A Study of the Toor Dal Manufacturing Process using Lean Six Sigma Tools to Solve Raw Material Processing and Storage Issues

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Abstract- This manuscript focuses on Toor Dal's purchasing and inventory storage in the Toor Dal processing industry. Since the raw material is not available throughout the year, storing the required raw material to produce the goods in the next few days is essential. The main problem consists of purchasing and storing raw materials from farmers. Typically, prices change according to market conditions, resulting in raw material damage if the product is held for a long time in unacceptable conditions. Generally, Toor Dal is the primary food source of the Indian people for afternoon lunchtime. In fact, within southern India, Toor Dal is consumed as the primary food stock. The crop is grown in certain months only, so it is imperative to store the food grains whenever it is available. Shelf life for Toor Dal is for more than one year. With lean practices and analysis, this author would like to implement a plan to store excellent quality products for a long time with heavy stocks.

Keywords—Agriculture, Lean Six Sigma, Manufacturing, Toor Dal.

I. INTRODUCTION

Toor Dal (red gram) is one of the primary food sources for Indians. The crop is only available in particular months, in specific locations. It is also called pigeon pea and has been cultivated for over 3500 years. Toor Dal originated in the southern peninsular region of India, consisting of tropical deciduous woodlands. Toor Dal traveled from India to East Africa and West Africa and ultimately reaching Europeans. Toor Dal is cultivated around a 3.90Mha area in India, where more than 3.17 million tons are produced annually [1]. Figures 1 and 2 pictorially illustrate the initial and the eventual outcome of Toor Dal before and after processing.



Figure 1. Image of the Red gram/ Pigeon pea

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Figure 2. Toor Dal Final Product

Toor Dal is very high in protein with 22 percent content, which is equal to three times that of most cereals. It is primarily consumed as a part of pulses, and it is crucial in the diet because of its attractive characteristics. Food essentials consist of Toor Dalchawal and roti-Toor Dal, bread-pulses important in the Indian food items. Ingredients include high levels of lysine, riboflavin, thiamine, niacin, and iron. For every 100gram of Toor Dal, nearly 335 calories of energy is present. The red gram can be grown at a temperature between 26 -30 degrees centigrade during the rainy season and at roughly 17 to 22 degrees centigrade in non-rainy seasons. Toor Dal needs a minimum of 120 to 180 days to grow the plant and produce seed, whilst it is scarce and sensitive. Toor Dal creates blossums during monsoons and cloudy weather. In India, Toor Dal is mainly cultivated on the different soils Entisols, Vertisols, Inceptisols, and Alfisols. To get more yield of the Toor Dal, good soil composition is required.

After a long span of more than four or five months, of good work with taking specific measures, the final product Toor Dal is available for harvesting. Afterwards, the product is transferred to the manufacturing unit, and the process is completed. Since the production will be in huge quantity, but only in few seasons or months, the pulses in storage place is located in warehouses with cold storage as there are many costs and problems associated in order to maintain good quality seed product [1].

II. THE NEED FOR RAW MATERIAL STORAGE

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III. SUPPLY CHAIN MANAGEMENT

Agriculture plays a significant role and acts as the backbone of the Indian economy, it contributes 13.7 percent of GDP, and 55% of people are employed at the base level of employment tasks. Here, the supply chain will have a considerable impact on the economy because of various costs and processes. The supply chain process from the farmer to the consumer is clearly shown in Figure 3 through the use of class-provided diagramming software [2]. Toor Dal is transferred to storage points, manufacturers, millers, importers, and exporters from the farmers with four more steps that include distributor, dealer, wholesaler, and ultimately retail to the consumer with an acceptable quality level.



Figure 3. The Supply Chain of Pulses from Farmers to the Consumer

IV. ORGANIZATION

Shut-in people rely upon online delivery for most of their food items, this system helps customers and alleviates undo restaurant management of the system. It also utilizes a computerized algorithm for defining the best solution for each order; making changes a necessary in manual handling of the food-the scope of the delivery industry associated with the budget and the return time. For example, the company Fabfurnish in India is an online furniture delivery company. They started their venture in 2011 at Gurugram, founded by three people Mehul Agarwal, Vikram Chopra, and Vaibhav Aggarwal. Through the development of their company, they have achieved a \$50 million fundraise from big industrial entities. This startup was going well, but one moment people are asked to replace the furniture which is not liked by them or which customer is not satisfied with, it is not an easy deal to replace. And company management failed to provide solutions to the many issues like refund, return, and warranty so customers began to lose trust in the company, until finally the company went out of business. Eventually, this company was acquired by the Future Group for \$2.25 million [3].

The main problem associated with purchasing and storing the raw material, since the availability of raw material is not often, is due to the seasonality of the crop that grows in particular months. It takes from 3-6 months to get the final product, and in the Andhra Pradesh area, the pigeon pea is available from November to February. As it is an essential crop and needs some climate conditions to grow with the best nutrients, people use fertilizers to supply good supplements. So, it is required to buy the raw material whenever it is available in bulk quantity. Multilocation storage is required in different locations depending on the availability of space in typically-used storage locations [4].

V. RAW MATERIAL STORAGE

In general, most of the raw material is stored in two types of conditions - cool and dry. Depending on how much is held, based on quality, the quantity will change-the dimensions of the stock room and also how your store is also essential to maintain product hygiene. Toor Dal handling systems vary depending on the product as men and machines will handle it upon availability. The storage is done in an order that efficiently unloaded whenever needed. Those food grains are packed in bags, and then goods are placed one by one on wooden racks because the bags should not touch the ground since they may spoil by any insects, as shown in Figure 4. The image illustrates shows how bags are placed in the inventory separately as blocks side by side. It is easy to load and unload the bags whenever required material from production. Hence by storing in large quantities, money is saved and handling is easy although while loading no grains should be spilled from bags on the floor or in trucks [4].



Figure 4. Storage of Raw Material Bags in Inventory

A. Types of Storage

Raw material is cleaned and purchased from farmers, which is then sent to storage plants from the crop field by trucks and lorry, depending on the quantity and how much time is needed to store the product in different storage sectors. The different types of storage are: In-plant Storage - This is located in the manufacturing plant, and working stocks are stored, and finished products are packed in bags. Product is kept here so limited space for the ongoing supplies like in small scale industry they maintain around 80-150tons; In cold storage - Here the food grains are stored in a very cool place, and the particular temperature is maintained not to damage the products. Certain chemicals are also used that insects do not affect the grains. Some private and government cold storages charge accordingly for 100-200 rupees per quintal per year in India. Here the red gram is stored

for up to two years; Rural / ManToor Dal Godowns -Most places are organized by their local godowns to store the produced crop in and around areas. It is a quick way to keep stock. In India, according to NABARD and NCCDC, these facilities hold around 36.62 lakh tons in 973 godowns. The CWC, SWC, and Co-operative societies have also constructed godowns as well; In-state warehouses/ Central Warehousing Corporation (CWC) - The food products are weighed and stored by the state warehouse department in their plants, and the prices are economical here that for the bag charged (roughly 6 rupees per month) and it is in dry condition. This is to store the red gram for only one to nine months. Figure 5 illustrates how the goods are packed in bags and stored in the state or central warehouse corporation godowns that are having a vast space with heavy truss structure for the roof. Figure 6 indicates the SWC / CWC outside facade, which is a typical construction throughout India, and has two doors from each block to load and unload the material with the workers' help. There are open windows for the wall to circulate air so that the goods won't damage, but here they can't be so long [5].



Figure 5. Toor Dal Packed in Bags and Stored in SWC/CWC Godown



Figure 6. State Warehouse Godown of Andhra Pradesh

B. Storage Costs

The cost deals with the total quantity of the product stored. For every bag, there is a specific fixed price of around 100 - 200 INR per year depending on the location and type of storage (Godowns, Warehouses, CWC, SWC). These costs do not include loading and unloading; along with this, 9% government tax should be paid additionally.

 $\ensuremath{\mathsf{VI}}$. The Process Involved in the Selection of Quality

The crop should be selected according to the product's quality since different types of products are available like UPAS-120, Pant A3, Prabhat, ICPL 87,

ICPL 151, T21, HY2, Pusa 84, and many others. Depending on the field, land, availability of resources, water, climatic condition, cost, culture.

A. Availability of Crops

In Andhra Pradesh, the availability of crops is excellent; in India, Maharashtra is the highest red gram-produced state and very high in Toor Dal's production. In Andhra Pradesh, the harvest is available around 8.17 percent of the total country production. Guntur region is the major in Andhra Pradesh for the red gram because more fields cultivate only Toor Dal products. And because of the monsoon climate, the crop will grow high and demand more farmers to produce.

B. Transportation

After the toor crop is picked by farmers and stored in sunlight to dry and the final toor raw material is obtained, the product is moved by trucks and lorries through the manufacturing and storage units. Transportation is mainly done by using trucks and lorry in India. Figure 7 shows the lorry full of raw material packed with sheets and then tied with ropes not to slip from the lorry while traveling. Here so many costs are associated with it like workers' cost, loading, transporting, unloading charge.



Figure 7. The Lorry Carrying Raw Material Goods

C. Checking the Quality

After bringing the crop, the pulses are divided according to the quality, and the sortex machine is used to segregate the granules to their sizes and then stored them in bags. Excellent quality seed has around 4000-5000 Indian rupees per quintal (100g) although the price will vary with respect to the quality.

D. Price and Analysis

Due to supply and demand in the market conditions, prices of the Toor Dal will vary, with perfect analysis according to the ground report the purchasing and selling of the crop should be done, as a businessman, no one wants to lose the money, so it is better for one individual to conduct the analysis prior to a purchase.

VII. PRODUCTION PROCESS

There are different steps involved in the manufacturing process of Toor Dal from the red grams. Toor Dal is extracted from the soil so it is has extra dust particles requiring cleaning as it is the most important thing in tandem with reduced moisture content, as it will be heated after oil treatment and then cooled—removing all the impurities and unwanted particles from which the final Toor Dal product will be obtained. In Figure 8, the process of manufacturing is shown step by step-by-step [6].

Step 1: Pre-Cleaning - The first step, here the toor is pre-cleaned to remove the dust particles with the use of stones with, a specialized de-stoner machine in the industry, the other two units are placed here that pre-cleaning and dumping, cleaning the unit, de-stoner unit. Then the raw materials are transferred into another tank where all the big particles are removed.

Step 2: Oiling - In the second step, the red gram is treated with oil which absorbs the hard waste particles and makes the seed easy to boil during the dryer's heat. The basis absorbs the oil, and where seeds are continuously rotated in the drums by treating with oil and then the oil is dropped in the sump which collets the oil and used for the next cycle. Now the seeds are left for nearly 48 hours rest in the oiling tank.



Figure 8. Process of Toor Dal Manufacturing

Step 3: Drying and Cooling - From the previous tank, the seed is passed through the dryer, then heated for around 4-5 hours depending on the size and moisture content; here, the moisture level is reduced. The dryer is transferred to cooling chambers where the required level of moisture is retained and maintained.

Step 4: De-husking - In this phase, the peal of the seeds is removed by passing through different shells. In this chamber, the Toor Dal pulses are equally divided into two halves. The perfect quality of Toor Dal got here only 75 % of the total is product is obtained, and the remaining 25% is still as expected.

Step 5: Splitting and grading - After the last process, now the pulses which are not split before are again passed through the splitting chamber to split the Toor Dal into two halves by using the machine. Now

the Toor Dal is passed through a grading machine that divides grains according to the grains' size.

Step 6: Sorting - The Toor Dal is divided by grades, then the grains are finally sent into the color sortex machine where the Toor Dal is divided according to the size and color. At this step the impurities are also removed as air pressure is applied so that the small size particles will be removed first and separated into different bags. The green color, yellow color particles are separated, and the green particles and dust materials are removed. In the machine for one ton of Toor Dal is sorted for every hour. Then the yellow Toor Dal is transferred to the polish device.

Step 7: Polishing – At this stage the Toor Dal is moved from the sorter machine to different polishing machines based on customer preference. Other people and locations use other quality Toor Dal so the level of polishing will be used and separated and then moved to the packing section in the same manner.

Step 8: Packing - Lastly, the product is packed in bags at 1kg, 2kg, 5kg, 10kg, or 25kg and sent to market distributors, from then it will be passed to wholesaler, to retail, then finally customer will get the best quality Toor Dal to cook and eat in their meal.

VIII. PROBLEM SOLVING BY USING LSS TOOLS

A. DMAIC Tool

With the help of the LSS tool DMAIC, where problems are solved, the process is utilized to reduce the cost and improve purchasing the raw material and storage work safely. DMAIC is a five-step process which involves (shown in Figures 9 and 10) [7].

- Define
- Measure
- Analyze
- Improvement
- Control



Figure 9: DMAIC

1) Define

It is the first step; goals, problems are clearly defined and mainly focuses on the minimization of wastage. Here the raw material problem is limited, and the availability of the crop fields is noted down, and the chart is prepared according to the availability, price, location, quality, transportation [8].

2) Measure

The process is documented, and valid measurements are taken to start the process. Here, the cost and availability of the crop and purchasing the raw material are measured and analyzed. All the availability of sources is listed, and charges are calculated. Some why-why diagrams, flow charts are used to draw the process maps [8].

3) Analyze

All the possible sources are analyzed. All the issues and project details are researched; the step identifies the gaps between the performance and goals, improvements need to be done, and the opportunities available. The inventory should be maintained correctly by purchasing all the raw material; the process flow charts and fishbone diagrams are used to analyze [8].





4) Improve

It is the fourth step, after analyzing required Improvements are made o the process. We need to control the process, and we get breakthrough performance. The inventory, raw material, details are maintained, and the details regarding this are noted. If there are missing sources, they are checked and maintained [8].

5) Control

The final step is to focus on the results by making proper changes. Each step is thoroughly monitored to get efficient products in the process. Here the sources of raw materials are noted, necessary tasks are done, the best approach is found, and perform the designed plan. The inventory is maintained with the raw material, Toor Dal is purchased, and from the farmers, the pulses are transferred to the storage points and the millers [8].

B. 5S Tool

5S is one of the LSS tools used for solving problems by improving workplace performance and cleanliness in the organization. The central concept of

the tool is to keep waste out and increase process efficiency. The 5S in the tool explained in Figure 11, are [9]:

- Sort
- Straighten Set in Order
- Shine
- Standardize
- Sustain



Figure 11. LSS 5S Tool

1) Sort

The first step is to sort all the equipment and materials and know the work process. Only essential tools, aids are present. The main objective is to reduce clutter and make it easier to find the resources required for work. Here, the quality of raw material is checked, and make a list where it is available.

2) Straighten (Set in Order)

All the items, work materials, required things should be prioritized in a to-do list; we need to set the order from high preference to least preference. Here in the industry, transportation, cleaning, purchasing should be calculated and make a list of order what to do first.

3) Shine

Here all the tools, machinery, equipment, and machinery are cleanly maintained; there should be a regular schedule for the plant's maintenance. The main motto of the workplace is to keep safe and stay safe, increase productivity. Here in the red gram, the product is neatly maintained after the sorting according to size and color and then sent to the packing.

4) Standardize

It is the process for the sorting, order, implementation, processing of the manufacturing. The central concept is to maintain all the branch operations consistent and work towards improving the industry's efficiency.

5) Sustain/ Self-discipline

The industry should implement all the 5S processes and increase profits along with the safety of the plant. That the raw material is transported to the manufacturing plant by removing all the unwanted costs like waste handling cost, maintaining time, time delay cost, and rent cost associated with the rent of transportation trucks, lorry, and machinery cost.

IX. CONCLUSION

In this paper, the Toor Dal step-by-step manufacturing process is explained, and by using the LSS tool DAMIC approach, the problem facing by the millers is described and shown possible solution how to deal with it. How to select the material's quality, what type of seeds to choose are identified, type of crops, availability of red gram is briefly shown in this paper. The raw material is selected by the quality, depending on the people we need to maintain the inventory stocks for the manufacturing Toor Dal. Since the crop is not available throughout the year, lean tools are used to keep stock correctly maintained and purchased. With the help of new software, raw material can be tracked. Any errors in the raw material may cause loss of money, manufacturing time, inventory cost, operating cost, handling charge, and employee time waste. So, it is imperative to monitor the storage of goods, know the availability of crops, and purchase accordingly by analyzing the market conditions' price variation.

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