



# PM Formalization of Micro Food Processing Enterprises (PMFME) Scheme

## HANDBOOK OF MAKHANA



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**ABBREVIATIONS**

1	PET	Polyethylene terephthalate
2	LDPE	Low-density polyethylene
3	FSSAI	Food Safety and Standards Authority of India

## CHAPTER – 1

### RAW MATERIAL

#### INTRODUCTION

Foxnut is commonly known as Makhana is an important aquatic crop. The scientific name of Makhana is *Euryale ferox Salisb.* The Makhana seed of an aquatic herb is a monotypic genus of the family Nymphaeaceae and is characterized by its hard seed coat (shell), black in colour and round shape with a diameter ranging from about 5 mm to 15 mm . Its seed is also called as Black Diamond. It is commonly known as Gorgon nut, Fox nut and Makhana in India.

It is grown in stagnant perennial water bodies like ponds, land depressions, oxbow lakes, swamps and ditches. It is a plant of tropical and subtropical climate. For its proper growth and development, the conducive range of air temperature is 20<sup>0</sup>C to 35<sup>0</sup>C, relative humidity 50% to 90% and annual rainfall 100 cm to 250 cm.

Makhana plant is considered as native of South-East Asia and China, but distributed to almost every part of the world. Its distribution is extremely limited to tropical to sub-tropical regions i.e. South-East and East Asia and is known to exist in Japan, Korea, Russia, North America, Nepal, Bangladesh and India. India and China are the only countries where Makhana is cultivated as crop. In India it is mainly distributed in the states of Bihar, West Bengal, Manipur, Tripura, Assam, Jammu & Kashmir, Odisha, Rajasthan, Madhya Pradesh & Uttar Pradesh but commercially produced in few states only.

In Bihar major Makhana producing districts including Darbhanga, Madhubani, Sitamarhi, Saharsa, Supaul, Araria, Purnea, Kishanganj, and Katihar. In West Bengal major Makhana producing districts limited to Malda & Uttar Dinajpur.

Makhana is considered as an aquatic cash crop in India Bihar in India is the leading state in its production and processing. It is estimated that Bihar accounts for more than 80 percent of total Makhana production in the country. The total area under Makhana cultivation in India is estimated to be 15000 Ha. It yields 1,20,000 MT of Makhana seeds, which after processing yields 40,000 MT of Makhana Pop. The estimated value of the production at farmers end is Rs 250 crore and it generates revenue of Rs 550 crore at trader's level.

In Darbhanga district of Bihar, Research Centre of Makhana under control of ICAR Research Complex of Eastern Region was established for research on different aspects of Makhana.

However the sector holds immense potential for value addition, product development and innovation, which would not only enhance livelihood of millions of fishermen but also bolster the economic health of the state and bring glory to this unexplored wonder crop called MAKHANA.

## NUTRITIONAL BENEFITS

Makhana or Fox Nut is a kind of hydrophyte used both as drug and food which exhibits much application and development prospect in the fields of medicine, food and economy. Makhana is the seed of a cash aquatic crop, which was popularly used as herb and food in China. Makhana possessed high nutritional value and many medical and health protection effects.

Popped Makhana is one of the most common dry fruits utilized by the people due to low fat content, high contents of carbohydrates, protein and minerals. It is considered to be nutritious and healthy food with a protein content of 10 -12%. Makhana is found superior to dry fruits such as almond, walnut, cashew nut and coconut in contents of sugar, proteins, ascorbic acid and phenol. Sixteen types of amino acid are present in the kernel. Both raw and fried Makhana are fairly rich in essential amino acids.

The values relating to essential amino acid index (EAAI) and chemical score (CS) of Makhana are close to that to fish. The EAAI in raw Makhana and popped Makhana are 93 % and 89 % respectively which are higher than the values for rice (83 %), wheat (65 %), Bengal gram (81.5%), cow's milk (88.8 %), fish (89.2 %) and mutton (87.24 %). Makhana protein (10-14%) is lower when compared to cereals but still it is nutritionally superior to many plant and animal based diets due to high EAAI and CS.

**Table 1.1 Nutritional Content of Makhana Seed and Popped Makhana**

Parameters	Makhana Seed	Popped Makhana
Carbohydrate (% by wt.)	57.0	79.8
Protein (% by wt.)	7.2	8.7
Fat (% by wt.)	0.3	0.5
Moisture (% by wt.)	34.7	10.4
Total Ash (% by wt.)	0.3	0.4
Crude Fiber (% by wt.)	0.5	0.2
Amylose (%)	19.0	18.2
Calorific Value (K.cals/100g)	259	358

Phosphorus (mg/100 g)	66.1	53.2
Potassium (mg/100 g)	35.6	42.0
Iron (mg/100 g)	0.8	1.4
Calcium (mg/100 g)	9.5	18.5
Magnesium (mg/100 g)	11.3	13.9
Sodium (mg/100 g)	48.2	71.0
Copper (mg/100 g)	0.3	0.5
Manganese (mg/100 g)	0.9	1.3
Zinc (mg/100 g)	0.9	1.1

### USES OF MAKHANA

Makhana is stored in two forms via seeds and Makhana pop. In India it is mainly consumed in popped form and in China it is consumed medicinally or for food. Makhana is the popped expanded kernel of the foxnut or gorgon nut. The nuts are collected from water and popped to remove the edible starchy kernel. The expanded kernel of the nut obtained through this process is called popped kernel and is known as Makhana in India.

Makhana pop has several uses. It is a highly relished food consumed as namkeen, kheer, curry, and so forth. Makhana pop is traditionally consumed as a snack, high-protein, low-fat food, sweet component and it has been used in traditional medicine. Popped Makhana is used in the preparation of a number of delicious and rich sweet dishes like Makhana kheer, vermicelli, halwa, flour, puddings and various other sweet dishes. The Flour produced from Makhana is used as substitute of Arrow Root. The flour is also used to make delicious dishes like sweet meat, soups, Makhana kheer and as thickener in different foods preparations.

Makhana is consumed as a non-cereal food by devotees during their fasts. Hence it solves the religious purpose. In every religion, Makhana is considered as the pious and divine food item. In Hindu religion, it is used in all the worshiping ceremonies, Hawan, Pooja etc. In addition to this, due to his heavenly nature, it is considered as the best offering to god and goddesses in temples. Even the Muslim Communities consume lot of Makhana during their festival of Eid. Makhana seeds are very rich in carbohydrate content.

In Manipur, Makhana is produced for its vegetable purpose where the well developed and almost matured fruits are picked up before their bursting and sold as prime vegetable in the markets. In some parts of Manipur, young fruits and leaf petiole is used as salad. Even seeds of matured fruits are used for the preparation of a number of local delicacies.

**VARIETIES OF MAKHANA.**

Makhana have mainly grown and cultivated with local varieties from last many years. After viewing Makhana commercial importance, ICAR Research Complex for Eastern Region, Patna (Bihar) has developed first variety of Makhana under the name of Swarna Vaidehi. This variety has potential of high yield and resistance to pests-common insects and disease.

**Table 2. Characteristics of Swarna Vaidehi Variety**

<b>Seed Characteristics</b>	
Colour of Seed Coat	Deep Black
Seed Shape	Spherical
Weight for 100 Seed (g)	92-98
Diameter of Seed (mm)	9.5-10.2
<b>Yield Aspects</b>	
Seed/Plant (g)	750-980
Seed/ha (q)	28-30
<b>Quality Characteristics of popped Makhana (Lawa)</b>	
Shape	Oblate
Size	2-2.5 cm
Colour	Sparkly White

## CHAPTER – 2

### METHODS OF MAKHANA PRODUCTION

#### CULTIVATION

Makhana is cultivated either in perennial water bodies having water depth of 4-6 ft or in the field system. Makhana plants germinate from the left over seeds of the previous season in pond system. When Makhana is grown for the first time in a new pond, the rate of sowing is 80 kg/ha. However when sowing is done annually, 35 kg of seed is required for 1 ha of water spread. The cultivation process mainly includes:-

**Pond System:** This is the traditional system of Makhana cultivation.

Makhana plants germinate from the left over seeds of the previous season and serve as planting material of subsequent crop. However, Makhana cultivation may not be started either through direct seed sowing or transplanting the plantlets in new water bodies. In the traditional system, apart from Makhana, air breathing fishes get enter into the ponds as wild fishes along with flood water and harvested by the farmers as an additional crop.

**Field system:** This is a new system of Makhana cultivation, which has been standardized by the research institute. In the system, Makhana cultivation is carried out in agriculture fields at a water depth of 1 ft. This system is very easy to operate and provides opportunities of cultivate the same fields in a year for cereals and other field crops. The Makhana seedlings are first raised as a nursery and then transplanted in the main filed at the optimum time. Depending upon the availability of field and nursery, the transplanting can be done in between first week of February to the third week of April. Through this system, the duration of Makhana crop is reduced up to the four months.

Sprouting takes place by December-January and the early leaves appear on the pond surface during January- February. During April-May, the entire water surface gets covered with huge, sprawling and thorny leaves, which float on the surface of water. Flowering begins in the month of April when the temperature is around 30<sup>0</sup> C and maximum flowering occurs in the month of May. Makhana flowers stay afloat for two days and then submerge inside water. Fruiting begins by mid of May and each plant bears around 10-20 fruits. Each fruit contains 40-70 seeds and roughly 100 seeds weigh around 80-100 gm. On an average, a plant of Makhana yields around 450-700 gm. of seeds. Makhana fruits burst inside water during May-July and the seeds float in water for a day or two and then settle at the bottom of the pond.



In local parlance, Makhana seeds are called guri. After fruiting, the gigantic leaves are cut and thrown out or left to decay, which enriches the soil health through addition of organic nutrient.

**Table 3. Comparison of Pond and Field System**

<b>Parameter</b>	<b>Pond Eco-System</b>	<b>Field System</b>
Water Requirements	Around 4-6 feet	Around 1 feet
Seed Requirements	80-90 kg/ha	20 kg/ha
Water Source	Natural water as perennial water bodies	Irrigation water or any other perennial source of water
Fertilizers and Manures	Not possible due to high depth of standing water	Can be applied very easily before and after the transplantation
Weed Management	Very tedious	Very easy
Crop Duration	Long to very long (8-10 months)	Short (4-5 months)
Seed yield	1.8-2.0 t/ha	2.6-3.0 t/ha
Scope for grain and fodder production	Not possible	Water Chestnut, Rice, Wheat, Barseem and other field crops can be grown in rotation.
Possibility of maximum no. of crops in a year	Two	Three
Intensification of cropping system	Makhana with Water Chestnut	Makhana - Water Chestnut Makhana - Barseem, and Makhana - Rice
Crop protection measures	Very tedious	Quite feasible
Cropping Intensity (%)	In general, 100 % in traditional system	200-300%
Net Income	Low to medium in traditional system	High to very high
Feasibility of harvesting	Very tedious. It can be done only by trained labourers	Very simple. It can be done even by unskilled

		labourers
Capital Investment	High to very high, depending on the situations	Invariably, medium to low
Scope of horizontal expansion of Makhana cultivation	Limited scope because it would depend upon the availability of natural water bodies	Wide scope

The major constraints of the Makhana cultivation includes the Lack of scientific knowledge of cultivation as most of the cultivation is done only by traditional methods, Lack of ownership of pond or land as the farmers/growers cultivates Makhana on leased private or government land or ponds.

### **HARVESTING**

The scattered seeds at the bottom of the pond or shallow water filed are collected manually during August - October. Harvesting of Makhana seeds is done by diving deep inside the water. The process of collection is strenuous involving a thorough sweeping of the entire bottom floor of the water area. Sweeping of the floor, making heaps and their retrieval requires several dives inside the water that makes the job really painstaking. Yield of Makhana varies normally from 1200 to 1500 kg per hectare. However in low depth water bodies yield varies from 1800-2200 kg per hectare.



**a. Makhana in field cluster**



**b. Makhana in pond cluster**



**d. Makhana Flower**

**c. Makhana Leaves**



**e. Makhana Fruit**



**f. Makhana Harvesting**



**g. Fresh Makhana Seeds**



**h. Raw Makhana Seeds**

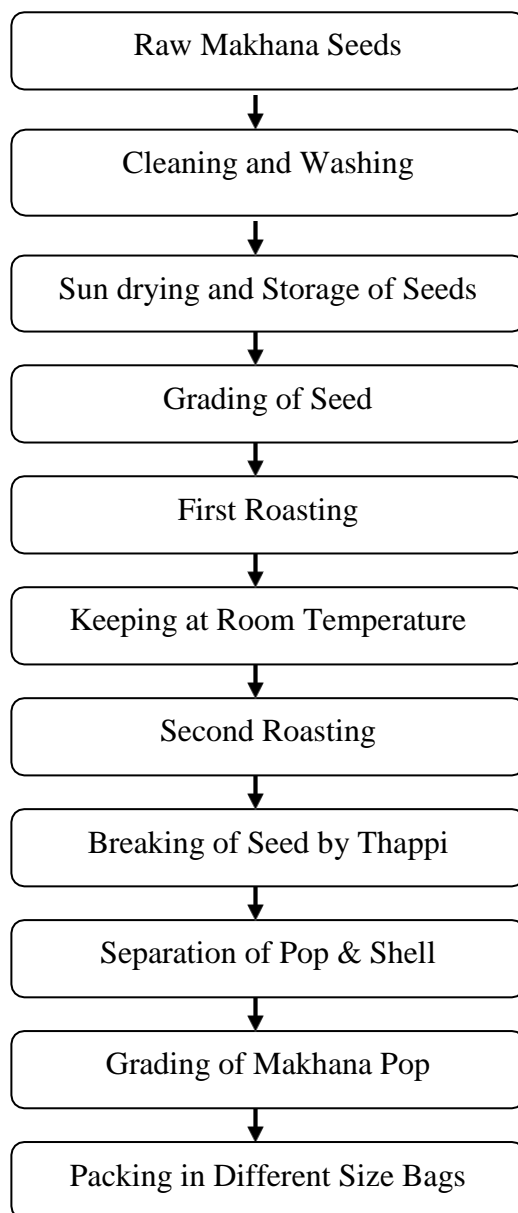
**Figure 1. Makhana Cultivation and Harvesting**

## CHAPTER – 3

### PROCESSING AND MACHINERIES

#### POST HARVEST OF MAKHANA

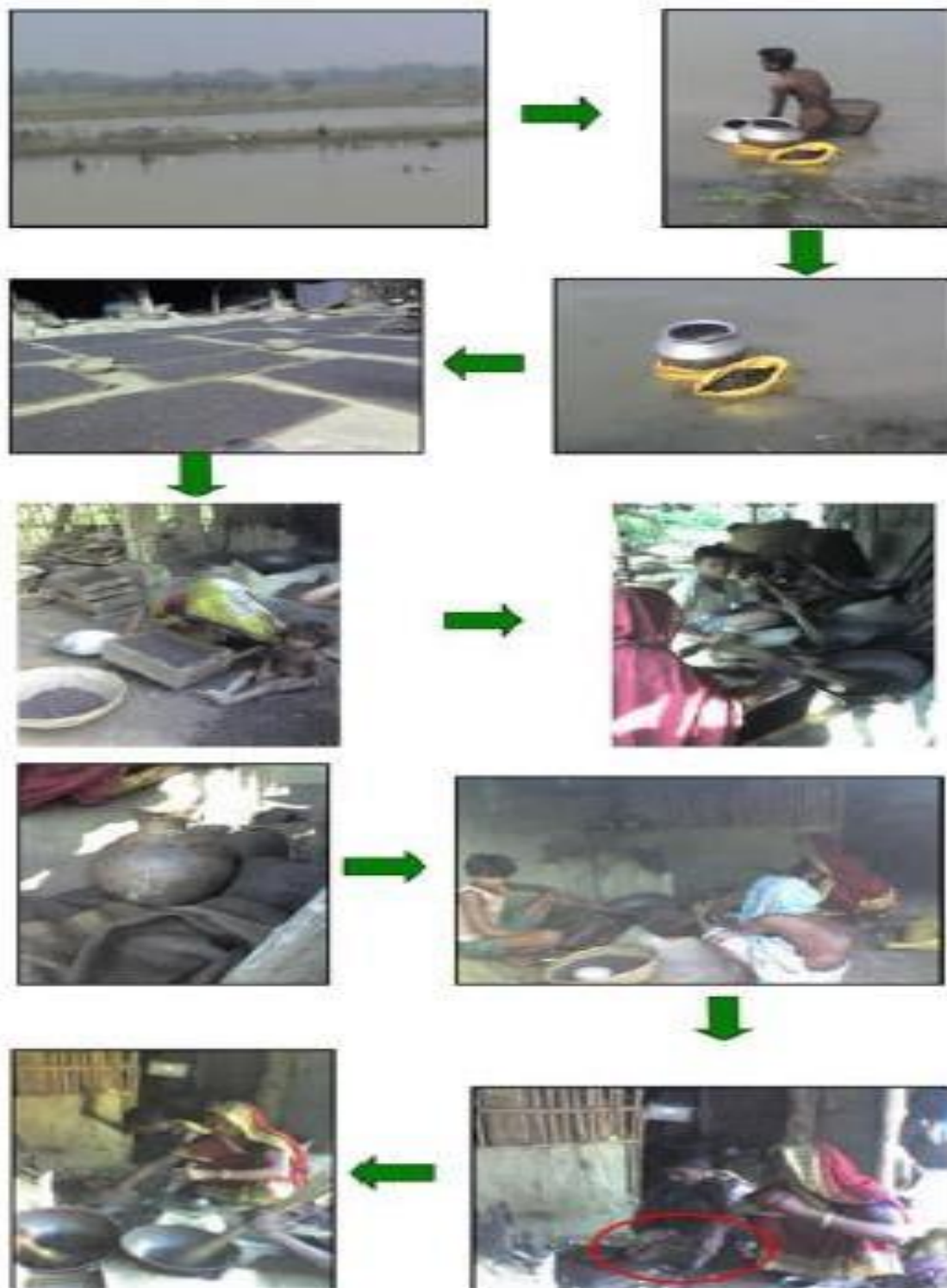
In general, the Post-harvest technology involves sun drying, size grading, pre-heating, popping, polishing, grading and packaging are explained below.



**Table 4. Post Harvest of Makhana**

- 1. Cleaning & Washing:** The matured fresh Makhana seed are first cleaned and removal of several foreign material other than seed and then washed to remove the dirt and mud.
- 2. Sun drying and Storage of seeds:** The cleaned makhana seeds are then sun dried on a mat or cemented floor for 2-3 hours under bright sun light to reduce the moisture to an extent of around 31% for temporary storage and transportation process.  
Storage of Makhana seeds are kept under ambient conditions. Generally seeds are stored for 20-25 days before processing. At regular interval sprinkle of water during storage are done to keep them fresh and to maintain the quality of the seed.
- 3. Size grading:** The sun-dried seeds are then categorized into 5 to 7 grades according to their sizes by means of a set of sieves. Grading of Makhana seed facilitates uniform heating of each nut during roasting and it increases the efficiency of processing.
- 4. Pre-heating:** The sun-dried nuts are generally heated in earthen pitcher or cast iron pan by placing them over fire and stirring them continuously. The surface temperature of the pan varies from 250° C – 300° C and required time is nearly 5 to 6 minutes at full capacity of the pan. After pre heating of nut, moisture content reduces to approximately 20 percent.
- 5. Tempering:** The storage of pre-heated seeds for duration of 48-72 hrs at ambient condition is known as the tempering of the seeds. Tempering of seeds is done purposefully to loosen the kernels within hard seed coat.
- 6. Roasting and popping:** It is the most important but laborious and painful operation of Makhana processing. About 300 gm of pre-heated and tempered nuts are taken and roasted in a cast iron pan in single layer over the fire at 290° C to 340° C surface temperatures with continuous stirring. After about 1.5 to 2.2 min, a cracking of sound is heard from the seed being roasted. The roasted seeds five to seven are scooped quickly by hand and kept on hard surface and sudden impact force is applied on them by means of a wooden hammer. As the hard shell breaks, the kernel pops out in expanded form, which is called Makhana pop or lawa. Depending upon the quality of raw material, the yield of Makhana varies from 35-40% on raw seed weight basis.
- 7. Polishing:** It is done by rubbing action of Makhana pops among themselves in bamboo baskets. Polishing facilitates more whiteness and luster to the Makhana.
- 8. Grading:** The popped Makhana lawa is generally graded into three grades at the producer level- lawa and thurri. The lawa is swollen and white with reddish spots whereas, thurri is semi-popped, hard and reddish in colour.

**9. Packaging:** Ordinary gunny bags for local markets and gunny bags with polythene lining are used for distant markets to pack popped Makhana. One bag having capacity of one quintal of sugar may contain 8 to 9 kg of good quality of Makhana.



**Fig 2: Post Harvest & Makhana Processing**



## TRADITIONAL TOOLS AND EQUIPMENTS

Following tools and equipment are used during post harvesting & processing of Makhana.

1. **Khonngi or Deli:** It is a small bamboo stick bucket with cylindrical shape. It is used for storing raw, popped seed and in polishing operation.
2. **Sieves:** Sieves are made of iron sheets with wooden frames. In general seven to ten sieves of different mesh sizes are used for grading of raw Makhana seed.
3. **Mats:** Mats are used for sun-drying raw Makhana seeds before roasting.
4. **Iron pan:** It is a cooking pan or utensil which is used for pre-heating and roasting of Makhana seeds.
5. **Aphara, Batna and Thaapi:** These are wooden appliances made of hardwood, mostly of shisum or mango. Aphara is a platform on which roasted seeds are hit with flat wooden hammer called Thaapi.
6. **Chula's (Earthen Pans):** They are utilized for roasting the sun dried seeds or guris without sand mix.
7. **Bamboo Sticks:** These are utilized to stir the Makhana seeds while roasting them.

## LATEST MACHINERIES AND EQUIPMENTS

The complete plant comprises following machines and systems. All the equipments functions are described below:-

1. **Raw Makhana Seed Washer:** This machine is used for washing and cleaning of raw Makhana seeds taken from ponds. Seed membrane, snails, dead fish pieces, mud, stones, and other impurities will be removed by this machine.
2. **Makhana Seed Grader:** This machine is used for grading seeds on the basis of seed size. Seeds have to be graded into 7 sizes (3-5 mm; 5-7 mm; 7-9 mm; 9-11 mm; 11-13 mm; 13-15 mm, and >15 mm).
3. **Makhana Seed Dryer:** This machine is fabricated for drying of graded raw makhana seeds from 35- 40% moisture content (wet basis) to 28-30% moisture content. Time and temperature combinations will also be optimized for different grades of seeds.
4. **Seeds Roasting Machine for Initial Roasting of Makhana:** This machine will be used for initial roasting of raw makhana seeds. During this roasting process, the starch present in the seed is gelatinized and protein is denatured. This is the most important step of popped makhana production process and even a slight change in processing conditions affect the end product quality

**5. Roasting and Popping Machine:** This machine is available with ICAR-CIPHET, Ludhiana. A Makhana popping machine was developed with the design and development of Makhana popping and decorticating machine with 25-30 kg/h capacity of conditioned nut and more than 90% popping efficiency at CIPHET, Ludhiana.

The machine can be divided into two parts namely roasting unit and decortication/popping unit. The roasting unit is essentially a thermic heating system of specified length with a conveying mechanism to convey the roasted nuts towards outlet. Temperature and duration of roasting are controlled electronically and feed rate is controlled mechanically. This unit is used for initial roasting for conditioning of as well as final roasting to produce popped Makhana. The decortications/popping unit consist of a casing and impeller assembly with hard impact surface. When the hot roasted nuts strike to the impact surface, the shell breaks and due to sudden pressure drop and popping of the kernel takes place. This unit can also be used for decortications of conditioned Makhana nuts to produce Makhana flour for various food and industrial applications.

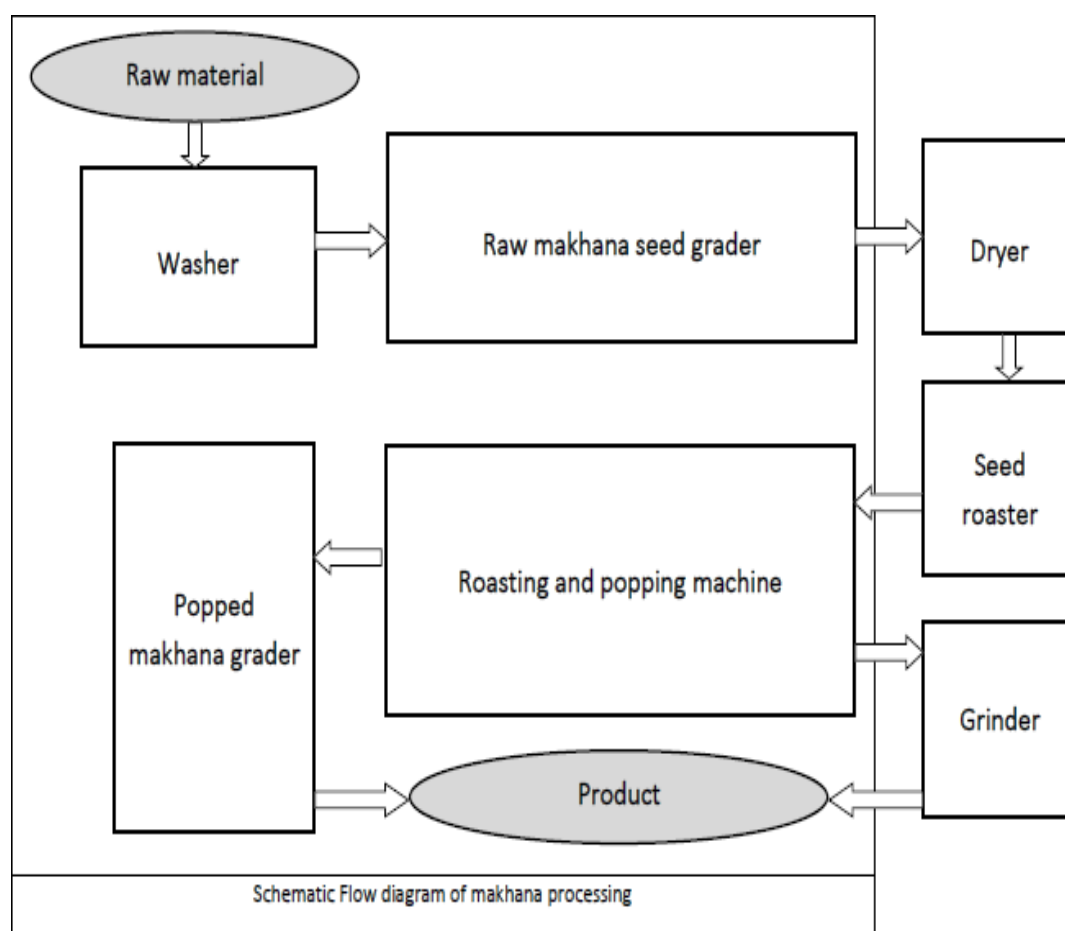
The process for conditioning, roasting, decortications and popping were optimized. The overall dimensions of machine are 1.5m × 0.75m × 2.0 m. Two electric motors of 1 hp each are required to run the machine. At optimum conditions, the popped Makhana recovery is more than 90% with less than 3% un decorticated nuts. Most importantly, flattening of Makhana does not take place in this machine and uniform shaped popped Makhana is obtained. This machine gives better quality popped Makhana and almost eliminates drudgery involved in present system of makhana processing. The same machine can be used for decortications of Makhana seeds to produce flour for further value addition. This machine developed by Dr. S. N. Jha and Dr. R. K. Vishwakarma, ICAR-CIPHET, Ludhiana. (Patent application no. 674/DEL/2013; dated 07.03.2013; Mechanized system for popping and decortications of Makhana seeds). This machine is now available and used for commercial production of Makhana.

**6. Popped Makhana Grader:** This machine is used for separation of husk, unpopped whole seeds, unpopped decorticated kernels, partially popped Makhana and popped Makhana.

**7. Un-popped Makhana Grinder:** This machine is used for fine grinding of unpopped Makhana kernels to produce the Makhana flour. This flour will be used for preparation of value added products.



**8. Control panel for the Plant:** This panel will control the operation of complete plant from one place. Individual machines or complete plant can be operated at a time from one place. It is an electronic and electrical based control panel. The power supply will be regulated from the panel. Each machine will be connected with the panel separately. It will consist of main switch, power break system, indicators, control/ on-off switches, main supply connection, safety devices etc. Separate indicators will be required for each machine.



**Fig 3: Flow Diagram of Makhana Processing**



**Fig 4: Makhana Roasting & Popping Machine**

## CHAPTER- 4

### VALUE ADDED PRODUCTS & BY PRODUCTS

#### VALUE ADDED PRODUCTS

Makhana pop has highly relished food consumed as namkeen, snacks, kheer, curry, breakfast cereals and so forth. Popped Makhana is used in the preparation of a number of delicious and rich sweet dishes like Makhana kheer, vermicelli, halwa, flour, puddings and various other sweet dishes. The Flour produced from Makhana is used as substitute of Arrow Root. The flour is also used to make delicious dishes like sweet meat, soups, Makhana kheer and as thickener in different foods preparations.

##### 1. Popped Makhana

Popped Makhana are first cleaned, graded, weight & then packed into different pack size as per the market requirements.

##### 2. Makhana Snacks

Popped Makhana are first cleaned, weight & then roasted followed by slurry flavouring in flavour (Masala, Tomato, Chilly, Chololate, Onion & Others) drum depend upon the market requirements and then packed into different pack size.

##### 3. Instant Makhana Kheer Mix

It is rich and creamy sweet with deliciously flavour. Roast the popped Makhana and some cashew nuts with ghee. Cool the roasted nuts. Grind it in a blender with some cardamom. Add milk powder and sugar and mix well and then packed into different small pack size as per the market requirement. To make more delicious you can add others chopped dry fruits. Add 2-3 tea spoons of instant Makhana kheer mix powder to 100 ml of water and mix well to prevent lumps. Cook for 3-5 minutes, till the kheer thickens. Kheer is ready to serve.

##### 4. Makhana Flour or Powder:

The Flour produced from Makhana is used as substitute of Arrow Root. The flour is also used to make delicious dishes like sweet meat, soups, Makhana kheer and as thickener in different food preparations. The Makhana flour can be mixed with wheat flour to make softer chapatti.

##### 5. Makhana Ready to Eat Breakfast Cereal

Ready-to-eat breakfast cereals belong to the category of foods that are inherently stable and have a long shelf life and much popular now a days. The Makhana is Flaked or reduction of size and mixed with dry fruits like almonds, Cashew Nut, Tutty Fruity and others. It may be

with flavour like honey, malt, chocolaty, fruity or plain. It may be uncoated, coated or product with added component. It can be served with milk, water, sugar or salt based on the end user requirement.

#### **6. Makhana Baby Foods or Porridge**

Popped Makhana are first cleaned, check the quality and then roast the Makhana on medium heat until golden. Once golden, check if ready by crushing 1 makhana piece between your fingers. If cracks into pieces and when further crushed turns into powder. Then cool the Makhana for 20 minutes before grinding. Grind the makhanas into a fine powder. Add the powder to a colander or strainer and sieve the flour and packed into airtight container. It may be mixed with Bengal Gram Flour (Sattu), Banana Powder to prepare different type of baby foods.

#### **7. Makhana Barfi**

Makhana Barfi was prepared from raw makhana powder (300 g) sugar (200 g) milk (1.5 liters) pure ghee (5 g), elaichi (Cardamom) powder (2 g) arrowroot powder (2 g) and then mixed them properly for ready to boil. The boiling temperature was 130-140° C for 30 minutes to thick consistency then cut into small pieces after cooling.

#### **8. Makhana Kalakand**

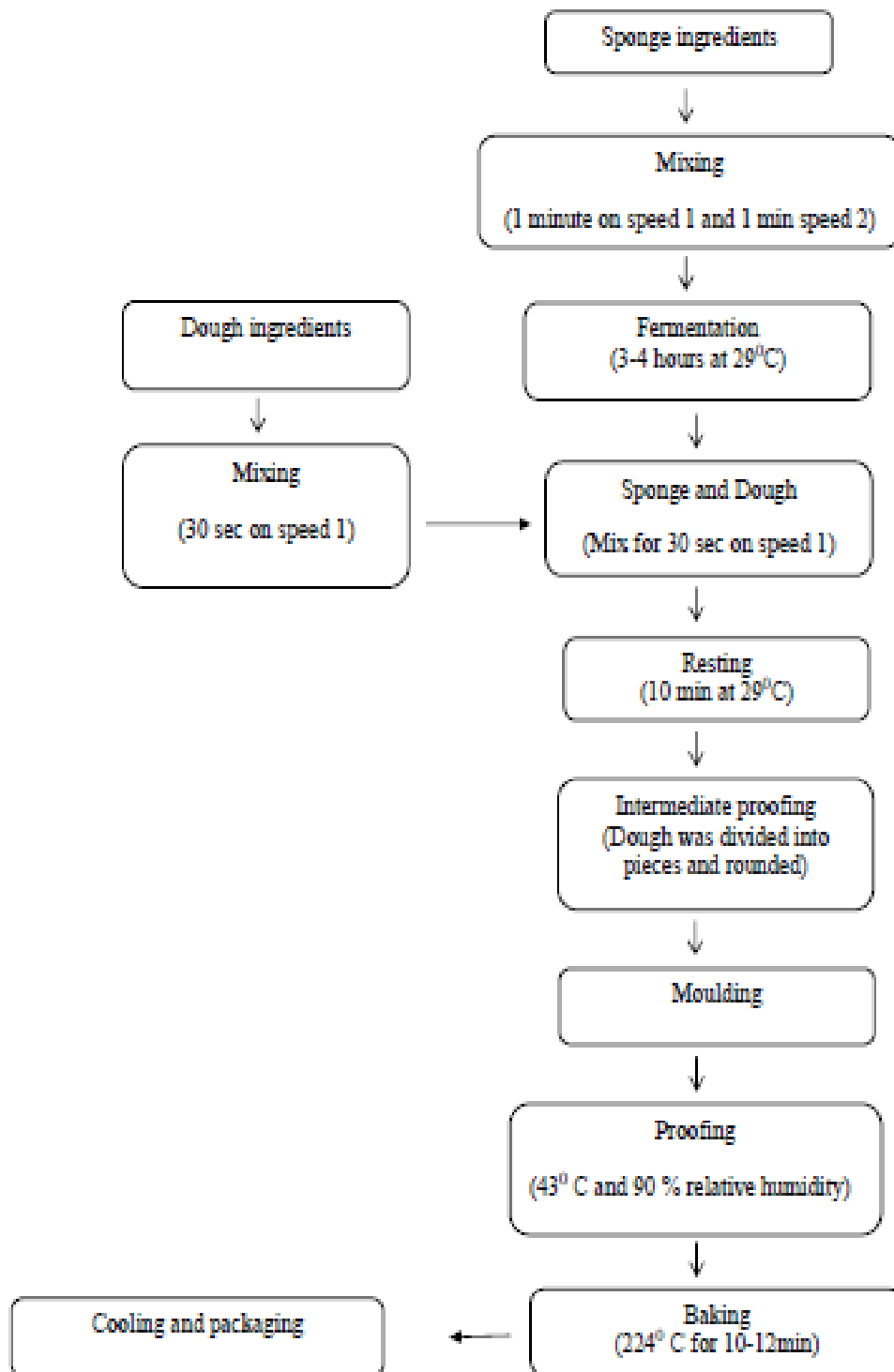
Makhana Kalakand was prepared from raw makhana powder (300 g), sugar (100 g), channa (600 g), milk (1.0 lit), pure ghee (5 g) and elaichi (cardamom) powder (2 gm). The boiling temperature was 130-140°C for 30 minutes to a thick consistency and then cut into small pieces after cooling of the resultant mass.

#### **9. Makhana Bread/Bun**

These are few new products which require much research and development. Take 100 kg of Mixture of Wheat and Makhana Flour or Powder for this recipe. Both Gluten rich and gluten free bread/bun can be prepared.

**Table 5. Sponge and Dough Formula**

<b>Ingredients</b>	<b>Quantity (kg)</b>	<b>Percentage (%)</b>
<b>Sponge</b>		
Flour	70	35
Yeast (compressed)	3	1.50
Water	46	23
Yeast food	0.3	0.15
<b>Dough</b>		
Flour	30	15
High fructose corn syrup (42%)	18	9
Shortening	6	3
Salt	2	1
Ascorbic acid	100-200 ppm	0.05
Water	variable	12.50
Calcium Propionate	0.12	0.06



**Fig. 5: Flow Chart of Makhana Bread or Bun**

**10. Makhana Cookies/Biscuit****Table 6. Ingredients of Makhana Cookies**

<b>Ingredients</b>	<b>Weight (kg)</b>
Flour	100
Sucrose	42
All-purpose shortening	40
High- fructose corn syrup	1.50
Nonfat dry milk	1
NaCl	1.25
Sodium bicarbonate	1
Ammonium bicarbonate	0.50
Deionized water (Variable)	20.75

Take 100 kg of Mixture of Wheat and Makhana Flour or Powder. Weighted amount of dry Ingredients were transfer into jar. Dry ingredients were mixed well. Appropriate amount of shortening were weighed into mixing bowl. Dry ingredients were added on top of the shortening. Mixed in mixer. Scraped creamed mass was transferred into cake dough mixing bowl. Weighed HFCS were transferred into 100-ml beaker. Add appropriate amount of water and swirl. Weighed amount of ammonium bicarbonate were added to HFCS-water mixture and swirl to dissolve. Liquid was added to creamed mass and mixed for 1 min, scraped every 15 seconds. Calculated amount of flours was added. Mixed for 10 sec while tapping side of bowl. Dough was scraped from mixer and bowl pins, scrape outer edge and bottom of bowl pushing dough between pins several times. Mixed for 10 sec, scraped, mixed for 10 sec. Dough was scraped gently from bowl. The dough was sheeted to thickness of 6 mm. The sheeted dough was made into circular piece by circular cookie cutter of 50 mm diameter. The circular dough piece were then placed on a tray which is covered by butter paper or greased surface and immediately placed in baking oven at  $205 \pm 5^{\circ}\text{C}$  for 11 minutes. On removal from oven it was cooled for 5 minutes and cookies were removed from baking sheet. Baking sheet was wiped with damp towel to remove grease. It was washed in warm, un soapy water, dried

thoroughly, and allowed to come to room temperature before next use. Cookies after baking were cooled to room temperature for 30 min, packed in sealed plastic bags and kept in an air tight container in a room at ambient temperature.

### **BY PRODUCT**

Makhana processing byproduct is bran+outer coat. Use of Makhana Bran as poultry feed ingredient may be used. Makhana outer coat may be used for fuel purpose.



## CHAPTER -5

### QUALITY

#### GRADES OF MAKHANA

The Quality of the Makhana depends on the size and colour of the lawa. After polishing, Makhana is graded into 2-3 grades namely Lawa or Rasgulla, Murra or Samundha and Thurri.

**Table 7. Different Grades of Makhana**

S. No	Quality Parameter	Grade 1	Grade 2	Grade 3
1	Size of the Makhana	(Fully Expanded) of diameter $\geq 15\text{mm}$ .	Fully Expanded of diameter $\leq 14\text{mm}$	Flattened and Irregular of any diameter
2	Colour of the Makhana	Creamy White	Creamy White with Less Light Reddish Spot	More Light Reddish Spots
3	Expanded or Irregular	Fully Expanded	Fully Expanded	Flattened and Irregular

Depending upon the requirement and demand from consumers, wholesalers are packing in various pack sizes and grades.

#### ANALYSIS OF PARAMETERS

The Quality parameters of Makhana may be analysed as per the FSSAI Manual of Methods of Analysis for various food products. Few parameters are listed below:

##### Proximate Compositions

Moisture

Protein

Total Ash

Crude Fat

Crude Fiber

Carbohydrate content

Energy Value

##### Microbiological Analysis

## **Mineral Contents**

## **Vitamin Contents**

### **STORAGE OF MAKHANA**

Makhana when properly stored may last more than a year under room temperature and air tight conditions. Following cares need to be taken for achieving the shelf-life.

1. Packages should be kept away from sun, rain and moist conditions in covered premises.
2. The room where the Makhana is to be stored should have dry atmosphere, free from unwanted odour as well as proofed against insects and vermin entry.
3. The room should have controllable ventilation where it could be able to give good ventilation in dry conditions and should have fully closed ventilation in damp conditions. Fumigation facilities should also be there.

## CHAPTER – 6

### PACKAGING AND LABELLING

#### PACKAGING REQUIREMENTS

Packaging materials shall provide protection for all food products to prevent contamination, damage and shall accommodate required labelling as laid down under the Food Safety Standard Act 2006 & the Regulations there under.

For primary packaging (i.e packaging in which the food or ingredient or additive comes in direct contact with the packaging material), only Food grade packaging materials are to be used. For packaging materials like aluminium plastic and tin, the standards to be followed are as mentioned under the Food Safety Standard (FSS) Regulations and rules framed there under.

Packaging materials or gases where used, shall be non-toxic and shall not pose a threat to the safety and suitability of food under the specified conditions of storage and use. The selection of packaging materials should take care of functional as well as market requirements.

For bulk packaging, there are no specifications. Commonly, jute fabrics such as hessian & Jumbo bags are generally used for bulk packaging.

For retail packaging variety of packaging materials are available based on design, strength & price.

**Table 8. Type of Retail Packaging**

S. No	Type of Packing	Strength	Cost
01	Polyethylene	Ok	Low
02	Pet Bottle	Good	High
03	Tin Can	Excellent	High
04	Extruded/Different Layered Film (Poly/PET/HDPE/LDPE/Metalized /Other)	Good	Medium
05	Aluminium Foil	Good	Medium

#### GENERAL REQUIREMENTS FOR LABELLING

Every pre packaged food shall carry a label containing information as required here under Food Safety and Standards (Packaging and labelling) Regulations.

The particulars of declaration required under these Regulations to be specified on the label shall be in English or Hindi in Devnagri script: Provided that nothing herein contained shall prevent the use of any other language in addition to the language required under this regulation. Label in pre-packaged foods shall be applied in such a manner that they will not become separated from the container. Contents on the label shall be clear, prominent, indelible and readily legible by the consumer under normal conditions of purchase and use;

**1. The Name of Food:** The name of the food shall include trade name or description of food contained in the package.

**2. List of Ingredients:** Except for single ingredient foods, a list of ingredients shall be declared on the label. The name of Ingredients used in the product shall be listed in descending order of their composition by weight or volume, as the case may be, at the time of its manufacture.

**3. Nutritional information:** Nutritional Information or nutritional facts per 100 gm or 100 ml or per serving of the product shall be given on the label containing the following:

- (i) energy value in kcal;
- (ii) the amounts of protein, carbohydrate (specify quantity of sugar) and fat in gram (g)
- (iii) the amount of any other nutrient for which a nutrition or health claim is made:

**4. Declaration regarding Veg or Non veg –**

Every package of “Vegetarian” & “Non Vegetarian” food shall bear a declaration to this effect made by a symbol and colour code.

**5. Declaration regarding Food Additives-**

For food additives falling in the respective classes and appearing in lists of food additives permitted for use in foods generally, the following class titles shall be used together with the specific names or recognized international numerical identifications:

Acidity Regulator, Acids, Anticaking Agent, Antifoaming Agent, Antioxidant, Bulking Agent, Colour, Colour Retention Agent, Emulsifier, Emulsifying Salt, Firming Agent, Flour Treatment Agent, Flavour Enhancer, Foaming Agent, Gelling Agent, Glazing Agent, Humectant, Preservative, Propellant, Raising Agent, Stabilizer, Sweetener, Thickener:

**6. Name and complete address of the manufacturer**

The name and complete address of the manufacturer and the manufacturing unit if these are located at different places and in case the manufacturer is not the packer or bottler, the name and complete address of the packing or bottling unit as the case may be shall be declared on every package of food;

**7. Net quantity**

Net quantity by weight or volume or number, as the case may be, shall be declared on every package of food.

#### **8. Lot/Code/Batch Identification**

A batch number or code number or lot number which is a mark of identification by which the food can be traced in the manufacture and identified in the distribution, shall be given on the label. Provided that in case of packages containing bread and milk including sterilised milk, particulars under this clause shall not be required to be given on the label.

#### **9. Date of manufacture or packing**

The date, month and year in which the commodity is manufactured, packed or pre-packed, shall be given on the label: Provided that the month and the year of manufacture, packing or pre-packing shall be given if the “Best Before Date” of the products is more than three months: Provided further that in case any package contains commodity which has a short shelf life of less than three months, the date, month and year in which the commodity is manufactured or prepared or prepacked shall be mentioned on the label.

#### **10. Best Before and Use By Date**

The month and year in capital letters upto which the product is best for consumption.

#### **11. Instructions for use:**

Instructions for use, including reconstitution, where applicable, shall be included on the label, if necessary, to ensure correct utilization of the food.

## CHAPTER – 7

### REGULATORY REQUIREMENTS

#### 7.1 REGULATORY REQUIREMENTS

Every Manufacturer, Processor, Repackaging unit, Relabelling Units & Other related Food Business Operators has to obtained Food Safety License or Registration form Food Safety Standard Authority of India (FSSAI) to carry out the business. Carrying a food business without obtaining a Food licence/Registration is illegal and unauthorized and violates the provision of the Food Safety & Standards Act, 2006. Based on the needs FSSAI has categorized the related food business operators into following categories.

**Table 9: Categories of FSSAI Certificates**

S. No	Category	Capacity	Annual Fee
1	Registration (Petty Food Business Operators)	Turnover not exceeding Rs. 12 lakhs and whose production capacity of food does not exceed 100 kg/ltr per day.	Rs 100/-
2	State License	All grains, Cereals & Pulses milling units without any ceiling on quantity and/or other Food Businesses more than 100Kg/Litre upto 2 MT/day. Turnover up to 20/30 crores/annum.	Rs 2000 to 5000/-
3	Central License	More than 2 MT/day. No grains, cereals and pulses milling units & other requirements also apply.	Rs 7500/-

Manufacturing or processing means each step in conversion of raw material derived from agricultural produce into products for intermediate or final consumption. Repacking means packing of food product into different sizes with labeling after doing minimal processing as required like sorting, grading, sieving etc. from wholesale packages. The food product is not manipulated & the composition or formulation is not affected or changed.

The Food Business Operators may apply online for obtaining FSSAI License or Registration Certificate at FOSCOS Website <https://foscoss.fssai.gov.in> with relevant documents based on business capacity. Detailed information has been provided in the website. The Food Business operators may apply for the other regulatory license like trade license, pollution license, factory license & Fire license etc based on the needs.

## **CHAPTER-8**

### **GMP/GHP/HACCP REQUIREMENTS**

To provide assurance of food safety, Food businesses must implement an effective Food Safety Management System (FSMS) based on Hazard Analysis and Critical Control Point (HACCP) and suitable pre-requisite programmes by actively controlling hazards throughout the food chain starting from food production till final consumption.

As per the condition under FSS (Licensing & Registration of Food Businesses) Regulations 2011, every food business operator (FBO) applying for licensing/registration must have a documented FSMS plan and comply with schedule 4 of this regulation. Schedule 4 introduces the concept of FSMS based on implementation of Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP) by food businesses.

### **GOOD MANUFACTURING PRACTICES/GOOD HYGIENE PRACTICE**

#### **Part I - General Hygienic and Sanitary practices to be followed by Petty Food Business Operators applying for Registration**

#### **SANITARY AND HYGIENIC REQUIREMENTS FOR FOOD MANUFACTURER/ PROCESSOR/HANDLER**

The place where food is manufactured, processed or handled shall comply with the following requirements:

1. The premises shall be located in a sanitary place and free from filthy surroundings and shall maintain overall hygienic environment. All new units shall set up away from environmentally polluted areas.
2. The premises to conduct food business for manufacturing should have adequate space for manufacturing and storage to maintain overall hygienic environment.
3. The premises shall be clean, adequately lighted and ventilated and sufficient free space for movement.
4. Floors, Ceilings and walls must be maintained in a sound condition. They should be smooth and easy to clean with no flaking paint or plaster.
5. The floor and skirted walls shall be washed as per requirement with an effective disinfectant the premises shall be kept free from all insects. No spraying shall be done during the conduct of business, but instead fly swats/ flaps should be used to kill spray flies getting into the premises. Windows, doors and other openings shall be fitted with net or screen, as appropriate to make the premise insect free The water used in the manufacturing shall be

potable and if required chemical and bacteriological examination of the water shall be done at regular intervals at any recognized laboratory.

6. Continuous supply of potable water shall be ensured in the premises. In case of intermittent water supply, adequate storage arrangement for water used in food or washing shall be made.

7. Equipment and machinery when employed shall be of such design which will permit easy cleaning. Arrangements for cleaning of containers, tables, working parts of machinery, etc. shall be provided.

8. No vessel, container or other equipment, the use of which is likely to cause metallic contamination injurious to health shall be employed in the preparation, packing or storage of food. (Copper or brass vessels shall have proper lining).

9. All equipments shall be kept clean, washed, dried and stacked at the close of business to ensure freedom from growth of mould/ fungi and infestation.

10. All equipments shall be placed well away from the walls to allow proper inspection.

11. There should be efficient drainage system and there shall be adequate provisions for disposal of refuse.

12. The workers working in processing and preparation shall use clean aprons, hand gloves, and head wears.

13. Persons suffering from infectious diseases shall not be permitted to work. Any cuts or wounds shall remain covered at all time and the person should not be allowed to come in direct contact with food.

14. All food handlers shall keep their finger nails trimmed, clean and wash their hands with soap, or detergent and water before commencing work and every time after using toilet. Scratching of body parts, hair shall be avoided during food handling processes.

15. All food handlers should avoid wearing, false nails or other items or loose jewellery that might fall into food and also avoid touching their face or hair.

16. Eating, chewing, smoking, spitting and nose blowing shall be prohibited within the premises especially while handling food.

17. All articles that are stored or are intended for sale shall be fit for consumption and have proper cover to avoid contamination.

18. The vehicles used to transport foods must be maintained in good repair and kept clean.

19. Foods while in transport in packaged form or in containers shall maintain the required temperature.

20. Insecticides / disinfectants shall be kept and stored separately and away from food manufacturing / storing/ handling areas.



## **Part II - General Requirements on Hygienic and Sanitary Practices to be followed by all Food Business Operators applying for License**

### **GENERAL REQUIREMENT ON HYGEINIC AND SANITARY PRACTICES TO BE FOLLOWED BY ALL FOOD BUSINESS OPERATORS APPLYING FOR LICENSE**

The establishment in which food is being handled, processed, manufactured, packed, stored, and distributed by the food business operator and the persons handling them should conform to the sanitary and hygienic requirement, food safety measures and other standards as specified below. It shall also be deemed to be the responsibility of the food business operator to ensure adherence to necessary requirements. In addition to the requirements specified below, the food business operator shall identify steps in the activities of food business, which are critical to ensure food safety, and ensure that safety procedures are identified, implemented, maintained and reviewed periodically.

#### **1. LOCATION AND SURROUNDINGS**

Food Establishment shall ideally be located away from environmental pollution and industrial activities that produce disagreeable or obnoxious odour, fumes, excessive soot, dust, smoke, chemical or biological emissions and pollutants, and which pose a threat of contaminating food areas that are prone to infestations of pests or where wastes, either solid or liquid, cannot be removed effectively.

In case there are hazards of other environment polluting industry located nearby, appropriate measures should be taken to protect the manufacturing area from any potential contamination.

The manufacturing premise should not have direct access to any residential area.

#### **2. LAYOUT AND DESIGN OF FOOD ESTABLISHMENT PREMISES**

As far as possible, the layout of the food establishment shall be such that food preparation / manufacturing processes are not amenable to cross-contamination from other pre and post manufacturing operations like goods receiving, pre-processing (viz. packaging, washing / portioning of ready-to-eat food etc).

Floors, ceilings and walls must be maintained in a sound condition to minimize the accumulation of dirt, proper drainage, condensation and growth of undesirable moulds. They should be made of impervious material and should be smooth and easy to clean with no flaking paint or plaster. Doors shall also be made of smooth and non-absorbent surfaces so that they are easy to clean and wherever necessary, disinfect.

Windows, doors & all other openings to outside environment shall be well screened with wire-mesh or insect proof screen as applicable to protect the premise from fly and other

insects / pests / animals & the doors be fitted with automatic closing springs. The mesh or the screen should be of such type which can be easily removed for cleaning.

### **3. EQUIPMENT & CONTAINERS**

Equipment and containers that come in contact with food and used for food handling, storage, preparation, processing, packaging and serving shall be made of corrosion free materials which do not impart any toxicity to the food material and should be easy to clean and /or disinfect (other than disposable single use types).

### **4. FACILITIES**

Only potable water, with appropriate facilities for its storage and distribution shall be used as an ingredient in processing and cooking. Water used for food handling, washing, should be of such quality that it does not introduce any hazard or contamination to render the finished food article unsafe. Water storage tanks shall be cleaned periodically and records of the same shall be maintained in a register. Ice and Steam Ice and steam used in direct contact with food shall be made from potable water and shall comply with requirements specified under. Food waste and other waste materials shall be removed periodically from the place where food is being handled or cooked or manufactured to avoid building up. The disposal of sewage and effluents (solid, liquid and gas) shall be in conformity with requirements of Factory / Environment Pollution Control Board.

Personnel facilities shall include those for proper washing and drying of hands before touching food materials including wash basins and a supply of hot and /or cold water as appropriate; separate lavatories, of appropriate hygienic design, for males and females separately; and changing facilities for personnel and such facilities shall be suitably located so that they do not open directly into food processing, handling or storage areas.

### **5. FOOD OPERATIONS AND CONTROLS**

No raw material or ingredient thereof shall be accepted by an establishment if it is known to contain parasites, undesirable micro-organisms, pesticides, veterinary drugs or toxic items, decomposed or extraneous substances, which would not be reduced to an acceptable level by normal sorting and/or processing. All raw materials, food additives and ingredients, wherever applicable, shall conform to all the Regulations and standards laid down under the Act. Records of raw materials, food additives and ingredients as well as their source of procurement shall be maintained in a register for inspection. Food storage facilities shall be designed and constructed to enable food to be effectively protected from contamination during storage; permit adequate maintenance and cleaning, to avoid pest access and accumulation.

## **6. FOOD PACKAGING**

Packaging materials shall provide protection for all food products to prevent contamination, damage and shall accommodate required labelling as laid down under the FSS Act & the Regulations there under.

## **7. MANAGEMENT AND SUPERVISION**

A detailed Standard Operating Procedure (SOP) for the processing of food as well as its packing, despatch and storage will be developed for proper management which in turn would help in identifying any problem and the exact point, so that damage control would be faster. The Food Business shall ensure that technical managers and supervisors have appropriate qualifications, knowledge and skills on food hygiene principles and practices to be able to ensure food safety and quality of its products, judge food hazards, take appropriate preventive and corrective action, and to ensure effective monitoring and supervision.

## **8. FOOD TESTING FACILITIES**

A well equipped, laboratory for testing of food materials / food for physical, microbiological and chemical analysis in accordance with the specification/standards laid down under the rules and regulations shall be in place inside the premise for regular / periodic testing and when ever required. If there is no in house laboratory facility, then regular testing shall be done through an accredited lab notified by FSSAI . In case of complaints received and if so required, the company shall voluntarily do the testing either in the inhouse laboratory or an accredited lab or lab notified by FSSAI.

## **9. AUDIT, DOCUMENTATION AND RECORDS**

A periodic audit of the whole system according to the SOP shall be done to find out any fault / gap in the GMP / GHP system. Appropriate records of food processing / preparation, production / cooking, storage, distribution, service, food quality, laboratory test results, cleaning and sanitation, pest control and product recall shall be kept and retained for a period of one year or the shelf-life of the product, whichever is more.

## **10. SANITATION AND MAINTENANCE OF ESTABLISHMENT PREMISES**

A cleaning and sanitation programme shall be drawn up and observed and the record thereof shall be properly maintained, which shall indicate specific areas to be cleaned, cleaning frequency and cleaning procedure to be followed, including equipment and materials to be used for cleaning. Equipments used in manufacturing will be cleaned and sterilized at set frequencies. Food establishment, including equipment and building shall be kept in good repair to prevent pest access and to eliminate potential breeding sites. Holes, drains and other places where pests are likely to gain access shall be kept in sealed condition or fitted with

mesh / grills / claddings or any other suitable means as required and animals, birds and pets shall not be allowed to enter into the food establishment areas/ premises.

#### **11. PERSONAL HYGIENE**

The Food Business shall develop system, whereby any person is carrier of a disease or illness likely to be transmitted through food,, shall immediately report illness or symptoms of illness to the management and medical examination of a food handler shall be carried out apart from the periodic checkups, if clinically or epidemiologically indicated. Arrangements shall be made to get the food handlers / employees of the establishment medically examined once in a year to ensure that they are free from any infectious, contagious and other communicable diseases. A record of these examinations signed by a registered medical practitioner shall be maintained for inspection purpose. Food handlers shall maintain a high degree of personal cleanliness. The food business shall provide to all food handlers adequate and suitable clean protective clothing, head covering, face musk, gloves and footwear and the food business shall ensure that the food handlers at work wear only clean protective clothes, head covering and footwear every day.

#### **12. PRODUCT INFORMATION AND CONSUMER AWARENESS**

All packaged food products shall carry a label and requisite information as per provisions of Food Safety and Standards Act, 2006 and Regulations made there under so as to ensure that adequate and accessible information is available to the each person in the food chain to enable them to handle, store, process, prepare and display the food products safely and correctly and that the lot or batch can be easily traced and recalled if necessary.

#### **13 . TRAINING**

The Food Business shall ensure that all food handlers are aware of their role and responsibility in protecting food from contamination or deterioration. Food handlers shall have the necessary knowledge and skills which are relevant to food hygiene and food safety aspects along with personal hygiene requirements, food processing / manufacturing, packing, storing and serving so as to ensure the food safety and food quality. Periodic assessments & training programmes shall be routinely reviewed and updated wherever necessary

#### **HAZARD ANALYSIS AND CRITICAL CONTROL POINT (HACCP)**

Implementing Hazard Analysis and Critical Control Point (HACCP) is crucial for any food business as it helps to identify weaknesses in the preparation and production of food. It also

identifies critical limits in compliance with food law and helps to take preventive and corrective measures.

HACCP is therefore, that management tool that provides a structured, systematic approach to the identification of hazards and methods of control that is not achievable by traditional testing and inspection approaches (quality control). During implementation of HACCP, it is imperative to set controls at each point of the production line at which safety problems (physical, chemical and microbiological) are likely to occur.

A HACCP plan is required to be in place before initiating the HACCP system. A HACCP plan consists of 5 initial steps and 7 major HACCP principles. The requirements for Sanitation Standard Operating Procedures (SSOPs) along with Good Manufacturing Practices (GMPs) & Good Hygiene Practices should be considered as Pre-Requisite for HACCP.

Documentation shall include (as a minimum) the following:

- HACCP team composition;
- Product description;
- Intended use;
- Flow chart;
- Hazard analysis;
- CCP determination;
- Critical limit determination;
- Validation process; and
- HACCP plan

**The HACCP plan shall include the following information for each identified CCP:**

- Food safety hazard(s) to be controlled at the CCP;
- Control measure(s);
- Critical limit(s);
- Monitoring procedure(s);
- Corrections and corrective action(s) to be taken if critical limits are exceeded;
- Responsibilities and authorities for monitoring, corrective action and verification;
- Record(s) of monitoring.

## CHAPTER- 9

### OPPORTUNITY FOR MICRO/UNORGANIZED ENTERPRISE

#### SCHEME FOR GROWTH OF MICRO FOOD ENTERPRISES

Government plan for “Vocal for Local” & ‘Atmanirbhar Bharat” with global outreach vision for enhancing the income of small food business operators & improving health and safety benchmark as a mega development scheme.

The scheme will be implemented under the key areas:-

1. FSSAI Registration of all the unregistered and unorganized food business operators (FBO).
2. Standardization of the micro food enterprise (MFEs) for technical up-gradation to attain the FSSAI food safety standard and providing technical aids from government agency to increase their brand marketing.
3. Makhana is also selected as Food Crop for cluster based approach.
4. Export promotion with improved health and safety along with integration with retail chain to enhance export market.

Makhana farmers may be linked to a micro finance institution (MFI), which would provide micro credit through formation of self-help groups, promote health insurance and mitigate risk.

#### MARKET POTENTIAL AND EXPORTS OF MAKHANA

The Makhana sector holds immense potential for value addition, product development and innovation. Bolster the economic health of the state & country and bring glory to wonder crop. The Makhana market will grow at a Compound Annual Growth Rate (CAGR) of almost 7% during the forecast period of 2019-2023. The global Makhana market size will grow by USD 72.5 million during 2019-2023.

Makhana is highly popular in countries such as India, China, Japan, and Thailand. The potential of the Makhana market in Western countries such as the UK and the US is still untapped.

**Table 9. Export Data of Makhana**

<b>Total Value &amp; Volume of Exports in India</b>		
Total Value \$1,388,394	Total Quantity: 292,822	
<b>Average Price</b>		
Average price per unit: \$4.74	Average value per shipment: \$1,126	
<b>Top Suppliers</b>		
United States: \$751,132	United Kingdom: \$171,480	Canada: \$120,861
<b>Top Ports of Discharge</b>		
Mundra: \$545,155	Nhava Sheva Sea: \$475,398	Sabarmati: ICD \$110,582

## REFERENCE AND SUGGESTED READINGS

1. Food Safety & Standard Act, 2006 & Regulations.
2. A Report on Makhana Production, Processing and Supply Chain.
3. Nutritional status of recently developed Makhana Variety “ Swarna Vaidehi”.
4. Business Plan for Makhana Cluster in Bihar.
5. ICAR -Research Center for Makhana, Darbhanga.
6. ICAR-Central Institute of Post Harvest Engineering & Technology.
7. <https://agriexchange.apeda.gov.in/Weekly eReport/Makhana Report.pdf>.