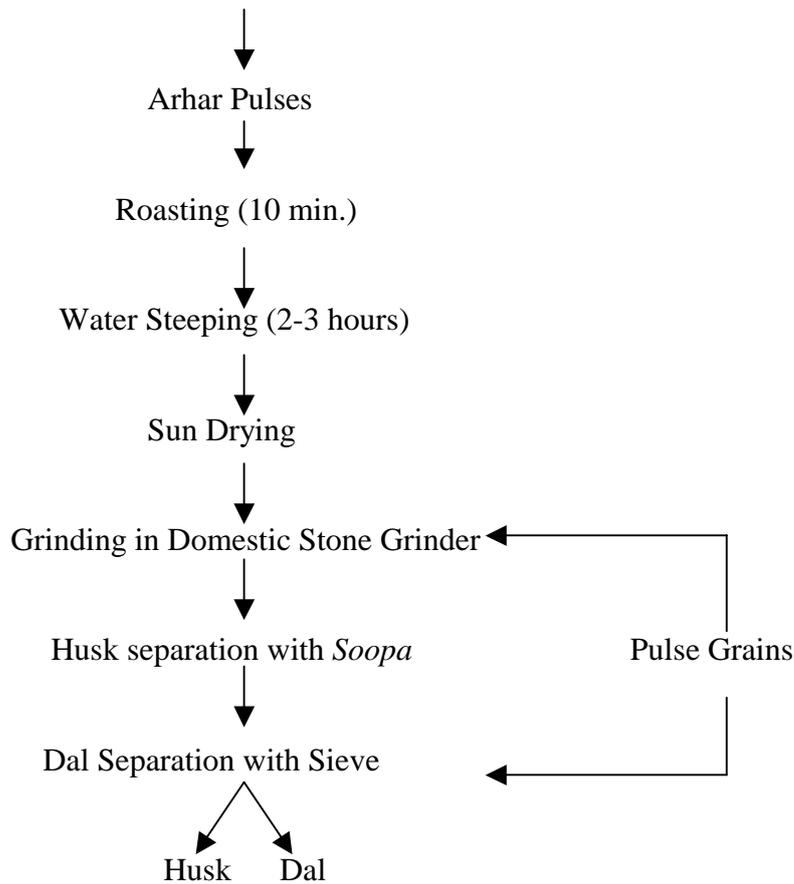


Fig. 2A: Dry Method of Pulses Milling

3. The oldest technique of processing pulses on home scale is to pound it in a mortar and pestle. Here, the operation is done in two steps, firstly to loosen the husk by wet or dry method and secondly removal of husk followed by cleaning. The first step of loosening the husk is achieved by treating the pulses with oil and or water, storing over night followed by sun drying. Later it is dehusked in a mortar pestle or by a hand operated stone mill (*hand chakki*). The husk is then separated out by hand sieves and winnowing *soopa*.

The Home scale milling methods vary from region to region and pulses to pulses. The general milling methods adopted for arhar and gram in Uttar Pradesh and Madhya Pradesh are explained through flow diagrams given at Fig. 3A and Fig. 4A in some regions, in hard legumes like arhar, where husk is tightly attached to cotyledons, the soaked grains are treated with red earth paste, stored for some time and later sun dried. Dehusking on home scale process is accomplished by pounding the grains in mortar and pestle or grinding in a hand operated stone mill (*hand chakki*). The husk is separated out by hand sieving and winnowing while polishing is usually not carried out .



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

4. Processing of pulses on medium and large scale is a commercial activity of millers. Though the basic principle for processing is same but the procedure for preconditioning treatment and dehusking varies. In general, the pulses have to undergo following unit operations for milling:
- i Cleaning and grading
 - i Drying
 - iii Loosening of husk
 - iv Dehusking
 - v Splitting
 - vii Polishing

The flow diagram of milling of arhar by dry method shown at Fig. 5A is an example of commercial pulses milling

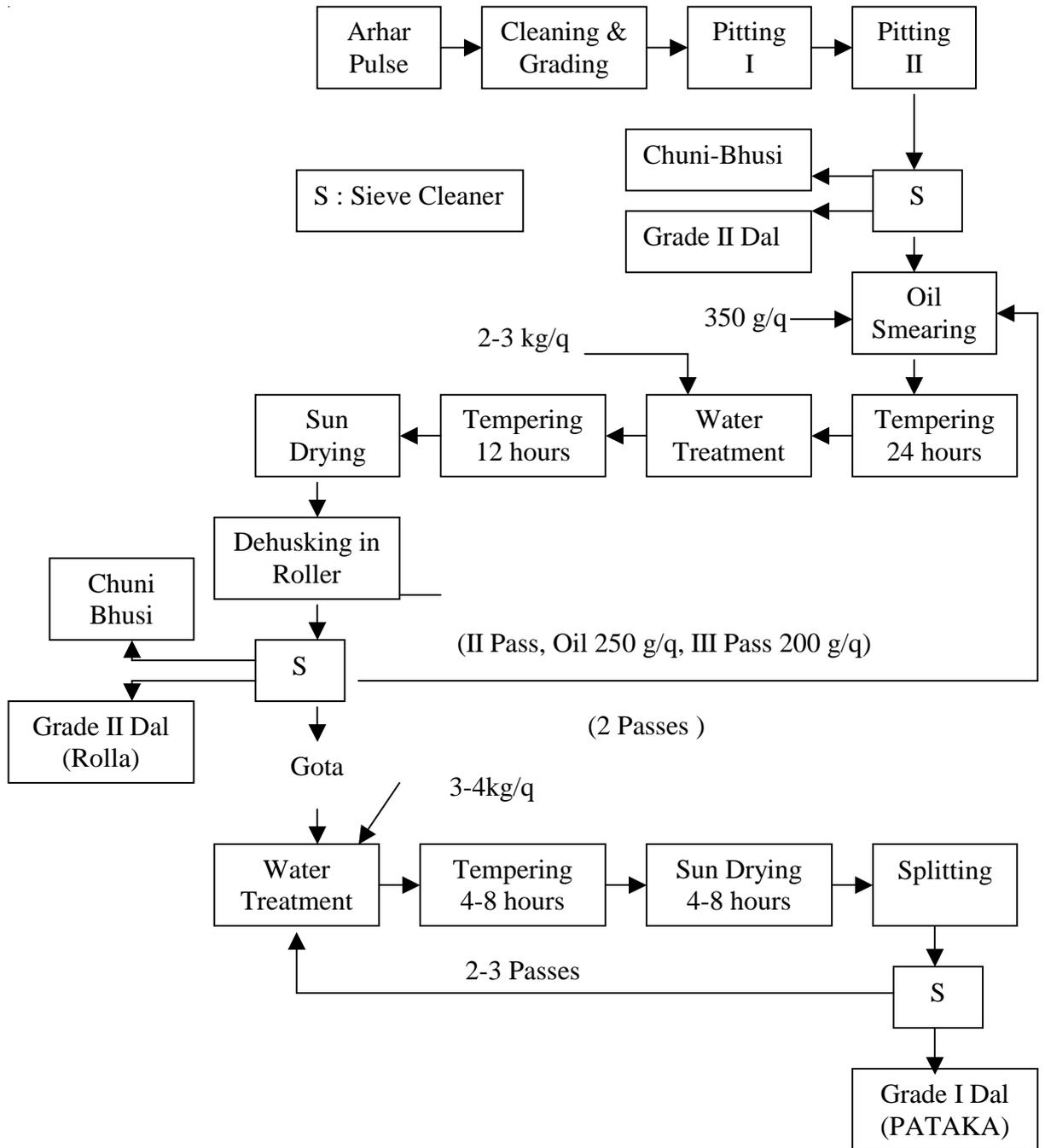


Fig. 4A : Arhar Milling (Wet Method)

5. **Loosening of Husk:** Loosening of husk is done to remove husk from kernel without breaking the kernel. Effectiveness of this operation decides the total recovery and quality of milled dal.
6. In Home scale methods, following machines and equipments are used:
 - (i) Hand grinding stone
 - (ii) Soopa
 - (iii) Clean pucca floor for sun drying
 in commercial methods, following machines and equipments are used:
 - (i) 2 Screen- Air- Cleaner-cum- graders

- (ii) Roller Dehusking machines
- (iii) Worm mixture for oil smearing
- (iv) Bucket Elevator
- (v) Phatphatia machine for splitting the GOTA
- (vi) Polisher for polishing dal
- (vii) Floor for sundrying of pulses and dal
- (viii) Weighing machines
- (ix) Bag Closure

7. Polishing is done to improve the appearance of dal surface to increase its market potential and market value. This is the last operation before packaging. In this operation, dal is imparted with a glazing appearance to improve its consumer's acceptance and market value. Depending upon the need, different materials like water, oil, soapstone powder and 'SELKHARI' powder are applied to dal surface. In some cases, removal of sticking powder from dal surface is considered sufficient to improve its surface glaze.

- (a) **Removal of Powder/Dust:** Cylindrical rollers mounted with the rubber mats or leather strips or cylindrical/ tapered emery rollers are used for 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.
- (b) **Water Polish:** This is used for urad, chana, masoor and arhar. In this 1-1.5 kg of water per quintal of dal is applied while passing it through anyone of the polishers mentioned above.
- (c) **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.
- (d) **Nylon Polish:** In this, 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. In west Bengal, a set of screw conveyors arranged in a battery for repeated rubbings is used. The flights and shafts are covered with nylon rope to impart gentle rubbing. This is used mainly for masoor, moong, tur and urad. In Agra, field peas (without milling) are given polish with '*selkhari*' powder (1.0-1.5 kg/q) by passing through Rubber Roll polisher. For polishing field peas, it is first cleaned and graded. The bigger size peas (60-65%) are subjected to powder polish while the smaller sized peas (35-40%) are split. In South India, similar polishing is given to whole moong and urad.

8. Describe arhar milling by dry method with the help of flow diagram

A flow diagram of arhar milling) by dry method is shown at Fig. 5A.

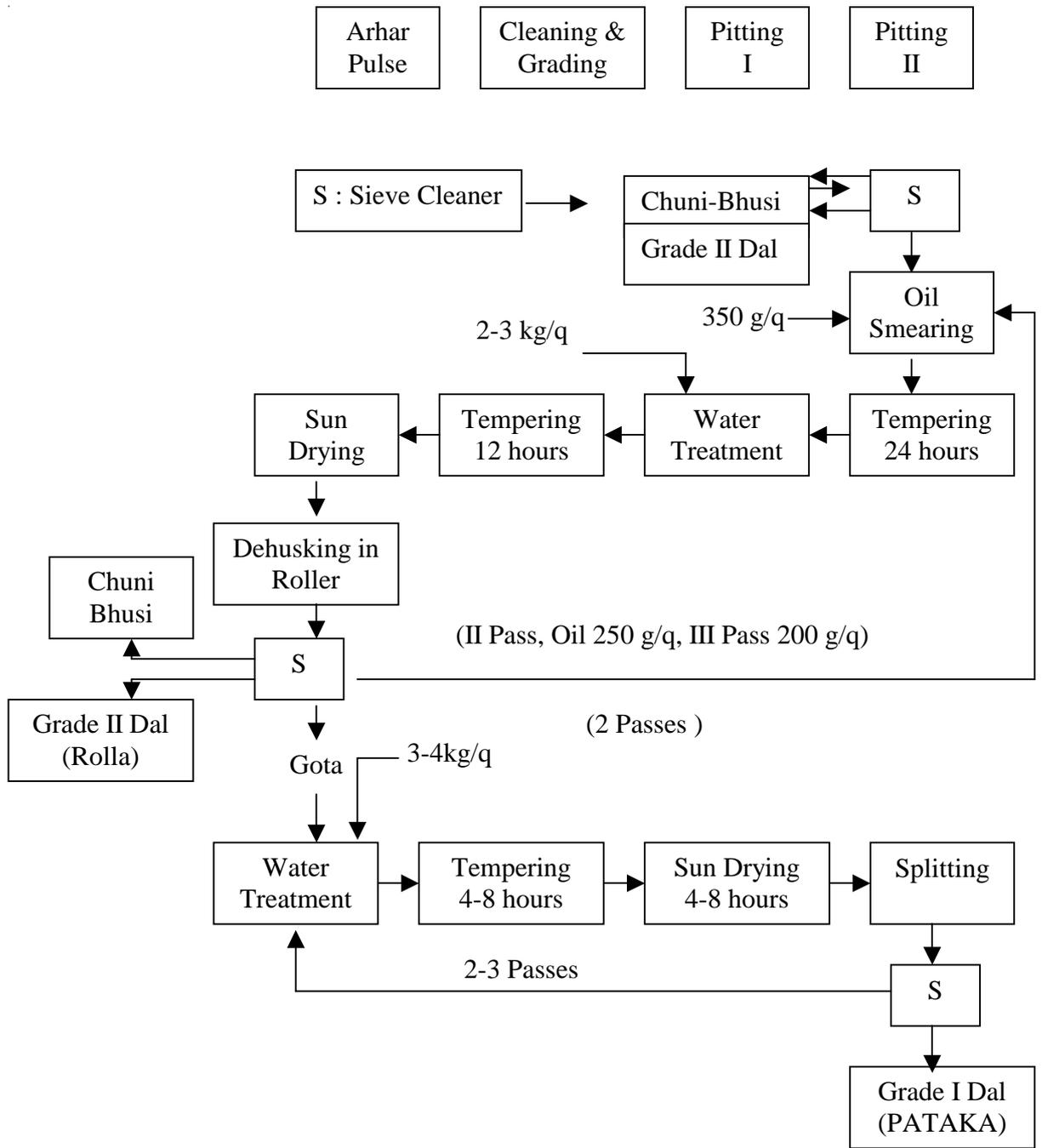


Fig. 5A : Arhar Milling (Dry Method)

9. Fig. 6A gives the Flow sheet for Bengal gram milling by Dry method.

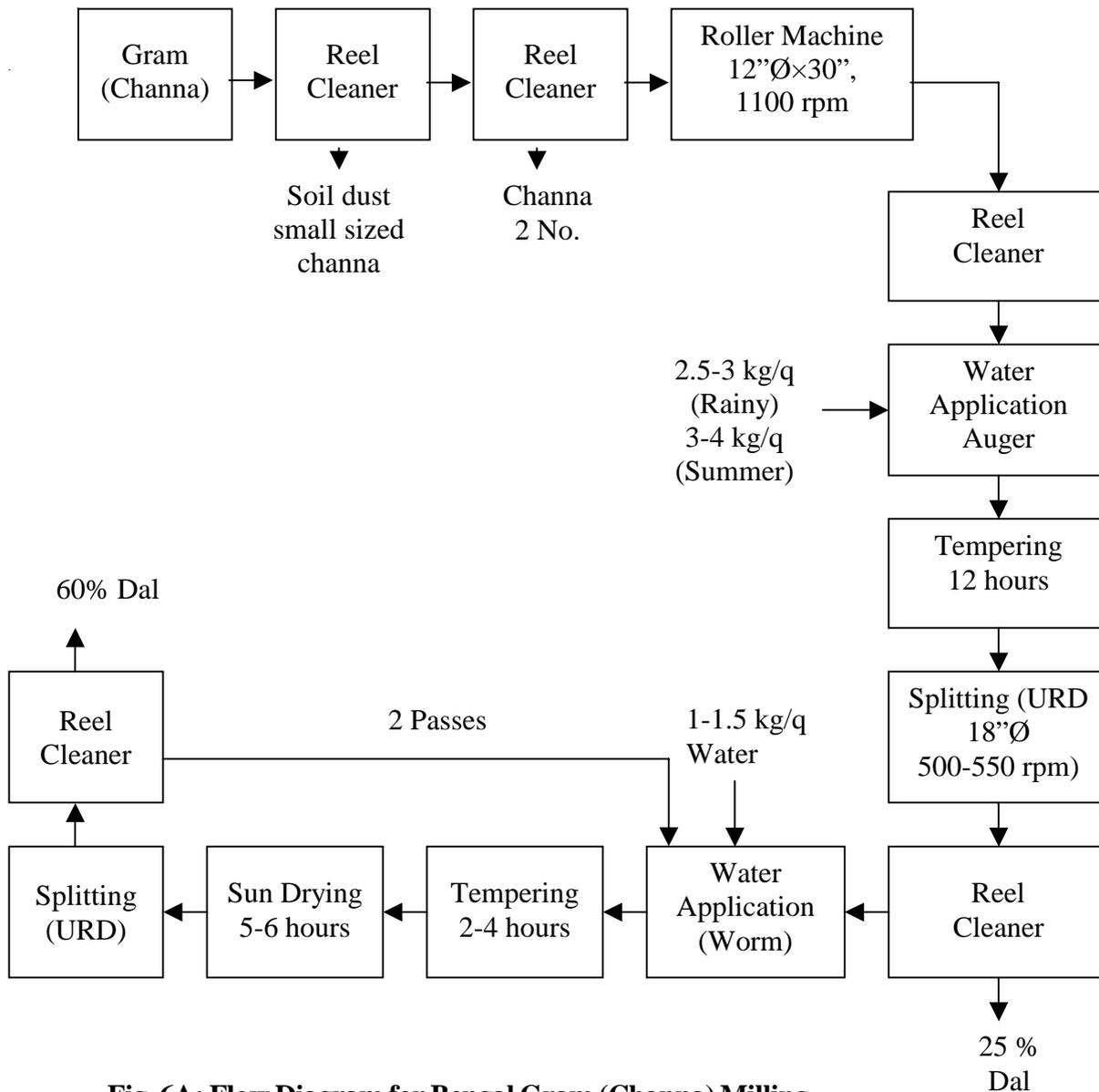


Fig. 6A: Flow Diagram for Bengal Gram (Channa) Milling

Arhar pulse is difficult to mill and thus requires special efforts to mill. Here, application of oil has to be done several times before it is fully dehusked. In Bengal gram, husk is easy to remove and thus only water application is sufficient.

10. The by product of pulses milling is chuni-bhusi. It is the mixture of broken dal and husk which is obtained during milling of pulses. As the mixture is not fit for human consumption, it is used as animal and poultry feed.

11. Besan is made from chana dal (Bengal gram). It's manufacture involves three major steps namely size reduction, sieving and packaging. Besan is made in rural areas and at home scale level in burr mills (*atta chakki*). Here, chana is ground to flour but size grading is not done. Capacities of such machines vary in between 50-100 kg per hour. Small dealers manufacturing 5-15 quintals of besan per day generally employ under-run disc shellers (30" dia disc, 275 rpm, 15 hp electric motor, 2 quintal/h capacity). Here too, size sieving is not considered necessary. Such dealers cater to the local requirement by supplying it directly to the retail shops in 20-50 kg bags.

Manufacturers selling their besan under a particular brand at little higher cost generally employ Pulverizers (hammer mill) along with reel sieves. The reel sieve is generally fitted with a fine nylon cloth (112 mesh). It has a blower rotating on its axis at 350 rpm. This helps in blowing out the fine powder out of the reel which is collected at one end by auger. The coarse powder discharged at other end is fed back to hammer mill by a bucket elevator. A hammer mill running with a 5 horse power electric motor has an average capacity of 2 q/h which can be fitted in an area of 625 sq.ft. Recovery of besan is 98% with 2% loss occurring due to burning in mill as well as getting lost in air in form of dust.

12. Puffing of pulses means to increase the size of individual pulses grains through water application and heat treatment. These products are traditionally used as snacks. It makes dal lighter with porous structure making it soft to eat. The increase in size is 1.5 to 2 times of its original size.

Bengal gram and peas are best suitable for puffing. The grains are first soaked in water for short duration (1-3 minutes), mixed with sand heated to 250°C and toasted for 15-25 seconds with agitation. After sieving off the sand, the grains are dehusked between a hot plate and a fast rotating rough roller. The yield of puffed product is about 65-70% by weight.

In a cottage industry, water addition and roasting of grains with sand are done manually in shallow iron pans followed by dehusking and hand winnowing. In large commercial process, previously heated and cooled grains are taken in a perforated bucket, dipped in water and charged through a conveyor to a heated revolving drum containing heated sand (250-260°C). Conveyor helix are provided in the drum to take the mixture of sand and grain poured at a specific speed to allow enough time for roasting. The grain remains with the sand for 25-30 seconds till it reached the exit end of the drum where it is screened over a wire mesh and passed on to a fast rotating roller. The sand is conveyed back to the feeding end of the drum through an outer shell having a helix in the reverse direction while it gets heated up and used all over again and again. The roasted grains get dehusked with a mild impact between knurled roller (4-5 inches dia and 3000-4000 rpm) and a hot M.S. plate (heated by fire wood or any convenient fuel), placed parallel to Roller in an inclined position. Most of the grains get dehusked, puffed and split. The husk is aspirated off and the puffed grains size graded in suitable sieve.

13. Rolling type machine is operated by an electric motor. It rotates one horizontal disc at about 350rpm. Two pins mounted over a shaft can be pressed against this disc through foot. This way the dough placed in between two polyethylene sheets and kept in between this disc and two pins gets rolled in during diameter (4-8 inches) in 6-8 seconds when motor is operated and pins are gradually pressed down. This papad has a uniform thickness all throughout. By acquiring skill, one can make about 500 papad (5kg) in an hour.
14. CFTRI has developed a papad mill where kneaded papad flour is pressed in round thin sheet by keeping the dough in between two polyethylene sheets and placing it in between two parallel discs. One disc is pressed against other with the help of foot through a lever. This way 2 to 3 inches papads are made. The capacity this machine is about 500 papad an hour.