



IJRASET

International Journal For Research in
Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 Issue: V Month of publication: May 2019

DOI: <https://doi.org/10.22214/ijraset.2019.5299>

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Easy Nutmeg Mace Separator

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Abstract: Our project, *Easy Nutmeg Mace Remover* mainly deals with solving the problem of the conventional, labor-intensive separation of the seed coat (red-colored aril/mace, locally known as *jadhipathri*) of one of Kerala’s largest cultivated plantation crop- Nutmeg (locally known as *jathi*) in the form of a flower shape, from the seed (*jathikkaya*) using hands, on introducing mechanisms for detaching the base of mace from the nutmeg seed as well as to simultaneously pull the seed out. A rubber-type material, preferably silicone, and a stainless-steel frame are used in the final product. Our solution is aimed mainly for common farmers, in usage as well as economical aspects (cost factors). Mainly, we had focused on finishing the entire process of mace detachment (as a flower) on relying on a pressing mechanism (applying pressure) as per class-2 leverage principle (as in the case of a lime squeezer). The entire working principle is based on pushing through a perforation. The size of the perforation, the manual pressure needed to be applied, as well as the rubber-type material, determine the major working of our design. A double layer silicone rubber layer is incorporated to provide improved tear strength while the process takes place. Our product also includes a pole at the center that holds the entire apparatus properly, and we have a circular ring to distribute the pressure applied throughout all single units where each nutmeg is placed so that all nutmegs are getting even pressure at the same time. The two ends along the diameter of this circle are also provided with handles for simplifying and speeding the process of applying pressure. We noticed that we are able to separate the mace of 10 units in 20-30 seconds time, which is very low when compared to the time taken for separating a single nutmeg in an existing way (using hand).

Keywords: Nutmeg Mace, Agri-Tech, Class 2 Leverage Applications, Silicone

I. INTRODUCTION

This project is mainly focussed on simplifying the post-harvesting operation of removing the red aril/mace/seed coat of the nutmeg, one of the massively cultivated plantation crops in Kerala, as a whole unbroken flower shape, thereby helping the farmers to obtain the premium price for the mace, thereby attempting to make it less labour intensive by permitting the removal of mace from multiple nutmegs within a time period shorter than taken to separate one at a time by hand.

Our field being agriculture aims at causing a change in a major common difficulty observed in the daily lives of many farmers living in the Spice Garden of India- Kerala. Kochi, being the world’s largest spice market, helped us in driving our project to solve a humungous problem related to largely cultivated plantation giving spices. For that, we chose, the only plant in the world that gives two spices- Nutmeg (locally known as *jathi* or *jayphal* or *jayithri*), which is a locally grown plantation crop in most parts of Kerala. Nutmeg (*Myristica fragrans*) produces two separate spices, namely nutmeg and mace. Nutmeg is the dried kernel of the seed and mace is the dried aril surrounding it. The nutmeg is indigenous to Moluccas Islands (Indonesia). Over 50% of the world’s export of nutmeg and mace is from Indonesia. Grenada is the second largest exporter of nutmeg and mace in the world. Then comes India. In India, nutmeg is mainly cultivated in Thrissur, Ernakulam and Kottayam districts of Kerala and parts of Kanyakumari and Tirunelveli districts in Tamil Nadu. This is observed in Table 1.1. Also, according to the Spices Board of India, Figure 1.1 shows Kerala as one of the nutmeg growing states.

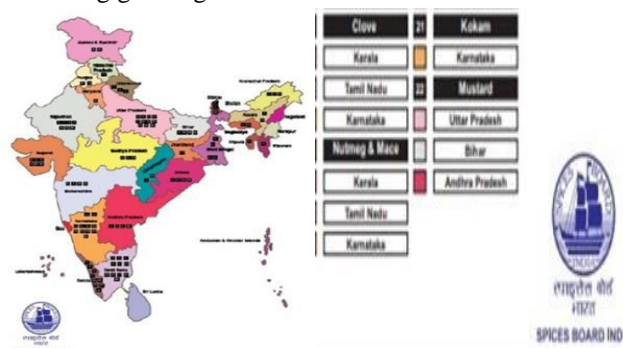


Figure 1.1: Nutmeg growing states..... [1]

Mace is the red seed covering of the nutmeg seed. It is a highly useful spice. In the processing of mace, the crimson-coloured aril is removed from the nutmeg seed that it envelops and is flattened out and dried for 10 to 14 days. The red colour changes to lighter shades of yellow or orange. Whole dry mace has a size of over 1 inch and consists of flat pieces.

Considering all the limiting factors, we arrived at a design solution, in which nutmeg can be separated in 7 seconds. The product is unique with:

- 1) Split ring mechanism
- 2) Closure provided for safe positioning of nutmeg, suitably of low-grade rubber
- 3) Round blade of small radius provided along with a perforation of appropriate circular shape on a rubber-type material suitably Silicone with moderate elasticity and high tear strength
- 4) Stainless steel for making the top and bottom sections of the frame.

The mace is separated without any damage and at a faster rate. The success rate in this method is 8 out of 10. A major advantage of this method is that a person without any prerequisites or skill can use this without anyone's help. This machine can be extended for a number of separators according to the requirement; thereby the cost of this mace separator is very low. The disadvantage of this product is that it is not automatic. It requires manual help.

Table 1.1: Nutmeg area and production in Kerala, Tamil Nadu and Karnataka during 2010-2011, 2011-2012, 2012-2013 and 2013-2014..... [2]

NUTMEG	KERALA	17545	11911	18161	12059	18462	12528	19628	13206
	KARNATAKA	145	172	176	77	147	150	NA	NA
	ANDAMAN & NICOBAR	70	5	70	4	70	47.5	62	4
	Total including others	17760	12088	18407	12140	18730	12730	19690	13210

A. Problem Statement With Explanation

“Conventional separation of unbroken or first grade aril (mace) shaped as a flower from the seed using hand and knife ensuring that mace isn't broken.” The problem statement evolves on the problem observed in one of the major post-harvesting processes involved in nutmeg cultivation- Separation of the red-coloured seed coat/aril/mace, from the nutmeg seed in the form of a flower itself on careful detachment from the pericarp (white coloured), using hand with the help of knife ensuring that the mace isn't broken at the base. This process has to be done on a daily basis for the nutmegs collected on a particular day. This is because, as the nutmeg along with red seed coat is left for a particular time, it undergoes drying, and if the aril dries for long, we'll not be able to get the mace separated in an unbroken form. This process also involves the use of a sharp knife in some cases so as to separate the covered portion of nutmeg mace if present at the top. We observed that the conventional separation of mace had the following disadvantages while relying on three procedures. While using the hand and knife, the main disadvantages observed were; the average time consumed to detach mace from one nutmeg is between 25 and 30 seconds, highly unsuitable for farmers relying on large area nutmeg plantations, due to time consumption and need for immense labour to do separation on a daily basis, the occurrence of breakage of mace will be more when done manually, and finally dried mace cannot be separated as a flower.

While tipping the nuts onto a sloping cement floor from a height of three to four meters, the problem observed was the damage observed on seed and sensitive mace. While soaking the nuts in water for four to twelve hours and then squeeze between the thumb and forefinger until the nut pops out, the disadvantage observed was that we require a longer time for drying the mace as well as seed.

B. Inspiration Towards Doing Project

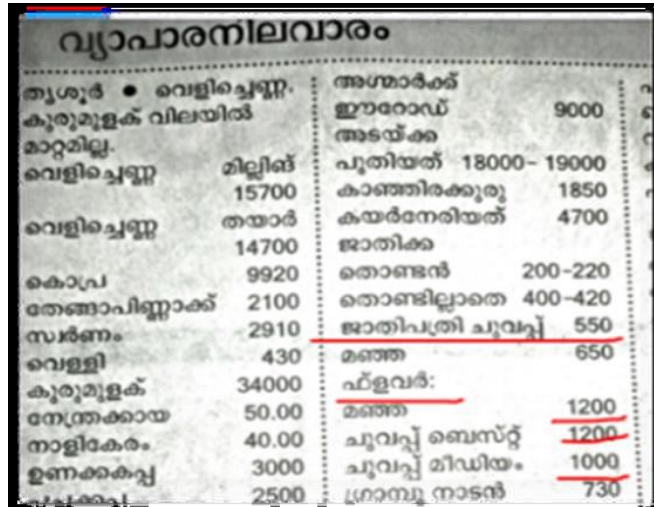
This project is mainly chosen on a basis of inspiration or motivation to revolutionize the cultivation of a peculiar plant-Nutmeg. Firstly, nutmeg has the greatest peculiarity that it is the only plant that gives two spices. Then, comes the fact that it is one of the largest plantation crops cultivated in our motherland, Kerala. Nutmeg is a historic fruit. In the fourteenth century, half a kilogram of nutmeg cost as much as three sheep or a cow. There have been even wars in the name of nutmeg. For instance, the Dutch waged a bloody war, including the massacre and enslavement of the inhabitants of the island of Banda, just to control nutmeg production in the East Indies. However, there are major difficulties in post-harvesting operations of nutmeg like drying, etc. which are even not solved after all these years. It is a crop possessing harvesting mechanisms which we, the present generation residing in Kerala,

come across in our day to day lives. We can understand its processing very easily and study those better from former generations. Nutmeg is even more special for Kerala, as we are having an ability of intercropping nutmegs along with coconuts for obtaining improved results in harvests.

II. LITERATURE REVIEW

The main objective of easy nutmeg mace separator, as the name suggests, is to separate the nutmeg seed from its mace. Nutmeg is the seed of a dark leaved tree and Kerala is well known for its collection and production. Nutmeg is cultivated for two spices derived from its fruit: nutmeg, from its seed, and mace. Mace is a lacy coating usually red in colour is found on the nutmeg seed. Nutmeg has various uses in culinary and pharmaceutical practices. In the market, the flower mace fetches a premium price and therefore, the mace should be removed carefully without any breakage.

There is a large difference in prices for the case of broken mace and unbroken mace as per the following newspaper records. With reference to the table given in *Malayala Manorama* newspaper as per 5th October 2018, as shown in Figure 2.2, it is to be noted that the price of nutmeg mace per kilo as a flower (mentioned as *jathipathri flower* in newspaper) takes more than twice when compared to that of the price of broken mace per kilo (simply mentioned as *jathipathri chuvappu/manja* in newspaper).



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	15700	കയർനേരിയത്	4700
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	14700	തൊണ്ടൻ	200-220
കൊപ്പ	9920	തൊണ്ടില്ലാതെ	400-420
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കുരുമുളക്	34000	മഞ്ഞ	1200
നേന്ത്രക്കായ	50.00	ചുവപ്പ് ബെസ്റ്റ്	1200
നാളികേരം	40.00	ചുവപ്പ് മീഡിയം	1000
ഉണക്കകപ്പ	3000	ഗ്രോസ്സു നാടൻ	730
പപ്പായ	2500		

Figure 2.2: Malayala Manorama Nutmeg mace prices.... [3]

Based on this, we understood the intensity of the importance of separating the nutmeg mace as a flower without it being broken. The mace can be unbroken, partially broken (at one end) or be in the form of tiny pieces. With reference to the case study “THE NUTMEG AND SPICE INDUSTRY IN GRENADA” done by Singh. R., Sankat. C.K. and Mujaffar.S., the nutmeg mace is graded as Grade No. 1, 2 and 3 and this can be understood from Table 2.1, which is given below.

Table 2.1: Grades of mace..... [4]

Grade	Description
No. 1	Whole Pale Mace
No.2	Broken Mace (mixed colour)
No. 3	Broken pieces and pickings

With reference to the descriptive review on *Myristica fragrans* by Honey Jose and 4 others (given in [5]), we understood that the nutmeg seed has various uses in culinary and pharmaceutical fields. Mace is used to flavour baked goods, meat, fish, vegetables and in preserving and pickling. In Kerala, grated nutmeg is used in food delicacies such as dessert and meat items for the flavour. Garam masala has nutmeg mace spice in it.

III. SYSTEM DESIGN

A. Diagram of Design (2-D)

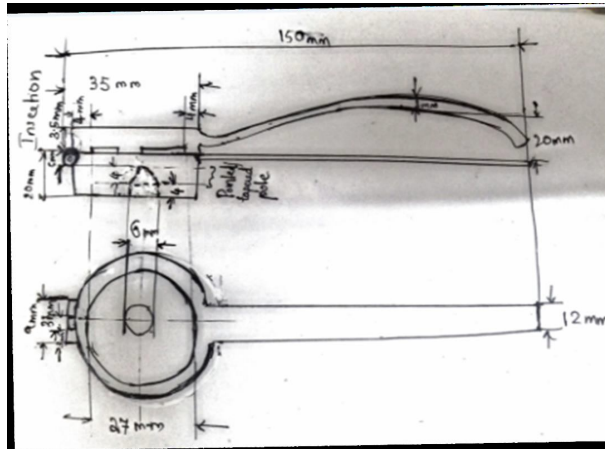


Figure 3.1: Front view and top view of entire apparatus

Our product is designed according to the consideration that the minimum length of nutmeg will be 16 mm, the minimum radius at the tip is 3mm, and the minimum radius at the base is 3mm. The given figure, Figure 3.1 shows the front view and top view of the entire device. The closure (rubber casing) is of 35mm length in front view. The outermost circle in top view represents steel holding, the inner circle shows the silicone layer and the innermost circle shows the cavity through which the nut comes out and the mace remains in the closure.

B. CAD Drawings

The CAD drawings, wireframe and solid forms are given in Figure 3.2 and Figure 3.3 respectively.

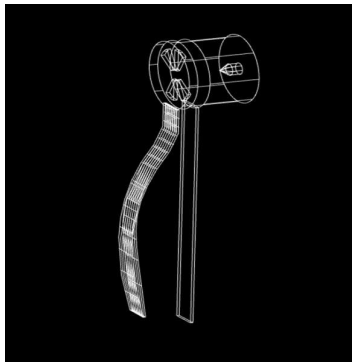


Figure 3.2: CAD Drawing- Wireframe



Figure 3.3: CAD Drawing- 3D Solid

C. Design Overview

The solution suggested to our problem simply involves; firstly, placing nutmegs on the base in a rubber casing, and during this, the base of nutmeg mace is detached from the white coloured sap holding seed and mace together, then, pressing the nutmegs from above using a circular ring, on trying to push them out through a perforation on a rubber-type material, and finally obtaining the secured unbroken mace from within the layers of rubber-type material that sweeps or brushes softly across the nutmeg seed in a direction opposite to that of applying force.

The main factors that determine the working are the size of nutmegs, the size of perforation, the compressive strength of base and top sections, and finally tear strength, flexibility, and elasticity of the rubber-type material chosen. The prototype can be seen as given in Figure 3.4. This is only for two-unit assembly, and we can extend it to 'N' no. of units in the form of a circle having a pole connecting the ends of all single units.



Figure 3.4: Prototype

D. Project Flow

1) Placing the nutmeg in the holder which is made of rubber. Simply place the nutmeg on the rubber seating placed at the base section with the base of the mace safely positioned to the emerging blade portion. This is shown in Figure 3.5.



Figure 3.5: Nutmeg placing mechanism

2) Pressing the top section on nutmeg.

3) Continue pressing for 10 minutes.

2nd and 3rd steps can be better understood from Figure 3.6 given below.



Figure 3.6: Pushing process

4) Seed comes out.

The seed comes out with pressure, and this can be viewed in Figure 3.7 given below.



Figure 3.7: Nutmeg coming out

5) Unbroken mace is obtained when top portion is opened.

Refer Figure 3.8 and Figure 3.9.



Figure 3.8: Mace taken out



Figure 3.9: Unbroken mace

E. Working Principle

Our project is inspired from the "LIME SQUEEZER" principle: The load, here lemon is at the middle, the fulcrum is at one end (hinge) and push is given by hand at another end. (Class 2 leverage principle is applied). We have also used a buckle mechanism for tightening the rubber-type material properly. The mechanism of punching holes also gave us an insight about separating the white sap from the base of the mace. The penetration of nut through the perforation is mainly the working principle applied in our solution. A push of nutmeg seed happens through the perforation formed in a material like rubber or plastic, which must return to its original shape (minimum elongation on further usage). This is shown in Figure 3.10. Specific advantages include the safe positioning of the base by placing it on a tapered pole of a minimal radius and that of the mace within the rubber closure provided. Rubber replacement facility is provided for fixing rubber within thin stainless steel "split keychain ring".



Figure 3.10: Push via perforation using Oyumaru

F. Methodology & Functioning Strategies

Initially, we had started off with mechanisms like a clutch of Octopus tentacle, but it was not applicable. The basic functioning strategies or methodology is explained in the next few sentences. The base is made of stainless-steel material and the center of the curved portion of the base is provided with sharp hemispherical blades as seen in the case of a paper punching machine. These blades are also made of stainless-steel. The white portion in Figure 3.11 showing the prototype depicts a portion of stainless steel. The blades can be observed too. The placing of nutmeg is in a low-grade rubber casing (similar to rubber finger caps) for flexibly lowering as pressure is applied. The top section has a stainless-steel frame, and at the center, there are multiple layers of rubber-type material (two layers are preferable, as, with increase in the number of layers, more pressure has to be applied by the user for enabling the seed to come out). It is shown in Figure 3.12. Multiple layers of rubber-type material are required so as to secure the perforation without allowing it to tear off when large nutmegs are used. The top section has the rubber-type material tightened to it in the form of a buckle mechanism, so as to not come off on applying pressure.



Figure 3.11: Sectional view of base of product



Figure 3.12: Top and base sections of prototype together

A circular ring, provided with handles at two ends along the diameter, preferably made of stainless steel, is used for applying pressure evenly to all the single units. All the single units are connected to a final unit, by connecting their longer ends to a pole, preferably made of stainless steel. The split keychain ring mechanism can be incorporated to tighten the rubber-type material.

G. Initial Prototype

Initially, we made mace separator with plastic material, to be specific egg white separator. We drilled a central hole to place hemispherical blades. Rubber housing was provided to ensure the safe positioning of the nutmeg. On the other hand top, part of the prototype was also made of same material. This time a wide hole was made to place elastic Oyumaru material. The material was placed in accordance with a buckle mechanism -a way to lock itself when high pressure is applied. Special adhesives at various times were used such as for joining two plastic holders, to join rubber housing with plastic etc.

H. Hardware Description

The major materials used are stainless steel, silicone and low-grade rubber. The pole, frame of the top and bottom sections, as well as the blades, are made of stainless steel. The frame should not be corrosive and shouldn't rust easily. We are not using plastic for the frame, as it has a lower ability to push nutmeg, and that it may tend to break easily as it's not hard. Although stainless steel has a broad range of properties, in general, when compared with mild steel, stainless steel has higher corrosion resistance, higher work hardening rate, easier to clean and maintain, higher heat strength, higher ductility, higher strength, and hardness and a more aesthetic appearance. Silicone (Chosen rubber-type material): Initially, we started off with Oyumaru, a Japanese thermoplastic elastomer, as they show advantages typical of both rubbery materials and plastic materials. The main benefit observed was the ability to stretch to moderate elongations and return to its near original shape creating a longer life and better physical range than other materials. However, we observed that pure silicone rubber was better as it had tear Strength: 55 PPI, which is higher when compared to Oyumaru, and elongation of 37.5%, which is lower when compared to Oyumaru. Silicone (Organic rubber is susceptible to ozone, UV, heat and other aging factors that silicone rubber can withstand well. Silicone, hence, works in many extreme environments. Low-grade rubber is used for providing the casing for nutmeg with flexibility.

IV. RESULT AND DISCUSSION

The product worked as expected. Easy nutmeg mace separator separates nutmeg at a faster rate than conventional methods. It is estimated therefore process will be completed in just 7 seconds. By increasing number of separator units, number of mace separated can further be increased. Success rate is 8 out of 10. Since nutmeg mace is so fragile, we doubted at quality of mace separated. But right use of smooth, elastic and strong silicon sheet ensured damage free mace. Chances of flipping of silicon material through frame was high, which reduced the efficiency of the product. To prevent this we added a kind of buckle mechanism on the frame and it worked. We looked for something simple in design and easy to handle. So we looked into the conventional methods already existing currently among the nutmeg farmers. In the next step, we studied the design of lemon squeezer, which work on the principle of lever system. So for trial, we bought a spoon-like shaped plastic moldings and placed them in pair, similar to lemon squeezer. We realized that the separated seed will smoothly come through the perforation made if the same perforation is covered with any elastic material. We made a central criss-cross shaped cut on the elastic material. Initially, usual household-purpose rubber was used and no nutmeg holder was inserted. The rubber lost elasticity after two trials. Moreover, it was very difficult to glue the rubber to the plastic mold. Even in the lightest pressure applied, rubber was pulled out from the prototype, which forced us to think of alternate material.

This was a poor method, as under pressure, the nutmeg got flipped and this damaged the mace completely. Oyumaru, a Japanese material was our next concern. Nutmeg holder was inserted. The material was obviously better than the general household rubber but had its own limitations.

The elasticity range was limited to 2 or 3 times and in some cases it even damaged the quality of mace. In this stage we introduced tapered pole, made of stainless steel, in the top part to break the bond between mace and seed. The elastic material that we next considered was silicone. Further improved condition was observed. Top of mace got damaged. Tapered pole tampered the mace. As the silicone sheet was smooth, seed came out very smoothly. Now, tapered pole was replaced by a set of hemispherical blades, similar to that of paper puncture blades in the top section. This helped to remove natural bonding of the nutmeg seed with mace. This further increased the success rate of nutmeg mace separator. Excellent performance was observed but the silicon sheet started flipping after 2-3 uses. Finally, two layers of silicone sheets were used. Punch blade was used. Two units were introduced. Nutmeg holder, made of rubber material was replaced with the older. Buckle mechanism was introduced. Silicone sheet remained in position after two –three times of use. Seed came out very gently. Elastic nature of rubber holder adjusted to the varying sizes of nutmeg. We noted that the system doesn't works under certain situations. First, for premature seeds, whose mace are closely attached to the seed. Separation of mace under this situation without getting damaged is very difficult. Next, the seeds which are really smaller than normal range come out easily through the perforation provided without getting mace separated. With the right choice of material, mace was separated with sufficient quality. Each time we made changes in the design, the time required to complete the separation of mace reduced, which means the efficiency of the system increased.

V. CONCLUSION AND FUTURE SCOPE

The easy nutmeg mace separator is a manually operated product made with an objective of separation of nutmeg mace from its seed. The product was made with the intention to save the time of farmers in mace separation and to increase the profit of the farmers. The main idea project started with the identification of the product in the agriculture sector. All four of us identified the product and briefly studied about their characteristic and ergonomic features. On the basis of various parameters, products were analyzed. Then, various problems in the agriculture wing were identified and we sorted out the best problem. The problem identified was inefficiency in the conventional methods of nutmeg mace separation. The process of separation with the hand was studied in detail. Different materials were taken into consideration. The right choice of material and the right allocation of them according to the requirement led to the successful completion of the project. The product is manually operated one, which can later be transformed to an automatic one. The aim of our project is to create a product, which will separate the mace of nutmeg with great efficiency in production process. Then we worked together for identifying various problems in the agriculture sector and then we sorted out the best. The average time taken by a person to separate mace in the conventional methods is between 25-30 seconds. No technical advancements are made in this area. The time taken is large as the white-coloured sticky layer holds seed and mace together, joining them. Risks or limiting factors are existing though. Nutmeg mace is fragile. A slight pressure beyond a limit can break it. So, when devising a machine, care must be taken not to apply too much pressure. Moreover, it is found that there is a white patch like part, also known as pericarp, which attaches the seed to mace. To separate mace, we need to ensure that this is broken. So, a sharp but small blade has to be incorporated. Some nutmeg the maces are fully covered at the tip. To slightly cut this covering another sharp blade has to be used. Another limiting factor is the varying sizes of nutmegs. A size adjusting structure has to be placed for the same.

VI. ACKNOWLEDGMENT

We thank Sahrdya College of Engineering and Technology for giving us all the required support and guidance to publish our project paper. Also, our sincere gratitude towards our project guide, Mr. Subodh Raj M.S..

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