Ministry of Food Processing Industries
Government of India

NIFTEM
Knowledge. Innovation. Outreach

PROCESSING OF PULSES

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PM Formalisation of Micro Food Processing Enterprises Scheme (PM FME Scheme)

INTRODUCTION

Pulses are one of the extensively consume crop across the world because of availability and low cost. On tracing the consumption pattern, it is very next to cereals. Pulses belong to "*Leguminoseae*" family(Lal, 2007).

According to FAO, Pulses are merely defined as dry edible seeds harvested from crop belonging to *leguminoseae* family.

Most common variety of pulses grown in India is chickpea, mung bean, black gram and pigeon pea.

India also imports pulses from Canada, USA, Myanmar and Australia.

INDUSTRIAL OVERVIEW

- Pulses are defined as dried edible seeds of cultivated legumes
- Pulses occupy important place in human diet
- They serve as major sources of dietary protein & energy
- Pulses are consumed in its dehusked and split form
- This processed form of pulse is termed as dal
- Pulses are generally consumed in the form of Dal

INDUSTRIAL OVERVIEW

- Pulse milling (Dal Milling) is accomplished in three major steps
- Namely: loosening of husk, dehusking and splitting of pulses
- Traditional methods for processing of pulses were resource intensive
- Modern technologies for pulse processing have replaced old methods
- Various methods are employed for pulse/Dal Mill (Tur Dal)ing
- Two broad classifications are wet & dry milling methods

MARKET POTENTIAL

- Global Pulse Market size was 115.3 Million Tons in 2019
- Expected to Grow at CAGR of 4.5% from 2020 to 2025
- It’s projected to reach 143.7 Million Tons by 2025
- Indian Pulse Market Size was 24.7 Million Tons in 2018
- Market Drivers:
  - Increase in demand of High Protein Foods
  - Increasing Population
  - Increasing Pulse Production

IMPORTANCE OF PULSES

- Cheapest source of protein
- Has ability to fix nitrogen and also supports growth of adjacent crops by fixing nitrogen.
- Decreased carbon footprint and water footprint.
- Can be used for animal feed.
- Emerging substitute to ethanol in fuel.

NUTRITIONAL ASPECT

- Pulses also have carbohydrate (50-55%) but these are digested at slow rate so has low Glycemic Index.
- Pulses are storehouse of dietary fibre. In about half serving of pulses, 7g of fibre is present.
- Consuming pulses (Deficient in tryptophan, methionine and cysteine) and cereals (Deficient in lysine) together help consumer to balance their nutrition profile and ingest high quality protein.
- Pulses are abundant source of micronutrients such as selenium, zinc, niacin, folate and riboflavin.
- Pulses are dense in vitamin A and E.
- Germinated legumes are rich in vitamin C and have enhanced absorption of all minerals.
- Pulses are free from cholesterol, gluten and are not famously known as food allergen.
- Exhibits anti-oxidant activity and scavenges free radical.

IMPORTANT FUNCTIONAL ATTRIBUTES OF PULSES

- Functional properties determine the behavior of a substance in food system during processing, storage and ingestion.

- Factors like polarity, size of molecule, conformation and sequence of amino acids have critical effect on functional attribute of pulse protein. These properties are efficiently exploited by food industry for development of many more novel food products.

- **Solubility** is a critical parameter and sometime a pre-requisite for other properties which are used in food industry.

- Polar amino acids are related to WAC and Non polar amino acids related to FAC. Generally pulse protein is found to have high **FAC** value (desirable as it increases palatability of food) and **WAC** value ranging from 1.3 -3.5g/g. This property greatly affects organoleptic quality of food.

- Due to the amphiphilic nature of protein, they make for an excellent **emulsifier** in many food formulations.

- Albumin rich fraction of pulse protein is found to be an excellent **foaming agent** (pea and lupin) almost a suitable counterpart for egg and soy.

- Protein obtained from lupin has weak **gelling property** but possess excellent thermal stability.

POST HARVEST LOSSES

- Pulses are non-perishable crop but because of high protein content they are susceptible to attack by insects and pests if not stored properly.

TABLE 1 : LOSSES AT DIFFERENT STAGES OF POST HARVEST SYSTEM

STAGE	TYPE OF LOSS
After Harvesting	Pest or rodent attacks
Drying	Insufficient drying leads to microbial attacks (mould growth)
Threshing	Inappropriate threshing leads to shattered grains and broken pulse grain attracts more insect infestation.
Storage	Improper storage conditions are thriving place of insects, rodents, pests and microbes
Milling	Increased broken grains and powdered pulses
Transportation	Loss in weight of product
Packaging	Defective packing leads to loss in quantity and quality of crop

HOW TO CURB POST-HARVEST LOSS

Few preventive measures can be adopted by pulse farmers to curb these losses:

1. Harvesting should be done when crop reaches maturity
2. Harvesting method employed should be appropriate.
3. Improved technology and equipment should be used.
4. Modern processing techniques should be used.
5. To save money, cleaning and grading should be done at low price.
6. Excellent packaging technology should be used.
7. Proper storage conditions.
8. Proper and efficient transportation and handling system.

PROCESSING OF PULSE

- Pulses are slow to cook, has low digestibility and possess many anti-nutritional factors which hinders the absorption of nutrients. To overcome these cons of pulses, processing is done to improve texture, taste, and flavor, bio-availability of nutrients, decrease anti-nutritional compounds, enhanced anti-oxidant activity and decreased microbial activity. Few processing techniques generally undertaken are splitting, soaking, germination, drying, roasting, fermentation and cooking.
- Processing affects the physical, chemical and nutritional makeup of pulses and a good understanding on the changes brought about through processing can help use processing techniques to their fullest potential.

1. ROASTING : In roasting, heat from a hot surface is given to food and simultaneously moisture from food is let out into air and then moist air is exhausted out from roaster. After moisture removal, series of browning and caramelization reactions follows.
2. SOAKING : In soaking, simply the pulse grains are soaked in tap water in ratio 1:5 v/v for 12 hours at room temperature. After 12 hours, grains are washed properly and drained.
3. COOKING: cooked using thermal processing techniques to bring in changes in texture, aroma, taste, flavor and nutritional availability. In this review, main focus would be on steaming, boiling and autoclaving or pressure cooking of pulses.
4. GERMINATION: The germination process is initiated when seed breaks out from its inactive state when it comes in contact of water. When out of dormant stage bioactive compound becomes alive and starts synthesizing more phytochemicals and phenolic which have health promoting benefits.
5. FERMENTATION: Fermented pulses has reduced level of ANFs, improved flavor, texture, taste, aroma, increased synthesis of amino acids and bioactive components thus enhancing digestibility of pulses.

PROCESS & MACHINERY REQUIREMENT

Flow Chart:

Machine	Description	Machine Image
Horizontal Cyclone Separator	➢ It's used to separate particulate matter within an air suspension using there weight difference. ➢ Used in wide range of plants ranging from thermal power plant to food grain processing plant.	
Destoner:	➢ It's a machine designed to remove stones from the given product, which in this case are pulses. ➢ Widely used in different food grain	

PROCESS & MACHINERY REQUIREMENT

Flow Chart:

Machine	Description	Machine Image
Emery Roll Dehusker:	➢ It's a machine which utilizes emery rollers to remove outer skin of pulses. ➢ The pulse or grain is simply pressed in-between emery rollers to break otter shell to liberate inner Endosperm.	
Classifier Separator	➢ It's a machine which is used to separate whole dehusked pulse from husk. ➢ Aspirator type machines utilize compressed air for cleaning purpose.	

PROCESS & MACHINERY REQUIREMENT

Flow Chart:

Machine	Description	Machine Image
Lentil Splitting Machine	➢ It's a machine designed to split the whole dehusked pulse into two halves, locally called as chakki. ➢ Different type of arrangements are available but to achieve this splitting.	
Pulse Grader	➢ It's a machine used to separate pulses into unbroken, partially broken & broken dal. ➢ This machine has it's own vibrator arrangement, which along with appropriate sieve or grader sheet can be effectively used for grading.	

PROCESS & MACHINERY REQUIREMENT

Flow Chart:

Machine	Description	Machine Image
Filling and stitching Machine	➢ The Automatic Weighing and Packing Machine support the process of precise weighing and packaging of animal feed pellets. ➢ The machine weighs the product with accurate measures and fills these in gunny bags.	

PROCESS & MACHINERY REQUIREMENT

Additional Machine & Equipment:

Machine Name	Description	Description Image
Weighing balance	Used for weighing the raw material and other product	
Material handling equipment	Material handling equipment is mechanical equipment used for the movement, storage etc. work.	

PROCESS & MACHINERY REQUIREMENT

General Failures & Remedies:

S. No.	General Failures	Remedies
1.	Ball bearing failure of various machine	➢ Proper periodic lubrication of all bearings in various machines. ➢ Regular replacement of all bearing to prevent critical failuraes.
2.	Power Drive Overload	➢ Ensure proper weighing & metering specially in case of semi-automatic plant. ➢ Install warning sensor in buffer region of loading capacity to ensure efficient operation.

PROCESS & MACHINERY REQUIREMENT

General Failures & Remedies:

S. No.	General Failures	Remedies
3.	Mechanical Key Failure	➢ Ensure that mechanical keys are replaced as per there pre-defined operational life. ➢ Prevent Overloading.
4.	Loss of Interface	➢ This problem is dominant in newly established automatic plant, one must learn to maintain rules in plant & ensure no employee goes near transmission lines, unless authorised. ➢ Provide proper physical shielding for the connections.

PROCESS & MACHINERY REQUIREMENT

Composition and nutritional data for Pigeonpea

Major minerals, Ca, K, P, Mg, Na, and trace minerals, Cu, Fe and Zn are found in pigeon pea.

Th

❑ Protein - 22.3 %	❑ Calcium - 73 mg/100 g
❑ Fat - 1.7 %	❑ Phosphorus - 304 mg/100 g
❑ Minerals - 3.5 %	❑ Iron - 5.8 mg/100 g
❑ Fiber - 1.5 %	❑ Moisture - 13.4%
❑ Carbohydrate - 57.6 %	❑ Calorific value - 335 Kcal/100 g

PROCESS & MACHINERY REQUIREMENT

Export Potential & Sales Aspect:

- Grown as a food crop, pigeon pea is a tropical plant.

  containing high nutritional value which makes them suitable for diet supplements practically for protein deficient consumers.

  The persistent nature of the product to grow almost anywhere in the world allows the farmers to take multiple harvests.

  The pigeon pea market is expected to observe the highest growth owing to low price product demand coupled with high storage facility.

- India accounts for 33 percent of the world's area under pulses and 22 percent of production.

PROCESS & MACHINERY REQUIREMENT

Export Potential & Sales Aspect:

- Due to the mismatch between supply and demand for pulses (i e, shortage of supply) the prices of pulse crops increased sharply over the years
- To meet growing demand, India has been importing pulses in
- large quantities in recent years.
- long storages, advanced hybrid seed production technology, enhanced production capacity, and logistical infrastructure can full fill the demand of pulces in India
- To meet growing demand, India has been importing pulses in

Effect of processing on pulses (thermal processing)

- The physical structure of protein is denatured, volatile fatty acid is degraded and starch is gelatinized and broken down into simpler sugars.
- The amino acids and sugars combine together to bring about browning reactions which attributes to good aroma and flavor.
- The quality of protein is compromised as the during heat treatment heat labile amino acids are lost.
- Heat sensitive protease inhibiting enzymes are destroyed thus improving the digestibility of protein and their absorption.
- Phytate complex which bounds iron is destroyed by the use of heat treatment thus enhancing the absorption of iron.
- Thermal processing is efficient in destructing trypsin inhibitors, therefore aiding in increased absorption of iron.

- TPC (Total Phenolic content) in chick pea, pea and lentil it increased due to release of compounds possessing high reducing power. Phenolics have excellent resistance to diseases such as Diabetes type –II, CVD and metabolic disorders.
- Cooking process enhanced the release of carotenoid by 16.28 % and tocopherol to 66.67 % in lentil.
- Starch digestibility of pulses increases because of destruction of heat sensitive α-amylase inhibiting enzymes.
- Total flavonoid content in lupin and faba bean has exhibited 7 – 40% reduction. Similar reduction in flavonoid and isoflavone was observed in green gram.
- Aroma of pulses is improved because of Maillard reaction between amino acid and sugars. In thermal processing with help of dry heat, caramelization also occurs. Degradation of fatty acid into esters, aldehyde and ketones also evolve aroma. Type of amino acid participating in the process also affects the profile of aroma evolved. Temperature should be controlled as at very high temperature, pyrolysis occurs and this leads to formation of acrylamide which is a potent carcinogen and has bitter taste too.
- Fat absorption capacity of processed pulses enhances as more non-polar protein sites gets exposed due to denaturation. Heat treatment of pulses increases WAC, gelling and emulsifying property.

Effect of processing on pulses (non-thermal processing)

- Non thermal processing of pulses using soaking, germination and fermentation are ought to increase digestibility, nutritional availability and decrease ANFs. But the effect of these processes depends on the type of pulses and extent of time devoted to each processing technique.
- Thermal processing of chickpea decreased saponins level by 59% and it has been studied that consumption of diet rich in saponin decreases cardiovascular diseases and obesity. So there are other phytochemicals which are lost during thermal processing so to nullify it food processors are shifting their focus to non -thermal processing.
- Enhanced soluble phenolic in germinated sprouts and anti-oxidant activity also increased in proportion with soluble phenolic .
- Total Phenolic Content of germinated chickpea increased to 86 and 156 % on second and third day of germination.
- Greater reduction in polyphenol and tannin content.
- Germinated green gram resulted in highest amount of flavonoid and isoflavone.
- Germinated and freshly cooked pulse samples showed decreased amount of RS whereas cooked pulse which was refrigerated for a day showed higher concentration of RS. Similar results were observed in black gram and cowpea.
- In lactic acid bacteria fermented chickpea total phenolic content increased but chymotrypsin and amylase inhibiting enzymes remained active.

HEALTH BENEFITS OF CONSUMING PROCESSED PULSES

Pulses are in possession of numerous phytochemicals such as phenolic acid, saponins, phytochemical and flavonoids which put up a fight with many pathological diseases.

1. CANCER: Consumption of pulses or legume tends to meet Recommended Daily Intake of 25g of indigestible fibre. These indigestible fibre exhibited properties to reduce as well as stop development of cancer (colon and rectum) in humans. A study reported that women who took pulses twice in a week had lesser occurrence of breast cancer. Pulses are abundant in zinc which reduces oxidative stress related issue and increase immunity. Pulses are rich in selenium; selenium has reported to decrease risk of breast and stomach cancers. Saponins present suppress growth and spread of cancer cells in respiratory and gastrointestinal tract. Trypsin and protease inhibitors present in pulses possess anti proliferative activity.

2. CVD : High fibre content of pulse reduces occurrence of CVD and keeps blood pressure at normal. Isoflavone in pulses reduces hypertension. In kidney beans, isoflavone facilitate the production of cardio-protective hormone (adiponectin) which reduced heart attacks.

HEALTH BENEFITS OF CONSUMING PROCESSED PULSES

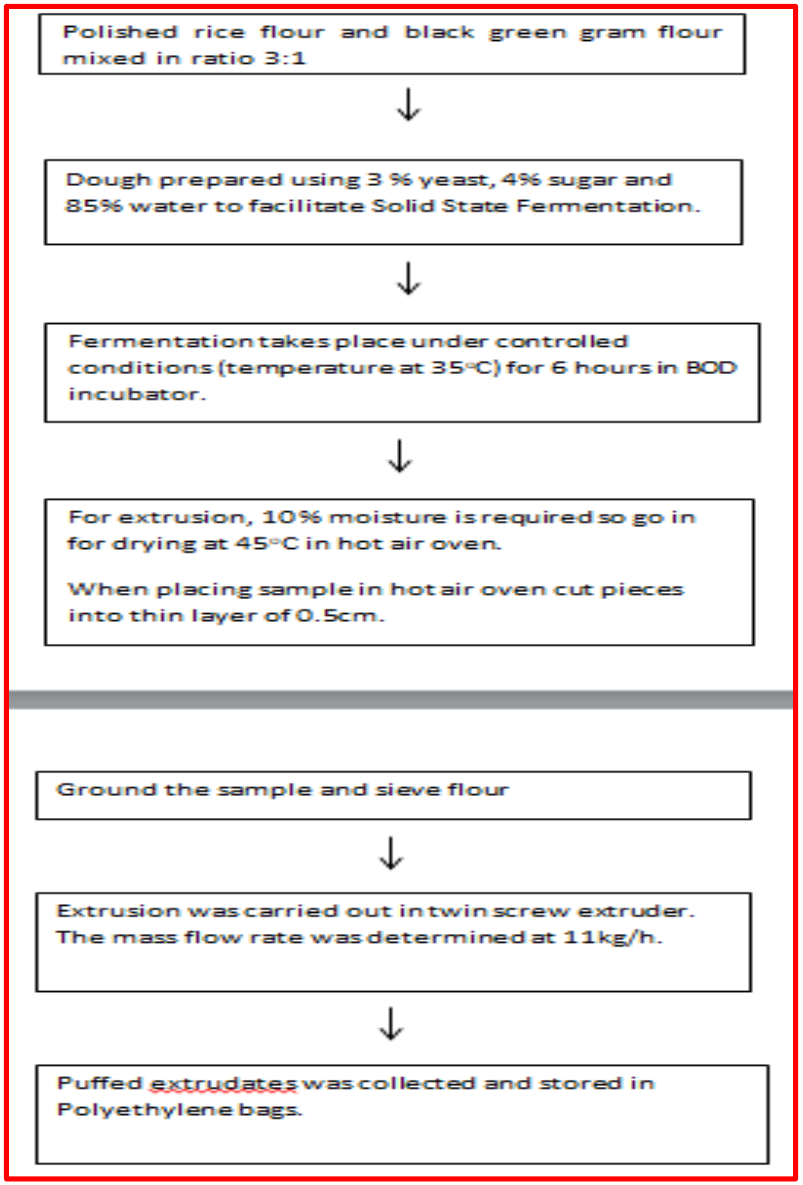
3. DIABETES : Cooked flor de mayo bean (FMB) showed anti diabetic effect by reducing blood glucose, increased insulin level and lowering creatinine. Fortified product also possessed high anti-oxidant activity and low GI. Resistant starch in pulses results in enhanced production of insulin thus controlling diabetes.

4. OBESITY: These fibers reduces calorie intake as it gives satiety. Study from NHANES concluded that individual who consumed pulses on daily basis had 22% less chance of being obese.

5. HIV: Lectin is carbohydrate binding protein which is natural self-defense mechanism of plant (majority pulses and legumes). Lectin in research studies have shown to inactivate HIV-1 reverse transcriptase which is responsible for production of viral DNA which causes mutation to original human DNA. Lectin is also reported increase immunity of individuals.

6. INFLAMMATORY DISORDERS: Mice fed on diet rich in navy and black beans presented decrease in inflammatory diseases especially colitis. There was also increase in anti-inflammatory cytokine when compared to control group. Longer life expectancy was recorded in pulse consumers. Studies have proven that adults who took pulses or beans on regular basis had low or no occurrence of depression and anxiety.

EXTRUDED PUFFED SNACK

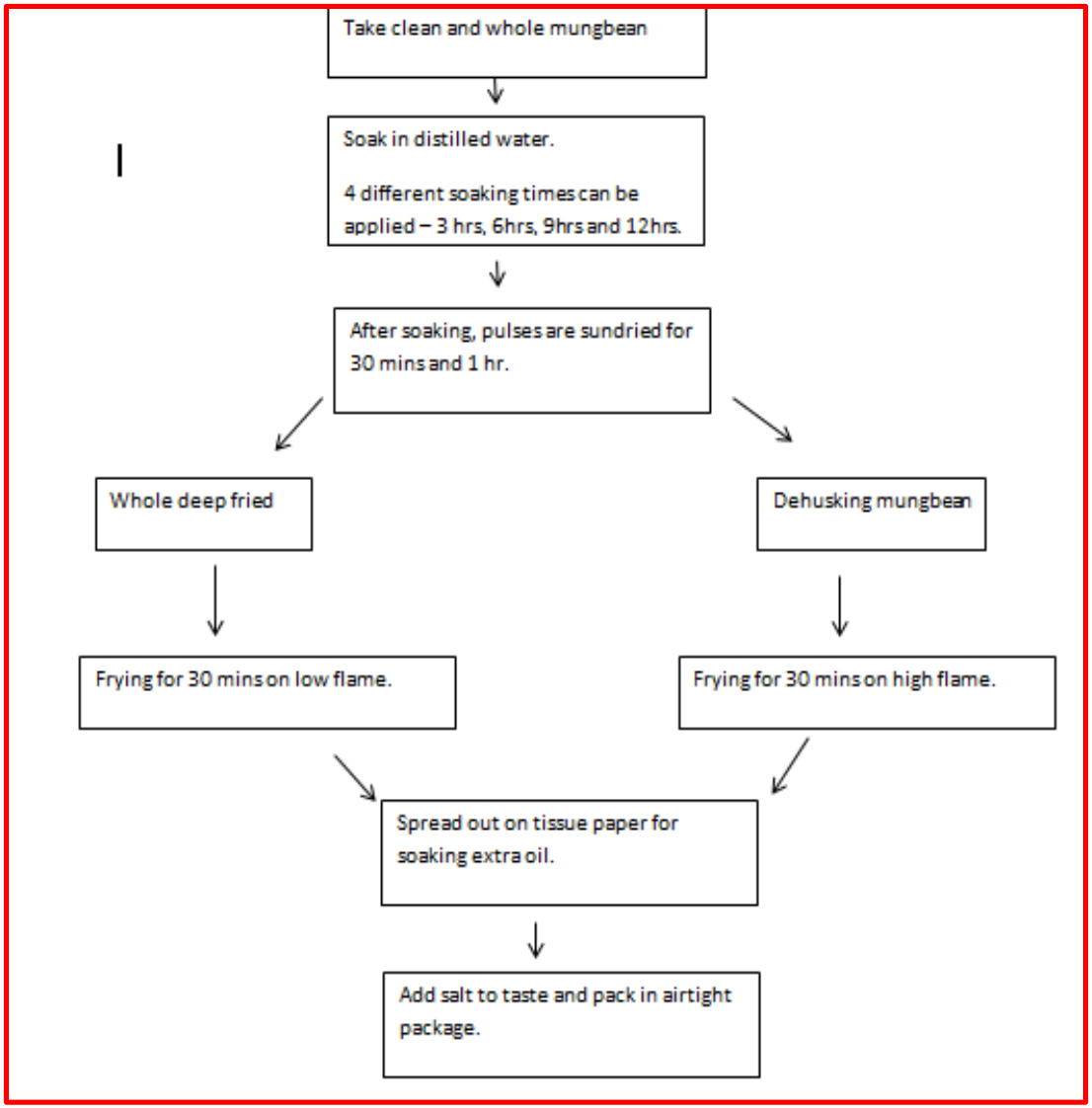


Black gram, both fermented and non-fermented were used to prepare extruded puffed snack. Puffed extruded snacks were prepared from both fermented and non-fermented black gram flour and it was found that fermentation has resulted in enhanced Total Phenolic Content and Antioxidant Activity. Bulk density reduced and Water Absorption Index increases. Water Solubility Index enhanced due to starch degradation during extrusion. Bioactive compounds extraction was also made easy due to extrusion processing. Similar results were seen in soyabean maize extrudates (Rani, 2020).

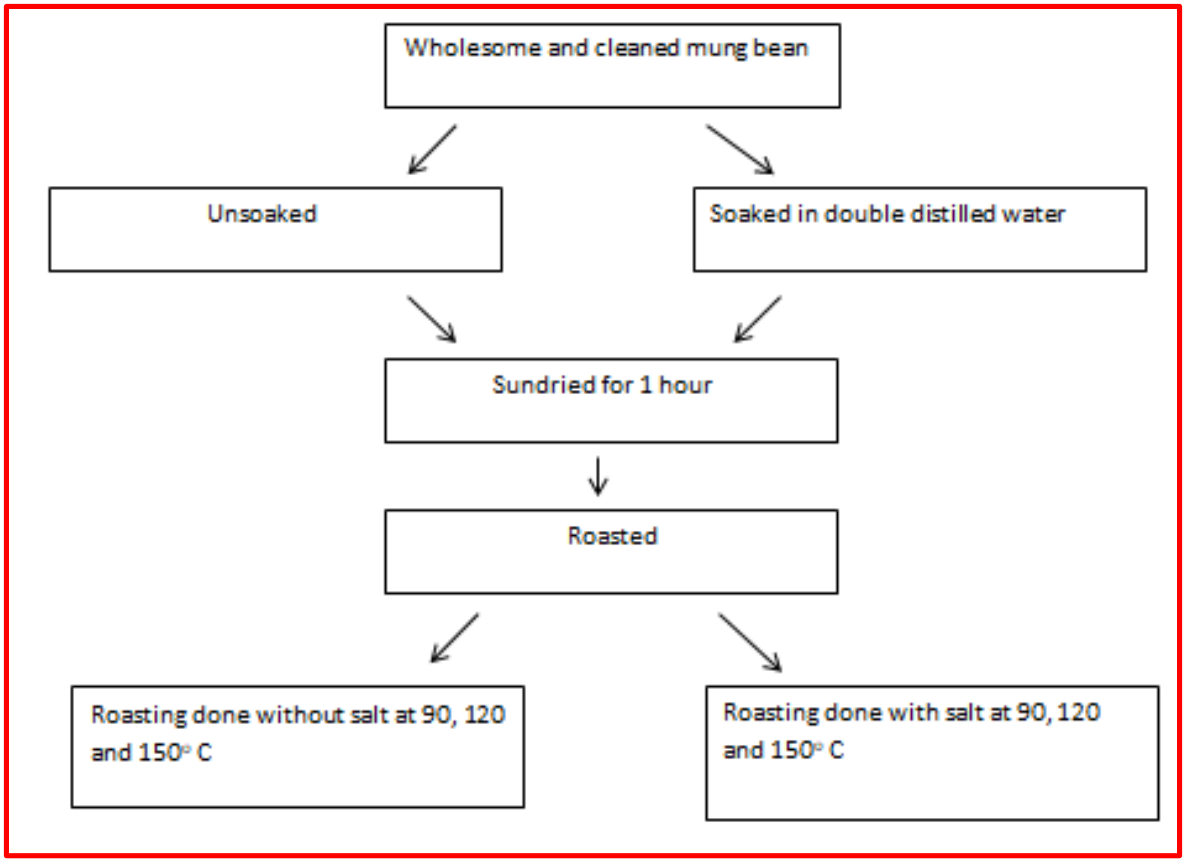
MUNG BEAN BASED SNACKS

WHOLE FRIED NAMKEEN AND DEHUSKED NAMKEEN

Dehusked fried namkeen showed greater reduction in moisture. Total ash content represents mineral content and it was highest in roasted and whole namkeen. This is because husk was not removed.

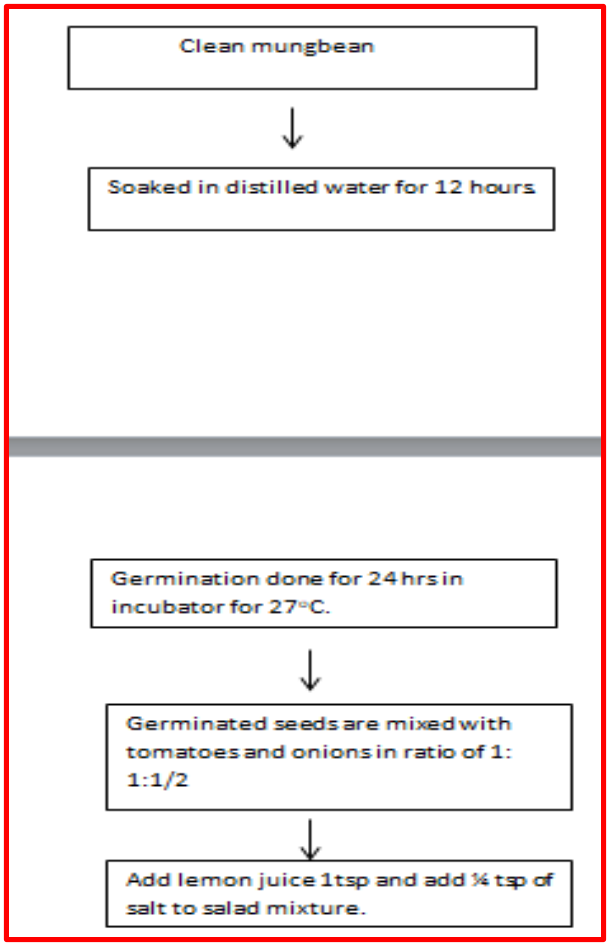

Take clean and whole mungbean
Soak in distilled water.
4 different soaking times can be applied – 3 hrs, 6hrs, 9hrs and 12hrs.
After soaking, pulses are sundried for 30 mins and 1 hr.
Whole deep fried
Dehusking mungbean
Frying for 30 mins on low flame.
Frying for 30 mins on high flame.
Spread out on tissue paper for soaking extra oil.
Add salt to taste and pack in airtight package.

ROASTED NAMKEEN



Iron content was seen to reduce in fried namkeen but increased in roasted namkeen.

GERMINATED MUNG BEAN SALAD



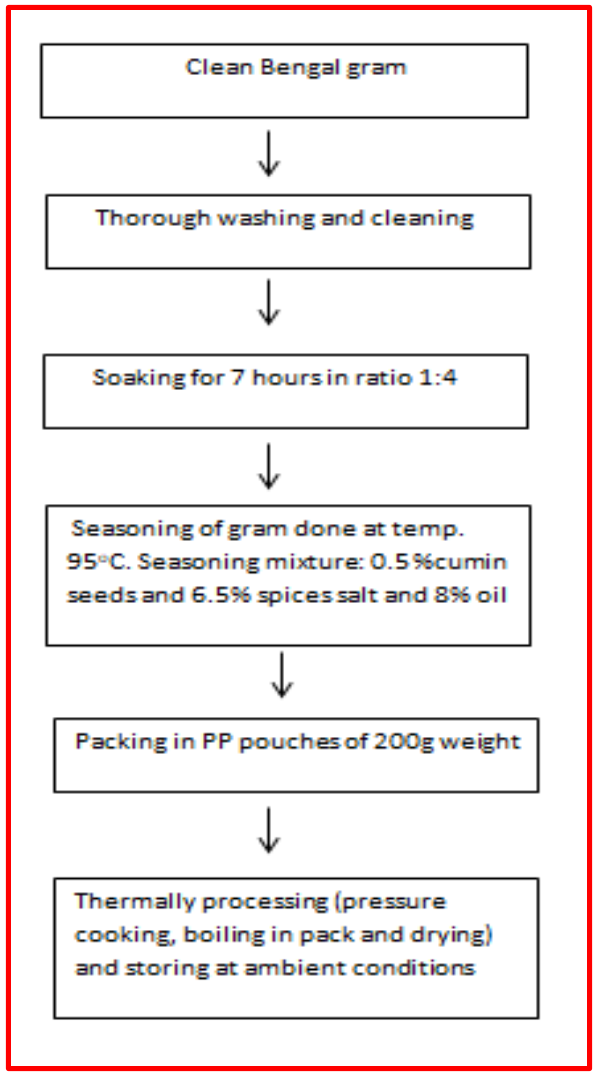
Germinated sample used for salad exhibited low mineral content of 3.97 % because mineral was leached into water and this water was later drained off. Thermal processing reduced calcium content but germination resulted in enhanced calcium content.

TABLE 2: Proximate composition of processed mung bean samples

Product	Parameter	PANT – 5 VARIETY	UPM-98	PANT – 2 VARIETY
WHOLE FRIED NAMKEEN				
	MOISTURE (%)	7.68	7.66	6.85
	ASH (%)	4.08	4.09	3.37
	PROTEIN (%)	23.88	23.49	21.69
	FAT (%)	14.08	14.08	13.06
	IRON (mg/g)	4.01	4.09	3.89
	CALCIUM(mg/g)	149	189	179
DEHUSKED NAMKEEN				
	MOISTURE (%)	6.53	6.63	6.01
	ASH (%)	3.30	3.35	2.21
	PROTEIN (%)	22.45	23.45	20.53
	FAT (%)	14.02	14.05	13.91
	IRON (mg/g)	3.79	3.72	3.56
	CALCIUM(mg/g)	144	144	178

ROASTED NAMKEEN	Parameter	PANT – 5 VARIETY	UPM-98	PANT – 2 VARIETY
	MOISTURE (%)	7.69	7.68	6.85
	ASH (%)	4.23	4.20	3.46
	PROTEIN (%)	23.33	23.37	21.56
	FAT (%)	1.71	1.63	1.51
	IRON (mg/g)	4.12	4.17	3.88
	CALCIUM(mg/g)	217	145	178
SPROUTED SALAD				
	MOISTURE (%)	63.39	63.41	63.22
	ASH (%)	4.24	4.21	3.47
	PROTEIN (%)	1.60	1.63	1.47
	FAT (%)	16.89	17.01	16.71
	IRON (mg/g)	3.21	3.09	3.08
	CALCIUM(mg/g)	153	153	113

CHANNA NIBBLE



Preparation of RTE channa nibble involved soaking, pressure cooking and seasoning. Different heat treatments were used like boiling water, microwave oven and cabinet heat dryer to thermally stabilize product inside pack. Better shelf life of about 112 days without preservative was seen in pack thermal stabilization offered by pressure. Cooking.

TEPARY BEAN BASED NAMKEEN

- Tepary beans are underutilized legume which is mostly grown in arid region and is aslo utilized by famous namkeen industries like Haldiram. Tepary bean flour is found to have ample amount of protein and carbohydrates. Phenolic content, flavonoid content and antioxidant activity is enhanced in flour when compared to other pulses. Germination of tepary beans have also shown to enhance these properties.

TABLE 3: IMPORTANT NUTRITIONAL COMPARISON OF UNPROCESSED AND PROCESSED TEPARY BEAN

PROPERTY	PROCESSED TEPARY BEAN FLOUR	UNPROCESSED TEPARY BEAN FLOUR
ANTIOXIDANT ACTIVITY ORAC		
TOTAL PHYTO.	28,758	6884
FREE PHYTO.	18,325	2,446
BOUND PHYTO.	10,433	4,438
ANTIOXIDANT ACTIVITY ABTS		
TOTAL PHYTO.	23488	8169
FREE PHYTO.	14288	2302
BOUND PHYTO.	9204	5867
PHENOLIC CONTENT	355	107
FLAVONOID CONTENT	180	84

CHICKPEA- SORGHUM MURUKKU

Chickpea flour, sorghum flour, chilli powder, salt, cumin and caraway seeds were mixed and dough was prepared with water.

↓

Divide dough into small balls

↓

Moulded into murukku mould.

↓

Extruded by deep frying in heated oil

Murukku is an extruded deep fried product (ICRISAT, 1991)(Boye, Zare, & Pletch, 2010). Chips and biscuits were also prepared from chickpea-sorghum flour.

FEW OTHER PRODUCTS AND THEIR PROCESSING CONDITIONS

PRODUCT	STATE	METHOD OF PROCESSING
CURRY		Mix with vegetable and meat and cook
PILAU	RAW GREEN SEEDS	Mix with rice and cook
HOLAN		Roasted seeds eaten as snack
CURRY		Mix with vegetable and meat and cook. Soak before cooking
CHAAT	WHOLE DRY SEEDS	Soak and later mix with potatoes and other fruits.
ROASTED		Soak and extrude at 240 ^{o}C for 2-3 mins results in puffed products.
SWEET CHANA		Extrude and coat with sugars.
CURRY		Mix with vegetable and meat and cook.

CONTD.

KHICHDI	DHAL	Soak and steam rice and pulses
SHAMI KABAB		Minced meat is mixed with dal and shaped as cutlet and fried in oil
HALEEM		Soak and mash a mixture of wheat, rice, millet and dhal followed by boiling of mixture.
NAMKEEN	DHAL	Soak and fry
HALWA		Soak and boil in milk. Add sugar and cook.
MISSI ROTI		Mix with wheat flour and cook bread
PAKODA	CHICKPEA FLOUR	Make batter and fry
SAWAYAN		Make batter and extrude it out in shape of noodle and fry.

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