Design and Development of a Pepper Plucking Equipment to Facilitate Pepper Harvesting

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Abstract
The primary goal of the study is to design and development of a pepper plucking equipment to facilitate pepper harvesting in the agricultural sector. Pepper, the king of spices is one of the oldest and the best known spices in the world. At present the pepper harvesting is done manually by the laborers climbing on the trees. So in order to avoid climbing and to solve the problems related in this field it is essential to have pepper plucking equipment. Though India is an agricultural country and majority of the population depends on agriculture for their lively hood, there is shortage of labor in some of the agricultural sectors. Nowadays this labor problem is more acute. Thus innovative methods are to be adopted to solve the problem of shortage of labor.

For designing of pepper plucking equipment, it is very important to understand the customer’s needs, main suggestions from the users and the trends in the market. A detailed ethnography research has been done in the pepper harvesting field for understanding the problems facing the area. Literature review, GEMBA studies and customer survey, market study etc has been done. From the output of the data analysis, Quality Function Deployment (QFD), & the product design specifications were made. According to the PDS five different concepts were generated in order to overcome the usability, safety and the ergonomic issues related to the problem.

The selection of the final concept was done by customer preference. Then, with the help of Dot matrix method a comparative ranking has been done by giving certain Weightage. On the basis of that, the concept which obtained highest score has been selected as the most feasible concept. The selected concept was developed into a 1: 1 working model. After conducting feasibility test the model was validated. So it can be very well concluded that the development of such kind of equipments will surely find a place in the market.

Key Words: Pepper Plucking Equipment, QFD, Dot Matrix

1 INTRODUCTION

PEPPER- “The King of Spices” is one of the oldest and the best known spices in the world. Pepper is grown widely in many countries like Taiwan, Sri Lanka, Indonesia, India etc. Pepper is a vine generally growing on supporting trees. At present pepper harvesting is done by manually plucking. Man has to climb on the trees using bamboo poles, ladders or rope rings. So it is a tedious task. This process of plucking pepper involves high risk that there are chances of falling from the ladder or the bamboo pole. Likewise it causes severe physical and health problems. So it is very essential to have a pepper plucking equipment in order to facilitate the pepper plucking process or the harvesting of pepper.

2. LITERATURE REVIEW
2.1 Literature Review Summary
Pepper grows on a vine that tangle itself up a host tree. Different methods are followed in different countries for harvesting pepper. In Vietnam, the practice of harvesting pepper berries is through netting practice. Rather than manually plucking, farmers lay a net a little bit above the ground and wait for the berries to fall down and collect the berries once in every two to three days. Another practice of plucking pepper is by way of manual plucking and putting the berries down to the ground where mat is spread. In Ecuador, Sri Lanka etc. pepper plants are usually grown up to a height of 2 meters on wooden poles fixed on the ground. So the harvesting of pepper is done manually by hands. In India also the same process of manual plucking is followed.

3 DATA COLLECTION & ANALYSIS
3.1 Product Study
Detailed product study has been conducted to find out the available products used in the pepper cultivation field for harvesting peppercorns. At present no specific pepper plucking equipment is available. Generally pepper plucking is done manually. Sometimes poles with a knife attached at its end (as shown in the figure) are used for plucking.

**Fig. 2 Knife Fixed on Pole**

In Kerala Agricultural University Mannuthy, it was found that the only equipment used for plucking is the “A” type step ladder. By standing on the ladder plucking is carried out manually.

**Fig. 3 A Type Ladder**

Since pepper vines grow on some host trees, it is necessary that for plucking one has to climb on the trees. Sometimes rope rings are used for climbing. These rings are put on hands and legs.

**Fig. 4 Rope Rings**

Often ladders made of iron or bamboos are used for climbing. Then standing on the ladders people pluck peppercorns with their hands.

**Fig. 5 Bamboo Ladder**

3.2 Summary of Product Study

From the detailed analysis it is clear that no specific equipment for plucking peppercorns is available. Only indigenous methods like climbing on the trees and doing the plucking manually is followed. Therefore the necessity of designing and developing a pepper plucking equipment became a felt need.

3.3 Gemba Study and Customer Survey

In order to identify unspoken customer requirements is to go and watch the customer at their work place or in the Gemba. Gemba is the Japanese word which means the real work place. From the GEMBA study we could identify the usability issues faced by pepper cultivators with regard to the present pepper plucking process. Since the harvesting of pepper is an important matter, it is necessary to have a detailed design research analysis for finding out a suitable machine or equipment in this field. Some of the data we could gather by GEMBA study is as follows:-

- Pepper plant creeps on Areca nut tree, jack fruit tree, mango tree etc.
- Generally ladders are used for climbing on the trees to pluck peppercorns.
• At present no particular machine is available for plucking pepper.
• It is very difficult for the cultivators to harvest peppercorns.
• Various health problems are occurring to the climbers.

3.4 Ethnography Study
By climbing on the bamboo poles the man directly plucks peppercorns with his hands.

3.5 Findings and Need Analysis
- Chances of falling from the poles are very high.
- Causes health problems like itching and other skin diseases.
- Non availability of climbers, as today’s youth are unwilling to take up this job.

The problems identified can well be solved, if an equipment or device is developed for plucking peppercorns. A person can use the equipment even from the ground.

4.1 Problem Statement
The importance of the product and the user requirement is clearly understood from the Customer survey and the GEMBA study. So it is essential to define the problems faced with these customer requirements.

4.2 Problem Definition
The important problem identified in the field of Pepper harvesting is the tedious manual plucking of peppercorns from the pepper vines. So introduction of mechanization in pepper harvesting field has become a necessity.

4.3 Study Objectives
- To carry out literature review on Plucking machines and understand the latest trends, present practices and collect relevant data.
- To collect data of existing designs through product study, visual design exploration, user study and market study.
- To analyze the collected data to arrive at PDS and QFD.
- To generate concepts as per PDS, create 3D models of the generated concepts and select the final concept using weighted ranking method and to make the working model of the selected concept.
- Concepts will be generated using sketching, ideation tools such as brain storming, mind mapping, theme boards.
- Five concepts will be generated and modeled with detailed features using software such as CatiaV5, Alias studio tools, Adobe Photoshop.
- To make 1:1 scale mock up model of the selected concept of the equipment.
- Concept evaluation for selecting the final concept will be carried out by the customer preference.
- 1:1 scaled physical model will be made with good aesthetics detailed features.
- Design validation will be carried out through user feedback.

4.4 Methodology Chart

4.5 QFD (Quality Function Deployment)
Quality Function Deployment is the method of transforming user demands into design quality. It is the quality technique evaluating the suggestions and ideas of key stake holders to produce a good quality product in order to fulfill customer needs. In QFD, customer voice has great significance and that has to be refined and converted into technical voice for product design process.
4.6 Product Design Specification

Product design specification is a statement showing that what a not-yet-designed product is intended to do. It is the process that helps to meet the needs and design considerations of the product. PDS helps to understand all the specified data with improved information.

5. CONCEPT GENERATION

Concept generation is vital in the process of designing. Various concepts are generated from the analyzed topics based on the PDS. These concepts considered aesthetics, shape, and ergonomic considerations. The needs, specifications, and technical considerations are used as a basis for generating various product concepts. In PDS the basic specification of the product has been prepared clearly. Mind mapping tool is used in order to explore idea generation.

5.1 Mind Mapping

Mind mapping is an important tool in the hands of a designer. It is a diagram used to represent ideas which are linked to or arranged around a central key idea. It can be termed as a Spider graph.

5.2 Concepts

The various concepts generated are detailed below:

5.2.1 Concept 1

The main mechanism used in this concept is pulley mechanism. While pressing the lever from the bottom, the brake cable pulls back & the upper blade moves towards the fixed blade and does the cutting. The top portion or the cutting part of the equipment consists of two sharp blades. The blade which is inserted into the pipe is fixed and the other one is the movable. The blade which is joined with the lever is in turn connected to a pulley by using cable wire. The hand lever for operating the equipment is given at the lower portion. In this concept, several small pulleys are given. This may lead to frequent damage and non-functioning causing repair and maintenance.

5.2.2 Concept 2

In this concept, while pressing the lever down the threads get pulled back causing the edges of the cutter to come closer. Thus the cutting of peppercorns is done. In this concept, player type operating mechanism has been introduced with torsion spring. The cutting blade is made of cast iron. The sharp edges are so designed to facilitate easy holding of peppercorns. The handle is made of aluminum. A lever is provided at the edge for easy operation. This
concept seems to be simple and compact. The wires are hidden and cause no discomfort, but the positioning of the sharp edges creates inconvenience.

5.2.3 Concept 3

Fig. 12 Concept 3

Since the equipment is meant for cutting, blades are inevitable in it. So in this concept also two blades are given, one is fixed and the other one is movable. The lower blade is fixed on the pole with the help of clamp tightened with screws. A hand rest portion is provided at the lower portion of the pole in order to have a comfortable hold.

- By moving the inside rod up from bottom, the upper blade moves up & it does cutting by pulling it down.
- The working of this concept may not be smooth & comfortable because of its method of operation.

5.2.4 Concept 4

Fig. 13 Concept 4

In this concept a variety compact design have been introduced. Here also two blades are provided for cutting. A disc is given at the head and strings are provided through small pulleys to the bottom disc. In the bottom portion of the rod another disc with lever is inserted within the pipe. It is tightened there with screws. In the middle part of the pole a provision for smooth holding is attached.

- While pulling the knob the string pulls the upper blade down, simultaneously the cutting process is done.
- This concept may be having the disadvantage that the operation of this equipment will not be smooth or practicable.

5.2.5 Concept 5

Fig. 16 Concepts 5

In this concept a cable wire is connected from the hand operating part to the cutting portion. When the hand lever is pressed, the spring gets compressed resulting in the cutting of peppercorns.

It is having a simple mechanism and low technology. It is very simple to operate i.e. the braking mechanism of bicycles have been evolved. The cutting portion has been so shaped that holding of the stalk is possible with this shaped cutter. Though this mechanism is familiar no such equipment is so far designed.

5.3 Concept Selection

Fig. 17 Cutting portion

5.3.1 Dot matrix method

In a product design cycle it is very important to select a final concept. For doing this each and every feature has to cross checked in detail. So many methods are there. Here the selection of the final concept has been done by Dot matrix method and through customer preference.

6. DETAILED DESIGN & WORKING MODEL

6.1 Concept Detailing

The selected concept is the concept 5 which got high weight age in the dot matrix method. This concept is very simple in mechanism and can operate easily without applying any high technology. Though this mechanism is familiar no such equipment is so far designed.
6.1.1 Parts details

Hand grip 1                      Hand Grip 2

Adjusting Knob               Hand lever

Aluminum Cover                 Yoke

6.1.2 Dimensional drawing

6.2 Ergonomic considerations

The Ergonomic study here considers standing in the erect posture and getting height at the slanting posture while plucking.

Hand grip inside diameter is considered for holding the equipment tightly and for the convenient holding of the equipment hand width without thump is followed.

6.3 Manufacturing Process

6.3.1 Drawing preparation & material selection

First of all two dimensional drawing of the proposed model have been prepared. Material procurement is the initial stage of any manufacturing process. Based on the drawing, the required aluminum pole, plastic materials, rubber materials, cable wire, tin sheet etc have been selected.

6.3.2 Manufacturing and assembly

After collecting all the required materials the manufacturing of the model started. Firstly, the assembly of the aluminum pipe with the head portion or the cutting part was made. Then the cable wire was attached to the brake lever.
Then the brake lever is inserted to the handle portion of the aluminum pipe and tightened with screws. Next a covering for the cutting portion was provided. Now the equipment is ready for feasibility test.

6.4 Advantages

This pepper plucking equipment is considered to be having some definite advantages. So far only the manual plucking of peppercorns is in practice. So the advent of equipment is welcomed by the customers. It is light weight and therefore can easily be carried from one place to another. Its price comes to nearly Rs. 450/- which is affordable to common man. Since this equipment is a simple one, chances of frequent maintenance will be less.

6.5 Validation

After completing the assembly and manufacturing process the model was taken to the user environment and subjected to usability and ergonomics. The validation was conducted on the user. The plucking of peppercorns with this equipment have been tried by the laborers including ladies. It is found that they can conveniently and easily pluck peppercorns. The users opined that it is a good equipment for harvesting peppercorns and a household should definitely have such one at home.

7. CONCLUSIONS

The inspiration for designing a pepper harvesting equipment originated from the fact that the pepper cultivating field does not have any equipment for plucking pepper. It is usually seen that the cultivators by using bamboo poles and ladders climb on the trees and harvest pepper with their hands. By conducting user study, market study, ethnography research, literature survey and interviews, the QFD and PDS are generated. Based on these various concepts of the proposed equipment are created. The selected concept was developed into a 1:1 working model. After conducting feasibility test the model was validated for studying human factors. So it can be very well concluded that the development of such kind of equipments will surely find a place in the market.
8. REFERENCES