CHAPTER 1

INTRODUCTION

1.1 Background of study

"“Asam gelugor” which scientifically called *Garcinia Atroviridis* is originated from Indo-China and Malay Peninsular” **[1].** "“Asam gelugor” contains intermediate nutrient. In every 100 gram (g) of “asam gelugor” contains: water 30.3 g, protein 2.7 g, fat 1.3 g, carbohydrate 51.9 g, fibre 12.2 g, calcium 85 milligram (mg), phosphorus 38 mg, iron 6.9 mg, sodium 27 mg, potassium 351 mg, carotene 155 µg, vitamin A 26 µg, vitamin B1 0.06 mg, niacin 0.4 mg, vitamin C 3.6 mg” **[2].** The fruit is one of the importance ingredient used in cooking as a condiment. From a fruit of about the size of an apple, the asam gelugor then needs to be sliced into smaller slices which were then exposed to the sun to dry it and it is then called “asam keping”. After the slices of the asam gelugor had dried up, it is then ready to be used in cooking. Almost all traditional Malay food used “asam gelugor” to give the sour taste of the food. “The fruit is also used as a health supplement by rural folk to counter the effects of influenza. More recently researchers have identified and isolated chemical properties which could be useful for the development of antihypertensive medicine. Besides, the leaf sap of “asam gelugor” is also used in post natal tonics” **[1].** “The lowest of the “asam gelugor” price can go down to RM 8.00/kg and at the peek price could reach RM 15.00/kg which is quite good and highly profitable. And when imported, the price for “asam gelugor” can go up to 35 USD/KG” **[1].**

1.2 Problem statement

It is a common knowledge that until today we never heard of the existence of asam gelugor processing facility. We commonly heard about coconut milk processing machine, tapioca slice machine, keropok making machine, banana crisp slice machine, pineapple slice machine and many other food processing machines. The potato chips are available all around major hypermarket in this country and obviously their cutting machine must be well developed. The irony is that actually "asam gelugor" or "asam keping" as it normally known is the important ingredient in our local delicacy as well as traditional medicine. Even though the market for this product is quite good and highly profitable but still the processing of asam gelugor is being done manually by slicing it using knife with hand. Now, this project is trying to change this scenario by inventing the better asam gelugor processing machine for the betterment of local food industry.

1.3 Significance of Study

Upon completion of the research, the final design will be fabricated to be the "asam gelugor" slicer machine. The design and the calculation of force analysis and velocity analysis will ensure that the machine mechanical parts will work accordingly. With good selection of materials in designing will add up to a cost effective machine. The experience in doing the machine drawing/assembly drawing/exploded drawing/cross sectioned drawing is the most beneficial aspect of this research work.

1.3 Objectives

Major objective is to design the asam gelugor slice machine to further improve the processing of "asam gelugor". Next is to determine the best material to be used in designing the slicer machine in terms of cost effectiveness and material which won't interfere with the food (asam gelugor) quality. To perform the force and velocity analysis of the machine parts. To fabricate the proto type of the designed machine. To test run the proto type machine.

1.4 Scope of the study

The scope of work for this project is to:

Design the slicer machine by using CAD software such as AUTOCAD or CATIA. To check the design and make sure it works smoothly if chosen to be the final design for fabrication process. All the calculations involve in slicing the asam gelugor is proper calculate to make sure it works after the fabrication of the prototype. To do force diagrams and the velocity diagram for the machine linkages. Appropriate driving mechanism such as hydraulic, pneumatic, electric motors or manually driven should be addressed.

Do research on the best material to be used in designing the prototype so that the prototype can be cost effective with no material problem which can effect the processing of the asam gelugor. Non corrosive material shall be used as the machine designed for processing food. Suitable machining technique for the machine components and linkages is also to be selected. Availability of materials in the market should also be considered before deciding on specific materials to be used.

Tools and equipment to be used will be identified and familiarized to avoid malfunctioning of the system. Accuracy of equipments used in the tests also will be checked in order to get accurate fabrication of the parts of the machine such as CNC lathe, CNC milling, EDM wire cut, EDM die sinker, AUTOCAD, Welding Set, Drilling machine, tap and die, etc

CHAPTER 2

LITERATURE REVIEW

While Malaysia is heading towards modernization still the “asam gelugor” processing is being done in a very traditional way. Currently lots of time wasted and the production quality would be very low by traditional way of processing. Thus it would be difficult for the asam gelugor to go for mass production especially for exporting business.

2.1 Design Specification

According to Serope Kalpakjian and Steven R. Schmid (2008)

> There are general product design considerations, in addition to the design guidelines outlined throughout this text. Some of the fundamental design considerations are:
> Can the product design be simplified and the number of components reduced without adversely affecting intended functions and performance? Have environmental considerations been considered and incorporated into material and process selection and product design? Have all alternatives designs been investigated? Can unnecessary features if the product, or some of its components, be eliminated or combined with other features? Have modular design and building-block concepts been considered for a family of similar products and for servicing and repair, upgrading, and installation options? Can the design be made smaller and lighter? Are the specified dimensional tolerances and surface finish excessively stringent? Can they be relaxed without any significant adverse effects? Will the product be difficult or excessively time consuming to assemble and dissemble for maintenance, servicing, or recycling? Have subassemblies been considered? Has the

use of fasteners, and the quantity and variety, been minimized? Are some of the components commercially available? And is the product safe for its intended application? (p 957)

The closest machine which can be the reference to the "asam gelugor" slicer machine design is the potato and banana slicing machine.

Bellerose, Richard J. says

This invention relates to a machine for continuously slicing potatoes or similar dimensioned objects. The device of this invention then is particularly adapted to the above-described needs and provides a gravity feeding mechanism which automatically holds individual potatoes or similarly dimensioned objects during slicing. When each potato is sliced the device then automatically feeds the next potato to be sliced. The device of this invention uses a cylindrical feed tube which is vertically disposed over a rotating fly wheel which mounts the slicing blade. Proximal to the slicing blade the feed tube has an expanded portion of elliptical cross-section. Potatoes are inserted into the tube, and individually enter the expanded portion. As the blade rotates slicing the potato the angled wall of the feed tube holds the potato against the slicer so that individual slices of desired thickness are automatically prepared **[4].**

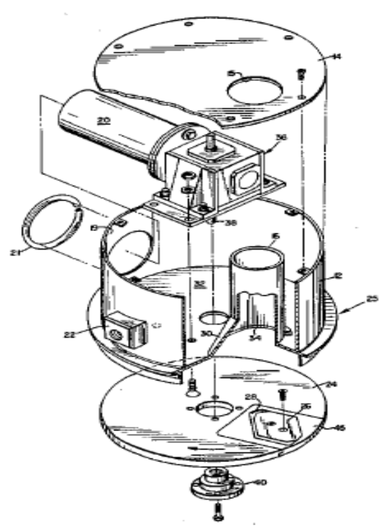


Figure 2.1: Potato slicer machine

Only that the potatoes and bananas are less hard compared to the "asam gelugor" which means extra forces and harder material for the knife should be used. While the basis of processing is about the same, potato and banana slicer machine can be good references in developing the "asam gelugor" slicer machine. With addition of automation of forces applied to the machine in cutting it would increase the production of "asam gelugor" significantly. With this machine designed, it is an intention to further reduce the cost and increase the profits from this "asam gelugor" business besides reducing the time taken in processing it.

Aldrich L. Jackson says

> This invention relates to an electrically operated automatic food slicer and slice counting machine in which provided means for automatically slicing foods such as meat, vegetables and other food where it is desirable to slice the same. This machine can set to count the number of slices to be delivered. Heretofore, conventional type slicers required manual operation of a trough or carrier which held the meat or food to be sliced and operated to carry the same past the slicing knife. This type of machine required a pushing and pulling operation, back and forth, by hand each time a slice was cut and some of this prior type of machine operated the sliding carrier automatically but required a more or less a complicated mechanism. In this type of machine, the clamping means pierces or bruises the body of the meat being sliced, and such process is relatively slow and does not provide any means of counting and delivering the number of slices desired and therefore requires constant attention of the operator. Further more on prior automatic slicing machine, the last portion of the meat or food underneath the clamp or holding means cannot be sliced. This invention is designed to overcome these undesirable features and have provided an automatic food slicer and slice counting machine which form with a stationary gravity food chute in which the meat or food can be freely placed and wherein it is held while slices are automatically cut from the same.**[5]**

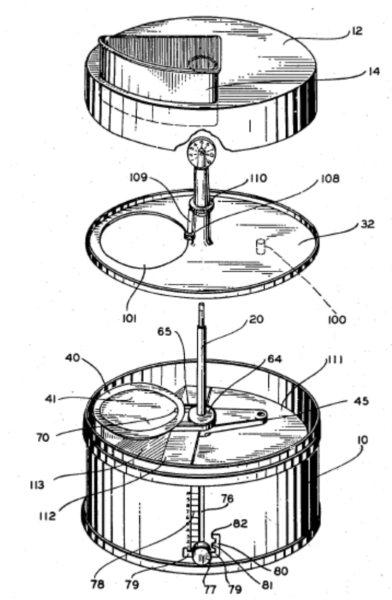


Figure 2.2: Automatic food slicer and slice counting machine

2.2 Material Selection

According to Serope Kalpakjian and Steven R. Schmid(2008)

> Regardless of the method employed, the following considerations are important in materials selection for products;
>
> Do the materials selected have the properties that unnecessarily exceed minimum requirements and specifications? Can some materials be replaced by others that are less expensive? Do the materials selected have the appropriate manufacturing characteristics? Are the raw materials (stock) to be ordered available in standard shapes, dimensions, tolerances, and surface finish? Is the material supply reliable? Are there likely to be significant price increases or market fluctuations for the materials? And can the materials be obtained in the required quantities in the desired time frame? (p. 968)

"There is no single thin blade material that is appropriate for all cutting applications, The ideal blade material would be highly wear and shock resistant, economical, available in a wide range of thickness and finish, readily sharpened to a fine quality edge, possess outstanding corrosion resistance, and have no distortion after heat-treatment. The material properties that are generally of most interest when choosing the optimum material for a particular cutting application includes: wear resistance toughness or shock resistance, corrosion resistance, influence on edge characteristics, shape control during heat treat, cost and also availability. Materials most commonly used in blade applications include: 1095 Carbon Steel, Heat-Treated Stainless Steels, 301 Stainless, 17-4 & 17-7 PH Stainless, High Speed Steels, Tool Steels, Extreme-Wear Tool Steels, Tungsten Carbide, High-Performance Zirconia Ceramic, and also Coatings" **[7]**. Another material that can be used for the blades are stainless steel 18-8, 304, 316.

Materials and parts to be chosen will relate to the availability in the market for example the bolts, nuts, screws and also material such as plastic, aluminium and also cast iron. Cost effectiveness must be considered during material chosen in order to maximize profits. Material for different parts must be chosen wisely as it must not interfere with the design and the performance of the slicer machine during the machining process. Besides, material selected should also not interfere with the product (asam gelugor) taste and quality. Material selected must also abide the guidelines provided by the government which includes Food Act 1983. Food Act 1983 no 13 give guidelines about food containing substances injurious to health. The act is as follow:
"

(1) Any person who prepares or sells any food that has in or upon it any substance which is poisonous, harmful or otherwise injurious to health commits an offence and shall be liable, on conviction, to a fine not exceeding one hundred thousand ringgit or to imprisonment for a term not exceeding ten years or to both.
(2) In determining whether any food is injurious to health for the purpose of subsection (1), regard shall be had not only to the probable effect of that food on the health of a person consuming it, but also to the probable cumulative effect of the food of substantially the same composition on the health of a person consuming the food in ordinary quantities" **[8].**

According to Budinskis(2005)

A primary material selection factor used by designers is material availability in the size and shape required for the part under design. A mechanical-property study may show that type 317 stainless steel is the best material for a support column under design. If the job requires a 10-ft-long, 4 in.-by-6-in. channel and this shape is not available in small quantities from a warehouse, this material cannot be used. Similarly if a material is required for an accurate machine base plate, a primary selection factor may be the availability of a material with good flatness tolerances. A checklist on dimensional property requirements should be mentally reviewed immediately after the part is designed. The checklist should contain the following factors: surface texture, lay, roughness, and like requirements, flatness requirements, allowable surface defects, stock dimensional tolerances, camber, surface cleanliness, edge tolerances, bow tolerances, surface reflectance, and also whether prefinished material should be used. (pp. 57-62)

2.3 Force Analysis

Force analysis done to determine the amount of force needed to slice the "asam gelugor", experiment will be done by applying knife with both end attached to weight. Little by little the weight is increased until the whole fruit is sliced. With the data acquired from the force analysis, velocity analysis then proceeds. Then, the power needed to operate the machine can be determined.

2.4 Fabrication

According to Serope Kalpakjian and Steven R. Schmid(2008)

The selection of a manufacturing process or processes is dictated by various considerations such as

Characteristics and relevant properties of the workpiece material, geometris features, shape, size, and part thickness and its variations, dimensional-tolerance and surface-finish requirements, functional requirements of the part, production quantity required, and costs involved in various aspects of the total manufacturing operation. (p. 978)

Chryssolouris says that “In general, there are four classes of manufacturing attributes to be considered when making manufacturing decisions: cost, time quality and flexibility” **[5]** (p. 9)**.** Costs related to manufacturing encompass a number of different factors such as equipments and facility costs, materials, labor, energy and also the cost of capital. In manufacturing system, time attributes related to the production rates. Higher production rates typically result in lower cost and lower quality as well. For machine flexibility, the ease of making changes required to produce a given set of part types.

According to Serope Kalpakjian and Steven R. Schmid(2008)

> to be a high quality marketable product the following characteristics must be considered:
>
> High reliability, perform the required functions well and safely, good appearance, inexpensive upgradeable, available in the quantities desired when needed and robust over their intended life. (p 960)

“The shape of a product may be such that it can best be fabricated from several parts, by joining them with fasteners or with such techniques as brazing, welding, and adhesive bonding. Other factors also must be considered in process selection such as minimum sizes and dimensions that can satisfactorily be produced” **[3]** (p. 974).

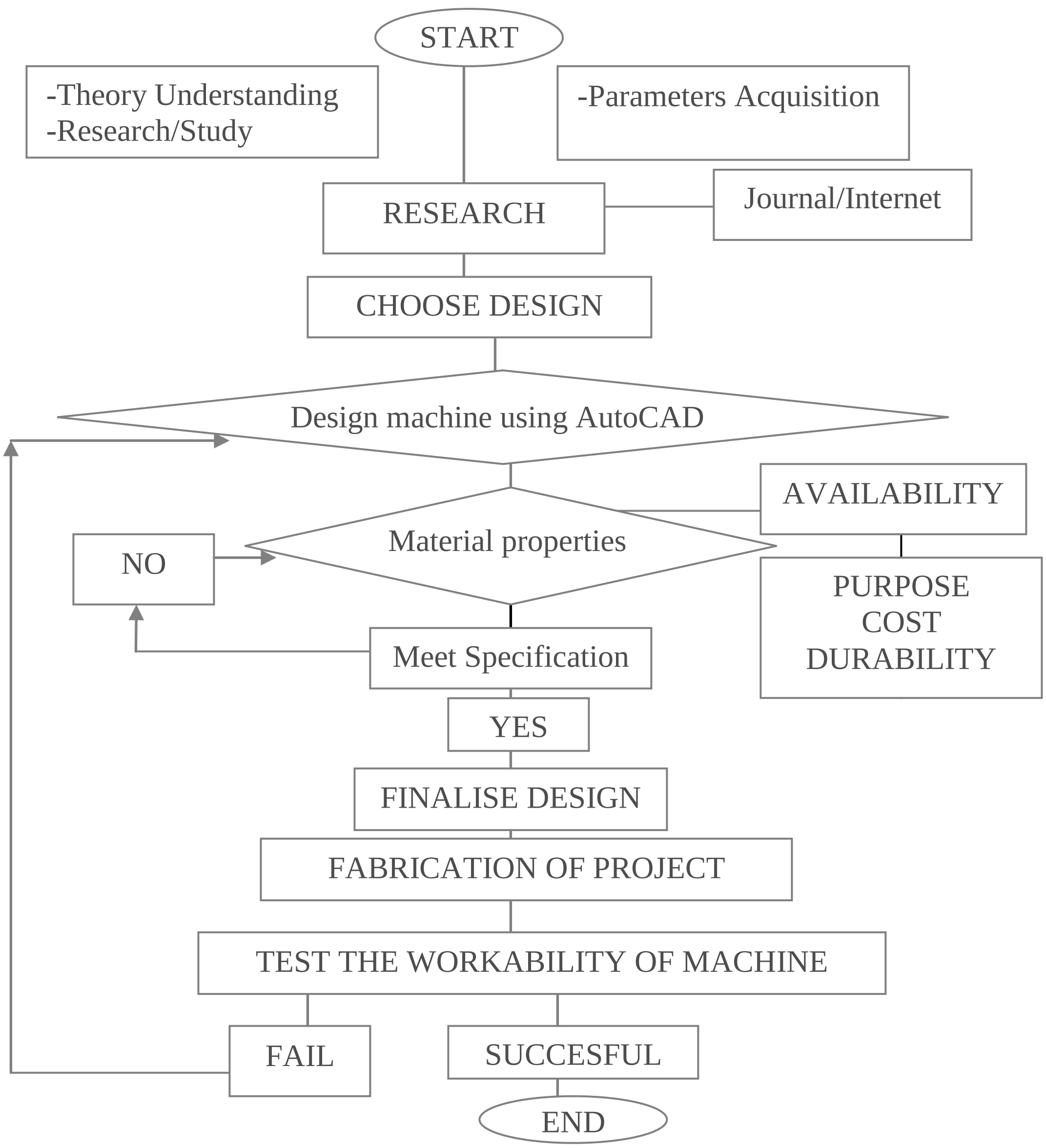
Other important factors to be considered in manufacturing process include dimensional tolerances and surface finish, production quantity or volume, production rate and also lead time.

Kalpakjian and Schmid stated that

the dimensional tolerances and surface finish produced are important not only for the functioning of parts, machines and instruments, but also in subsequent assembly operations. In order to obtain closer dimensional tolerances and better surface finish, additional finishing operations, better control of processing parameters, and the use of higher quality equipment and controls may be required. On the other hand, the closer the tolerance and the finer the surface finish specified, the higher is the cost of manufacturing; because of the longer manufacturing time and greater number of processes involved. (p. 974-975)

CHAPTER 3

METHODOLOGY



CHAPTER 4

RESULTS AND DISCUSSION

4.1 Drawings

Three drawings of the possible "asam gelugor" slicer machine have been made and one will be chosen as the final design to continue with the force analysis and also for fabrication.

The designs are as follow:

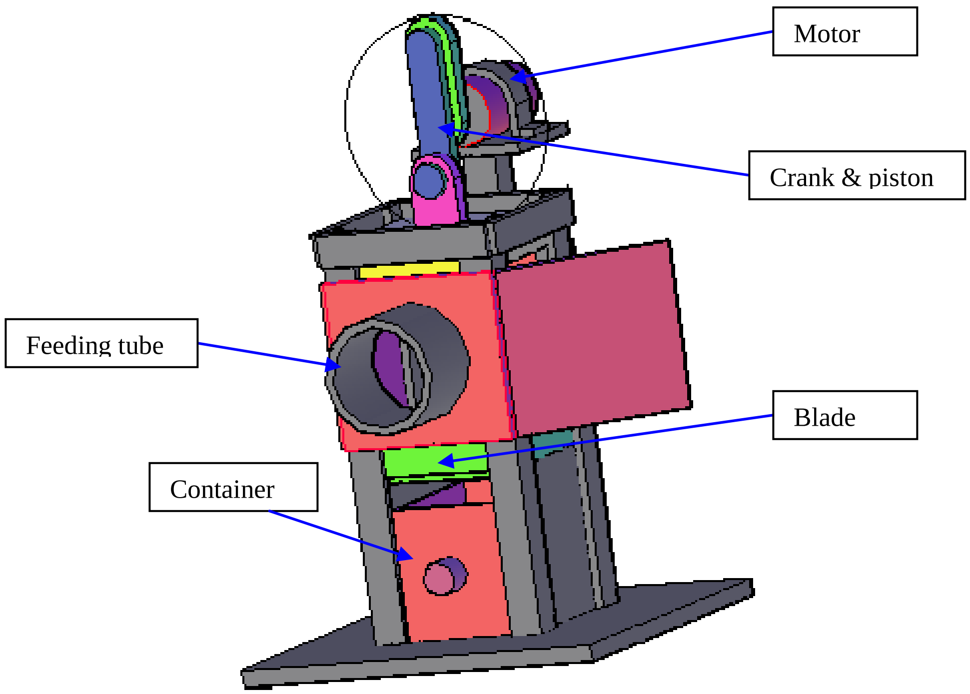


Figure 4.1: Design 1

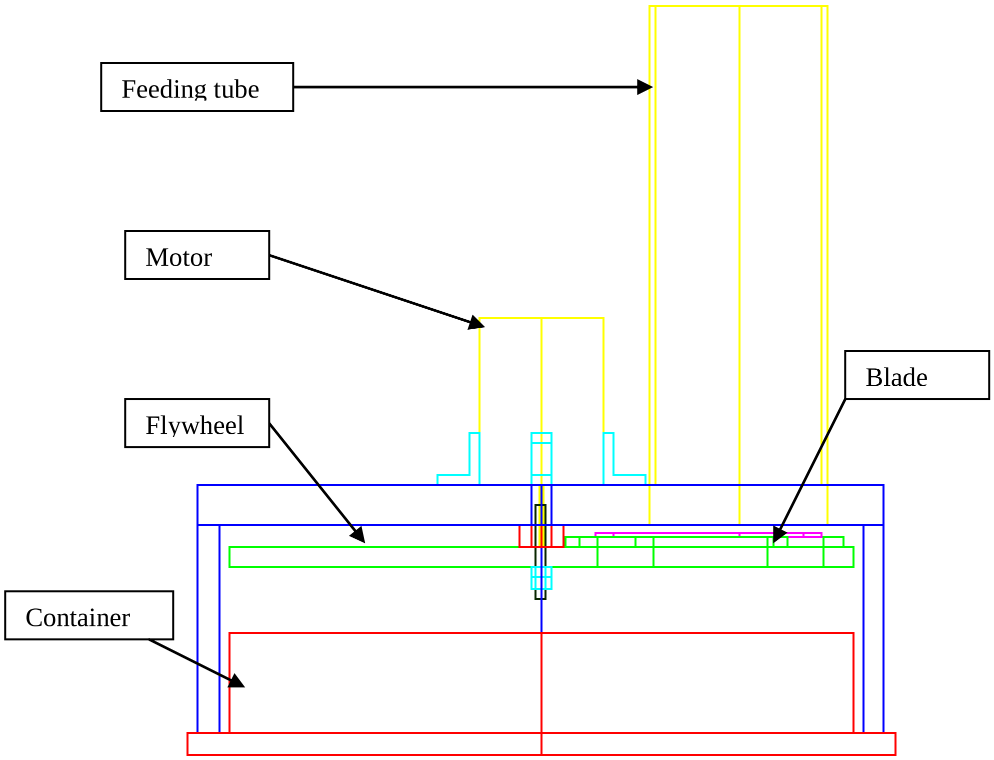


Figure 4.2: Design 2

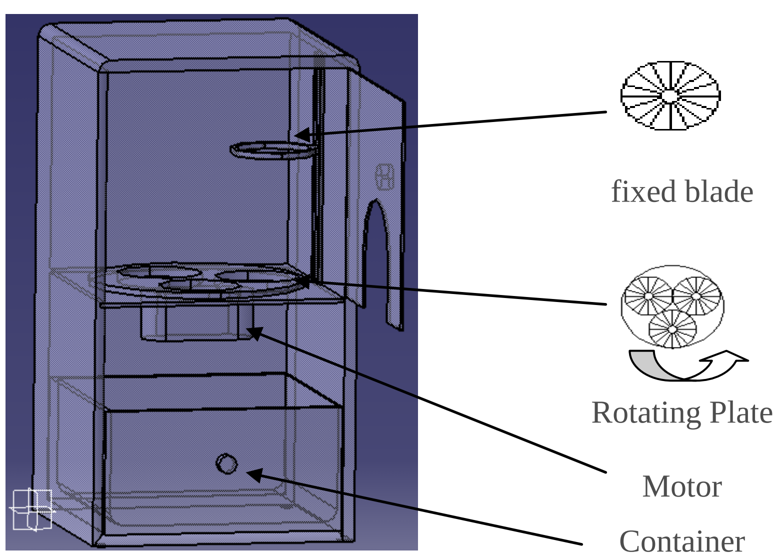


Figure 4.3: Design 3

For more detail drawings and accurate dimensions refer to appendices

For design 1, the mechanism for cutting the "asam gelugor" fruit is by using piston to exert force on the "asam gelugor" with the blades placed below the "asam gelugor". Asam gelugor is located in between the piston and the blades. When the piston moves towards the "asam gelugor", the whole fruit are going to be sliced down at once. Container would be below the blades to contain the sliced fruit. And for the fruit feeding, there's slot design to feed the fruit into the machine manually.

For design 2, the mechanism of cutting the fruit is by slicing it from on end to the other end. Only one blade is design as it only cut one slide at a time. The flywheel will be rotated by the motor in circular motion, while the blade will slices the fruit as the fruit is moving downward by the force of gravity. For feeding system, it is automatically by gravity. The fruit will move down automatically without manual force. Container is placed below the flywheel.

For design 3, the mechanism of cutting the fruit is by using 2 blades while the "asam gelugor" fruit is placed between the blades. One blade is stationary while the other is moving towards the other blades. There are 3 stationary blades to place more "asam gelugor" fruit. The stationary blades can only rotate in circular motion to cut the other "asam gelugor" fruit which is placed on the other blades. Container to contain the sliced fruit is placed below the stationary blades.

4.2 Comparison and Weight Analysis of the Designs

This comparison and weight analysis is done to choose the best design out of all the design that had been made. Marks are given for each criteria needed in building the prototype of the machine. The comparison and weight analysis is as follow:

Marks: 5 = excellent 4 = very good 3 = good 2 = intermediate 1 = poor

Table 4.1: Comparison and weight analysis of designs.

Criteria&[weight]	Design 1	Design 2	Design 3
Complexity **[4]**	Lots of parts and quite complex design. **[2x4]**	Not very complex design. **[4x4]**	Quite complex design **[2x4]**
Easier to fabricate **[5]**	High level of precision and accuracy needed during the fabrication and setting process. **[2x5]**	Not very high level of precision and accuracy needed. **[4x5]**	Not very high accuracy and tolerances needed in fabrication **[3x5]**
Processing time **[5]**	Very fast as it slices the whole fruit at once. **[5x5]**	Not very fast as it slices one slice at a time **[2x5]**	Very fast as it slices the whole fruit at once. **[5x5]**
Stability **[3]**	The height of the design is quite high and the usage of piston will affect the stability of the system. **[2x3]**	Low in height the only movement will be in rotational motion. **[4x3]**	The height is quite high. **[2x3]**
Feeding system **[3]**	It is an addition system to the slicer machine. **[2x3]**	Automatic by gravity. **[5x3]**	Manual by hand **[1x3]**
Cost **[5]**	As this design have lots of parts and material needed for fabrication and also need high precision and accuracy, so the costs to build one are going to be costly. **[2x5]**	Not so complex design to fabricate so the cost should be quite low. **[4x5]**	Cost of the part and fabricating is quite high as many blades have to be fabricated. The size of the machine is big, thus lots of material needed **[2x5]**
Total	**59**	**93**	**67**

From the analysis, design 2 has the most total marks, so the design that is chosen to proceed with the force analysis and fabrication process is going to be design 2. In terms of complexity of the design, design 2 score more marks compared to the other designs as it far simpler compared to the other designs. Besides, low level of accuracy and precision needed in fabrication of the parts and also during the setup of the machine parts. In terms of stability, design 2 beats the other designs as the only movement in this machine is in rotational which quite stable compare to linear movement is. And also in terms of height, design 2 is lower in height compared to design 1 and design 3. For feeding system of “asam gelugor” fruit, it is automatically by gravity for design 2 while for the other designs, need to create a different system for the feeding purpose. In terms of cost, it is estimated that design 2 are going to use lower cost for fabrication and materials as the design is quite simple and less parts compared to the other designs.

The only criteria that design 2 lose to design 1 and design 3 is for the processing time. Processing time in this context is the time that the machine needed to slice the one whole fruit. For the design 1 and design 3, the machine slices the whole fruit at once while for design 2, the machine slices it starting from one end to the other end of the fruit which consume longer time compared to design 1 and design 3.

4.3 Design Specification of the slicer machine:

1. Cutting Blade is placed on top of a rotating wheel with hole just below the blade for the fruit to move downward.
2. Rotating plate is contained inside casing for safety.
3. Motor is use for drive system and must be able to exert ample power needed to slice the fruit.
4. Perspex is used in designing the casing to appreciate the see-through characteristic
5. Can feed fruit maximum size of 80mm diameter
6. Materials use in making the machine is non corrosive and also non toxic
7. Able to slice the fruit in any arrangement
8. Single blade is used
9. The clearance of the blade from the rotating plate is 5mm.
10. Blade is not fixed and can be easily removed for cleaning purpose and blade replacement.

4.4 Possible Materials for the Blades

In selecting the material for the blade, there are some criteria to be as the guidelines. The material to be used must be corrosive resistance, can stand the force exerted, high availability in the market and also low in cost. The machine are going to be used to process food, so the material chosen must not interfere with the quality of the food processed. The material to be selected also subjected to the availability in the market. It must be available according to the shape, thickness, size and also amount needed. And the possible material for the blade is as follows:

"STAINLESS STEEL 18-8:
300 series stainless steel having approximately (not exactly) 18% chromium and 8% nickel. The term "18-8" is used interchangeably to characterize fittings made of 302, 302HQ, 303, 304, 305, 384, XM7, and other variables of these grades with close chemical compositions. There is little overall difference in corrosion resistance among the "18-8" types, but slight differences in chemical composition do make certain grades more resistant than others do against particular chemicals or atmospheres. "18-8" has superior corrosion resistance to 400 series stainless, is generally nonmagnetic, and is hardenable only by cold working **[7]."**

"STAINLESS STEEL 304:
The basic alloy. Type 304 (18-8) is an austenitic steel possessing a minimum of 18% chromium and 8% nickel, combined with a maximum of 0.08% carbon. It is a nonmagnetic steel which cannot be hardened by heat treatment, but instead. must be cold worked to obtain higher tensile strengths. The 18% minimum chromium content provides corrosion and oxidation resistance. The alloy's metallurgical characteristics are established primarily by the nickel content (8% mm.), which also extends resistance to corrosion caused by reducing chemicals. Carbon, a necessity of mixed benefit, is held at a level (0.08% max.) that is satisfactory for most service applications. The stainless alloy resists most oxidizing acids and can withstand all ordinary rusting. HOWEVER, IT WILL TARNISH. It is immune to foodstuffs, sterilizing solutions, most of the

organic chemicals and dyestuffs, and a wide variety of inorganic chemicals. Type 304, or one of its modifications, is the material specified more than 50% of the time whenever a stainless steel is used. Because of its ability to withstand the corrosive action of various acids found in fruits, meats, milk, and vegetables, Type 304 is used for sinks, tabletops, coffee urns, stoves, refrigerators, milk and cream dispensers, and steam tables. It is also used in numerous other utensils such as cooking appliances, pots, pans, and flatware. Type 304 is especially suited for all types of dairy equipment - milking machines, containers, homogenizers, sterilizers, and storage and hauling tanks, including piping, valves, milk trucks and railroad cars. This 18-8 alloy is equally serviceable in the brewing industry where it is used in pipelines, yeast pans, fermentation vats, storage and railway cars, etc. The citrus and fruit juice industry also uses Type 304 for all their handling, crushing, preparation, storage and hauling equipment. In those food processing applications such as in mills, bakeries, and slaughter and packing houses, all metal equipment exposed to animal and vegetable oils, fats, and acids is manufactured from Type 304. Type 304 is also used for the dye tanks, pipelines buckets, dippers, etc. that come in contact with the lormic, acetic, and other organic cids used in the dyeing industry. In the marine environment, because of it slightly higher strength and wear resistance than type 316 it is also used for nuts, bolts, screws, and other fasteners. It is also used for springs, cogs, and other components where both wear and corrosion resistance is needed **[7].”**

“STAINLESS STEEL 316:

For severe environments. Of course, there are many industrial processes that require a higher level of resistance to corrosion than Type 304 can offer. For these applications, Type 316 is the answer.Type 316 is also austenitic, non-magnetic, and thermally nonhardenable stainless steel like Type 304. The carbon content is held to 0.08% maximum, while the nickel content is increased slightly. What distinguishes Type 316 from Type 304 is the addition of molybdenum up to a maximum of 3%. Molybdenum increases the corrosion resistance of this chromium-nickel alloy to withstand attack by many industrial chemicals and solvents, and, in particular, inhibits pitting caused by chlorides. As such, molybdenum is one of the single most useful alloying additives in the fight against corrosion. By virtue of the molybdenum addition, Type 316 can withstand corrosive attack by sodium and calcium brines, hypochlorite solutions, phosphoric acid; and the sulfite liquors and sulfurous acids used in the paper pulp industry. This alloy, therefore, is specified for industrial equipment that handles the corrosive process chemicals used to produce inks, rayons, photographic chemicals, paper, textiles, bleaches, and rubber. Type 316 is also used extensively for surgical implants within the hostile environment of the body. Type 316 is the main stainless used in the marine environment, with the exception of fasteners and other items where strength and wear resistance are needed, then Type 304 (18-8) is typically used **[7].”**

“HEAT-TREATED STAINLESS STEEL

Suitable for industrial and medical applications, 400 series martensitic steel is much more corrosion-resistant than carbon steel and can be sharpened to equally-keen edge sharpness. Specialty Blades maintains an extensive inventory of Razor Blade Stainless steel in thicknesses from .010”-.062” thick, as well as 420 “Cutlery Grade” Stainless steel **[7].”**

“301, 17-4, & 17-7 PH STAINLESS STEEL

Suitable for industrial and medical applications, 400 series martensitic steel is much more corrosion-resistant than carbon steel and can be sharpened to equally-keen edge sharpness. Specialty Blades maintains an extensive inventory of Razor Blade Stainless steel in thicknesses from .010”-.062” thick, as well as 420 “Cutlery Grade” Stainless steel **[7].”**

“HIGH-SPEED STEEL

High-speed steel offers high wear resistance. M-2 high speed steel provides six to ten times more wear than conventional blade steel, while M-4 is three times more durable than M-2. High-speed steel also has excellent temper resistance, holding hardness even when exposed to temperatures up to 1,000 ° F.

We now make razor blades from M-2 High Speed Steel for increased performance vs carbon or stainless blades **[7].”**

“TOOL STEEL

This family of tool steel offers a wide array of material choices not available from producers of strip-sharpened blades. Choose the high wear of D-2, the shock resistance of S-7, the corrosion resistance of ATS 34, the balanced wear and toughness properties of A-2, or give us a call for even more tool steel options **[7].”**

“EXTREME-WEAR TOOL STEEL

With blade life up to 25 times greater than conventional blade steel, A-7, CPM 440V® and A-11 tool steel offer superior wear resistance to other steel and are more shock resistant than carbide or ceramic **[7].”**

“ZIRCONIA CERAMIC

Recent developments have made it possible to produce extremely sharp blades from transformation-toughened zirconia ($ZrO2$), commonly referred to as "zirconia ceramic". Although not recommended for high-shock applications, the Rc 75 hardness and low friction coefficient make zirconia ceramic particularly effective in film slitting operations, where blade life can be more than 100 times that of conventional steel.

Other characteristics of Zirconia that make it an attractive material in many applications include: Superb Corrosion Resistance, Non-magnetic, High Electrical Insulation Properties **[7].”**

All the materials listed are corrosion resistance. As subjected to corrosion resistance, mostly available in the current market and also the cost of the material, the possible candidates to be selected as the material for the blade are stainless steel 18-9, 304, 316.

4.5 Possible Materials for the Casing

Material for the casing must be corrosive resistance as the quality of the food must be preserved as to abide the Food Act 1983. The material must also be available in the right amount and size to be used for the fabrication process. So, material chosen is subjected to the market availability according to the amount, size and shape needed. The fabrication process will be dependent on the available machines and tools which appropriate for selected material. In selecting the material for the casing, cost would be the most important criteria as lots of the material will be needed to fabricate the casing. The possible materials for the casing are as follow.

PLASTIC (PERSPEX)

There are lots of advantages to choose plastic. "First, is that they are low in cost; the material cost is low and they can usually be shaped with low cost processes (injection molding, etc). Second, they usually do not need to be painted: the color can be "free" and exists throughout the part thickness. Third, they are usually made with processes that yield net shape or near-net shape. Secondary operations such as machining or flash trimming are often unnecessary. Fourth advantage is that they do not rust. Fifth, they can be easily made cosmetically pleasing with colors and texturing in the forming process **[9]** pp. 227." The most common plastic material use is polyethylene. Besides, by using plastic (Perspex) one can have a see-through machine and can clearly see the internal mechanism of the machine.

"The resistance of' 'Perspex' to outdoor exposure is outstanding and in this respect it is superior to other thermoplastics. After many years under tropical conditions the degree of colour change of both clear and coloured materials is very small. The best stability is developed if the 'Perspex' is shaped. 'Perspex' softens gradually as the temperature is increased above about 100C. At a temperature of 150-160C it is sufficiently rubber-like to be shaped easily. Because it is a true thermoplastic, it retains the property of softening on re-heating even after shaping. When the temperature of a shaping is raised above a particular level the material demoulds and will revert in time to its original form. Provided that the temperature does not rise above 80C the shaping will remain stable indefinitely. When 'Perspex' is first heated to its shaping temperature it will shrink approximately 2% in both length and breadth, this shrinkage being accompanied by an increase in thickness sufficient to maintain the total volume constant. 'Perspex' has a low water absorption but although the equilibrium water content is small, its effect on dimensions may not be negligible and absorbed water may have a slight effect on mechanical properties, acting to some extent as a plasticizer. The water content of' ‘Perspex' as supplied is in the range 0.5-0.8% by weight. The abrasion resistance of' ‘Perspex' is roughly comparable with that of aluminum but because the material is indented rather than removed, the resultant visual effect is rarely noticed in service. The low relative density of' ‘Perspex', 1.19, enables large components to be made which are sufficiently strong to be self-supporting and yet light in weight. Although 'Perspex' will burn, it is difficult to ignite except by an open flame playing on an edge. A typical rate of burning measured by BS 2782 method 508A using 6 mm clear 'Perspex' is 21 mm/min. In the surface spread of flame test specified in BS 476 Part 7 it receives a Class 3 grading, which includes hard woods such as mahogany. When tested to BS 476 Part 6 fire propagation tests it fails under both indices. Unlike wood and similar materials, burning 'Perspex' does not produce smoke, nor does it continue to smolders after the fire has been extinguished. Engineers are familiar with the concept of creep in metals-i.e. a non-recoverable deformation which increases with time under static load. 'Perspex' shows a somewhat analogous behavior but, in contrast to metals, the strain, which is sensitive to temperature and stress level, is wholly recoverable at a rate depending on temperature **[13]**”. Besides, according to Lucite International PERSPEX is fully recyclable **[14].**

ALUMINIUM

“Aluminium also had several of advantages to be chosen. First is the Strength to Weight Ratio. Aluminium has a density around one third that of steel and is used advantageously in applications where high strength and low weight are required. This includes vehicles where low mass results in greater load capacity and reduced fuel consumption. Second is the corrosion resistance of Aluminium. When the surface of aluminium metal is exposed to air, a protective oxide coating forms almost instantaneously. This oxide layer is corrosion resistant and can be further enhanced with surface treatments such as anodising. Next is about the toxicity of Aluminium. Aluminium is not only non-toxic but also does not release any odors or taint products with which it is in contact. This makes aluminium suitable for use in packaging for sensitive products such as food or pharmaceuticals **[12].”** The density for aluminium is 2700 kg $m^{-3.}$

WOOD

Wood is lightweight. If it is to be the material of the casing, then the total weight of the casing going to be low. This will make this machine easier to be moved and portable. In addition, wood also quite a stable material and non toxic. It will not react with the food which may interfere with the quality of the food. Wood also is easy to be machine compared to metals as it has lower hardness compared to metals. Thus, plenty of tools can be used in machining wood. About the availability of woods, it is easily found anywhere and the price also cheaper compared to most metals. One of the wood types available in Malaysia is Merbau. Merbau is a heavy hardwood with a density at 12% moisture content ranging from 740 to 900 kg/m3 and averaging 800 kg/m3.

4.6 Comparison and Weight Analysis of the Casing possible materials

3 = good **2** = intermediate **1** = poor

Table 4.2: Comparison and weight analysis of designs.

Criteria & [Weight]	Perspex	Aluminium	Wood
Price	Cheaper compare to aluminium [2]	The most expensive compared to wood and Perspex [1]	Very cheap [3]
Weight	Light. Density = 1190kg/cm3 [2]	Heaviest. Density = 2700kg/cm3 [1]	Lightest. Density = 800kg/cm3 [3]
Non toxic	Yes [3]	Yes [3]	Yes [3]
Corrosion resistance	Yes [3]	Yes [3]	Yes [3]
Easy to fabricate	Very soft material. Easy to fabricate [3]	Quite hard material [1]	Soft material. Easy to fabricate but hard to get accurate cuttings compared to Perspex [2]
See-through	Yes [3]	No [1]	No [1]
Total	**16**	**10**	**15**

From the table 4.2, Perspex score the highest cumulative point compared to Aluminium and Wood. So the project will proceed by using Perspex as the material for the casing.

4.7 Force and Velocity Analysis

This experiment is to determine the force that exerted to the fruit. The same amount force may be also used when manually cut the fruit.

Figure 4.4: The load holders are placed at the every end of the knife.

Figure 4.5: The load is added to the load holder.

Figure 4.6: Stop increased the load when the fruit is fully cut. The final load is 60 N.

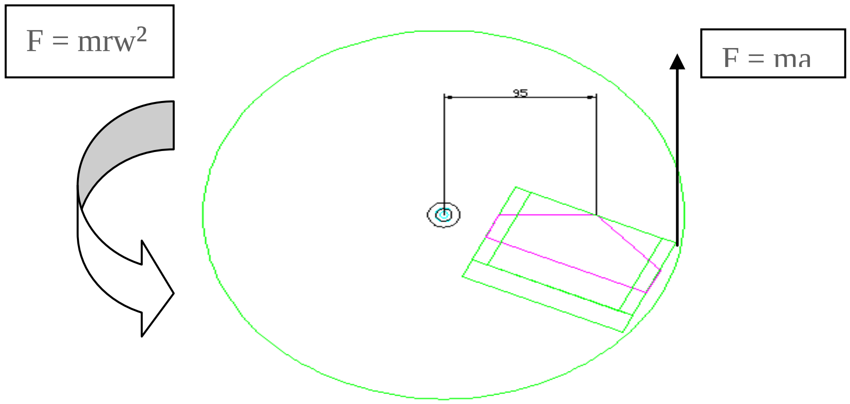


Figure 4.7: Rotating plate force diagram

Volume = Π * (radius_flywheel) ^{2} * thickness

= Π * (0.15m) ^{2} * 0.01m

= (7.068583471 * 10 ^ -4) m^3

Density of:

Perspex = 1190 kg/cm^3 ; Wood(Merbau) = 800 kg m-3 ; Aluminium = 2700 kg m^{-3}

Mass of flywheel = Density * Volume of flywheel

Mass =

- Perspex = 0.841161433kg
- Wood(Merbau) = 0.565486678kg
- Aluminium = 1.908517537kg

Linear Acceleration = Force / Mass

Linear acceleration =

- Perspex = 71.32994648ms^{-2}
- Wood(Merbau) = 106.1032953ms^{-2}
- Aluminium = 31.43801345ms^{-2}

Angular velocity = √[Force / (Mass * (radius_blade))]

Angular velocity =

- Perspex = 27.40148795 s^{-1}
- Wood(Merbau) = 44.44177992 s^{-1}
- Aluminium = 13.1679348 s^{-1}

Linear velocity = radius_blade * angular velocity

Linear velocity =

- Perspex = 2.603141355 ms^{-1}
- Wood(Merbau) = 4.221969092 ms^{-1}
- Aluminium = 1.250953806 ms^{-1}

Power = Force * linear velocity

- Perspex = 156.1884813 Nms^{-1}
  = 156.19 Watt @ 0.209300294 hp
- Wood(Merbau) = 253.3181455 Nms^{-1}
  = 253.32 Watt @ 0.3394488 hp
- Aluminium = 75.05722836 Nms^{-1}
  = 75.06 Watt @ 0.1005804 hp

4.8 Machine Fabrication and Assembly Process

Figure 4.8: Rotating plate

Figure 4.9: Rotating plate

Figure 4.10: Casing Top view

Figure 4.11: Casing 3D view

Figure 4.12: Casing bottom view

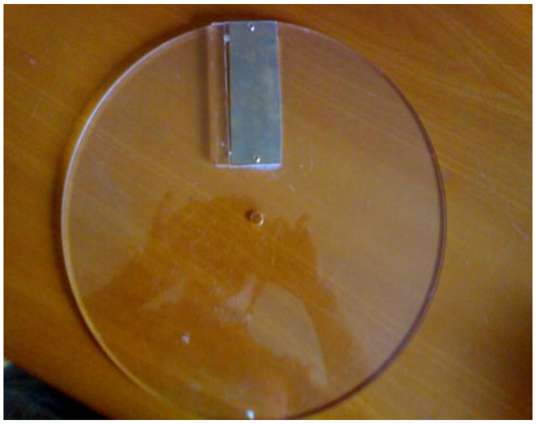


Figure 4.13: Rotating plate with blade

Figure 4.14: Blade

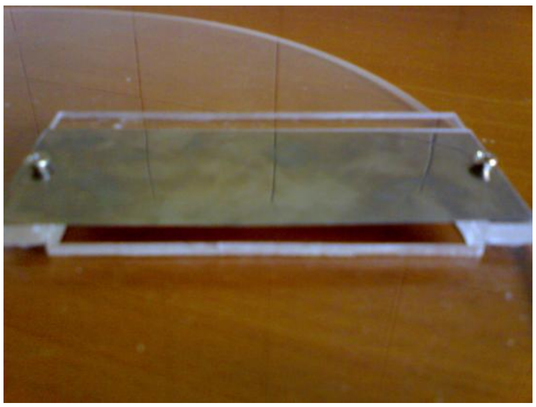


Figure 4.15: Blade

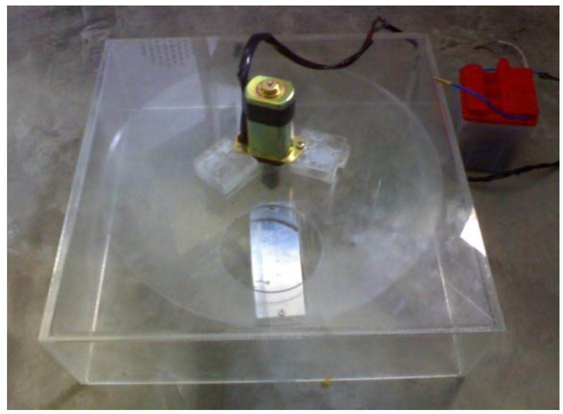


Figure 4.16: Slicer machine 3D view

Figure 4.17: Motor

Figure 4.18: Threaded shaft

Material used for the rotating plate and casing is Perspex. Reason for the usage of Perspex is because of the see-through characteristic of Perspex. So that the slicing mechanism can be see clearly during the exhibition process for better understanding of the machine. The material was bought from Globe Plastic Industries (Ipoh) Sdn Bhd. Some of the fabrication process being done there including fabricating the casing and rotating plate. While some of the fabrication process taken place in UTP (building 21) including drilling hole at the rotating plate, fabricating the blade to be used, fabricating the threaded extended shaft by drilling hole for motor's shaft insertion and making threading..

4.9 Test run of machine

Figure 4.19: Sliced Asam gelugor

Slice by hand = 60sec per fruit

Slice by machine = 30sec per fruit

Output by using machine is **double** compared to manually slice the fruit by hand

4.10 Cost analysis of the project

Casing + fabrication + adhesive = RM146

Rotating Plate + fabrication = RM40

Motor = RM50

Blade = RM4.50

Total = **RM240.50**

Revenue per 1 kg fruit = RM8

Slice by hand = 60sec per fruit

Slice by machine = 30sec per fruit

Output by using machine is **double** compared to manually slice the fruit by hand

Table 4.3: Total no of fruit sliced and total no of kg fruit sliced by hours

	total no. of fruit sliced		total no of kg fruit sliced	
hours	machine	manual	machine	manual
1	120	60	36	18
2	240	120	72	36
3	360	180	108	54
4	480	240	144	72
5	600	300	180	90

Table 4.4: Cumulative revenue by hours

	Cumulative revenue (RM)	
hours	machine	manual
0	-240.5	0
1	47.5	144
2	335.5	288
3	623.5	432
4	911.5	576
5	1199.5	720

Revenue calculated only includes machine cost and profit from amount of fruit processing by both methods.

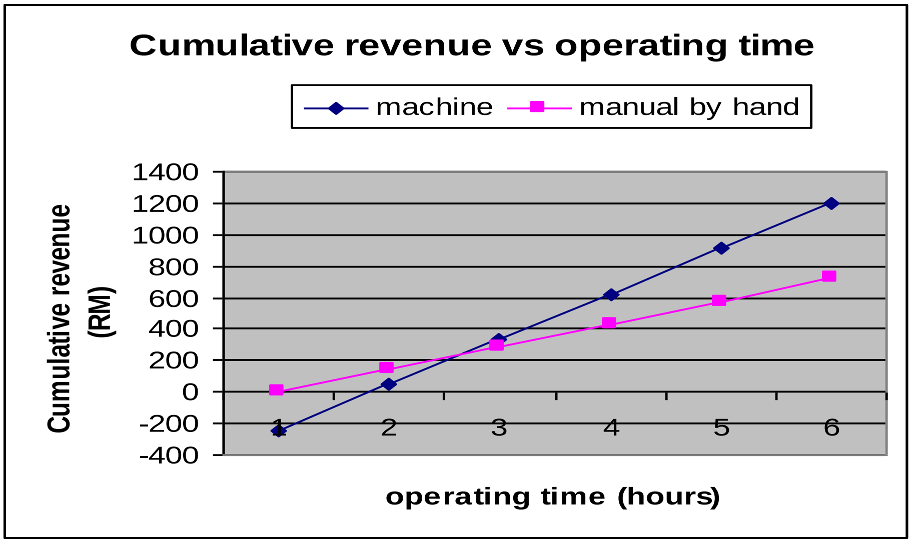


Figure 4.20: Graph of cumulative revenue vs operating time

For electric usage cost:

Malaysian electric tariff

For the 1st 200 units per month = 21.8 cent/kWh

For the next 800 units per month = 25.8 cent/kWh

For additional units per month = 27.8 cent/kWh

power window motor power = 250watt

0.25kW * 21.8 cent/kWh * 5 hrs * 20 operating days = 545sen @ RM5.45

CHAPTER 5

CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

The initial stage of this project is more towards designing the machine with engineering software such as AutoCAD. One design selected to proceed with. Force and velocity analysis of the design have been calculated to make sure enough power supported to make sure it works after fabrication done. The approach taken toward the project will ensure that the design is fully optimized and fully functional. Earlier determination of which machine to be used will give an ease to student during the fabrication process. Material to be used was chosen wisely during fabrication for cost effectiveness of the machine. And list of possible material have also been selected. After fabrication process completed, assembly of the machine is then done to finally proceed with test running the machine. Adjustment made to the machine if any error encountered during test run for smoother running of the machine. From the test run, the result is that by using this machine the production can increase to double the traditional method. And from the cost analysis, the profit gained over certain period of production time is higher compared to the traditional method. The conclusion is that by using this machine, one can increase the production output and also increase the profit gain.

5.2 Recommendations

Through experiment and test run, there are some ideas the author think can be useful to further improve the machine. First, by implementing the usage of dual blade placed in opposite arrangement to improve stability of system. Second, the casing can be made of heavy material or be fixed for further stability. Next is by adding motor speed controller and using AC current. Then improvement of the feeding system by making it to be continuous can also be done to further improve the machine.

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