DEVELOPMENT OF FRESH CUT VEGETABLES.

(Elabatu, Banana blossom, Immature jak fruit)

By

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DECLARATION.

The work of this thesis was carried out by me at the Food Research Unit, Department of Agriculture, Gannoruwa, Peradeniya, under supervision of Mr. Senarath Ekanayake and Mrs. K.M. Somawathie. A report on this has not been submitted to any other university for another degree.

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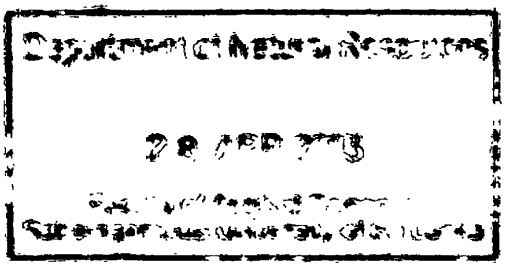

AFFECTIONALY DEDICATED TO

MY LOVING PARENTS

AND

BROTHERS.

ACKNOWLEDGEMENT.

First and foremost I wish to express my gratitude to Mrs. K.M. Somawathie, she is my internal supervisor, for giving me to valuable guidance and the support in making this effort successfully.

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Finally I remember my loving parents brothers & colleagues who are always helped and encouraged me in numerous ways to make this study successfully.

ABSTRACT.

Minimally processing is one of the modern food preservation techniques. Now it is gradually popularized even in Sri Lanka due to busy lifestyles of the consumers.

This study was conducted to preparation of fresh cut (Minimally processed) Immature jak fruits, Banana blossoms and Elabatu. Also select best preservative with its concentration, select suitable packing material, desirable storage temperature and evaluation of shelf life. Because still not done proper quality in Sri Lanka about fresh cut products.

Prior to preparation raw materials were properly washed. Then sorting and grading was done. Just after cutting above three types of vegetables were dipped into different SMS (Sodium metabisulphaite) solution and kept 5 minutes. Allow to few minutes to drain-off excess solution. Then these vegetables were packed and heat sealed. Finally store under refrigerated condition.

To determine the best preservative, fresh cuts were prepared by using Citric acid and SMS. Among them SMS treated samples presented high visual quality during the storage period. So SMS selected as a best preservative. Then fresh cuts were prepared by using 0.1% - 0.5% SMS solutions. To select the best strength, visual quality were checked every day. Residual SO_2 amount was measured by using Monier Willium method.

Fresh cut were packed by using Polyethelene, Polypropilene, Styroform boxes and Plastic boxes. Visual quality and weight loss were measured every day to select the best packing material

Prepared fresh cut were stored in three different temperature ($8^{\circ}c$, $10^{\circ}c$, $12^{\circ}c$) To select the best temperature visual quality were checked daily.

To evaluate the shelf life overall acceptability of fresh cuts were checked daily and microbiological test was done. Finally sensory evaluation was done to evaluate the cooking quality of fresh cut vegetables.

After the experiment following conclusion were obtained, Best preservative is 0.1%, 0.3% and 0.4% SMS solutions for Banana blossoms, Immature jak fruit and Elabatu respectively, best packing material is Low – density polypropylene. suitable storage temperature is $8^{\circ}C$ for above three types of vegetables Optimum shelf life of the fresh cut Banana blossom is 7 days Immature jack fruit and Elabatu can kept 4 and 5 days respectively

Fresh cut products are microbiologically desirable. According to the results of sensory evaluation there is no significant different at 5% level in between cooked fresh cut samples and cooked unprocessed vegetables.

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ABBREVIATIONS

KMS – Ptassium Metabisulphaite

SMS - Sodium Metabisulphaite

TPC - Total Plate Count.

VQR – Visual Quality Rating

PE - Polyethylene.

PP - Polypropilene.

TSS – Total Soluble Solids.

EB - Enzymatic browning.

NEB - Non- Enzymatic browning.

MR - Maillard Reaction.

AVG - Average.

et al.-and others.

etc - and so on or so forth.

No. – Number.

CHAPTER – 01

INTRODUCTION

A large number of preservation techniques are using food processors for both perishable and nonperishable food items. Among them minimal processing or "Fresh-cut" is the latest trend (kader and barrett, 1994).

Due to busy lifestyles consumers haven't sufficient time to consume unprocessed vegetables. Because preparation of some vegetables are quite unpleasant thing. As an example jak fruit has gummy latex. Elabatu and banana blossoms have rapid browning after cutting. It is cause to discolour consumers hands and cloths. Those are cause to poor consumption of some vegetables.

One way of avoiding the preparation problem is processing. But processed fruits and vegetables show lack of nutritional quality, reduce natural flavor and appearance.

So modern food industries try to do minimal processing to prevent those problems. Because of minimally processed fruits and vegetables retain their natural quality (firmness, colour, flavor, aroma, etc.) and nutritional value more than conventionally processed foods.

Also the purpose of minimally processed foods in to deliver to the consumer a like fresh fruits or vegetables product with an extended shelf-life an maintain sound nutritional and sensory quality (Wiley, 1994).

Fresh cut includes products that contain live tissues or those that have had slight modifications to their freshness conditions but have kept their quality and character similar to those of fresh products (Wiley, 1994).

Minimally processed fruits or vegetables are more perishable than the unprocessed roe materials from which they are made. The latest trend is to prepare the product close to the source of the production.

Also minimally processing refers to trimming, peeling, sectioning, slicing, and coring of vegetables.

Recently the people of both developed and developing countries who are tend to consume fresh-cut vegetables. So fresh-cut vegetables are available in the local super markets and the popularity gradually increases.

❖ Objective;

To introduce high quality fresh-cut vegetable to the local consumers.

❖ Specific objectives;

i. Preparation of fresh-cut vegetables.
ii. Determination of desirable preservative and strength.
iii. Selection of a suitable packing material.
iv. Determination of suitable storage temperature.
v. Evaluation of shelf life.

CHAPTER – 02
LITERATURE REVIEW

2.1 Fresh cut vegetables;

During the last 15 years consumer demand for freshness and convenience has led to the evolution and increased production of fresh cut fruits and vegetables. In Europe this market grew explosively in the early 1990s. In the United States the sales of fresh cut products are expected to increase more than three times from 1994 to 1999. (Olivera 1999.) Now in Sri Lanka like developing countries peoples also tend to consume fresh cut products.

These products are submitted to a minimal process or combination of minimal process, taking advantage of the hurdle concept. Theses processes include operations of handling or preparation and preservation. Preparation includes: operations of separation, such as peeling, coring, Trimming, Selecting, Sorting and Grading as well as operations to reduce the size such as Chopping, Slicing, Dicing, Granulating and Shredding.

Consumption of fresh cut vegetables had a higher increase in the market than fresh cut fruits, because the preparation of vegetables are more time consuming.

Common denomination for this type of products are: Minimally, Lightly, Fresh - Prepared, Pre-cut, Pre-prepared, Cut-prepared or "Ready to eat" vegetables.

These products are characterized by a shelf life shorter than the unprocessed row materials.

The increase in convenience for the consumer has however a detrimental effect on the product quality. Physiologically, the operations of preparation will damage the operation of the cells, promoting contact between enzymes and substrate the entry of microorganisms, and creating stress conditions.

The consequences of wounding are;

1). Increase in the respiration rate.
2). Production of ethylene.
3). Oxidative browning.
4). Water loss.
5). Degradation of the membrans' lipids.

These alteration will increase decay. Thus attention must be focused on extending shelf life by maintaining quality and assuring food safety throughout the harvesting, handling, packaging, storage and distribution.

2.1.1 Some reasons for the increases in demand of minimally processed foods.

1). Changers in societal consumption patterns.
2). Availability of certain products.
3). Consumer purchasing power.
4). Consumer preferences.
5). Life styles.
6). Greater awareness of health and safety as related to food.

2.2 Definition of the fresh cut foods.

There are several definitions proposed for fresh cut foods.

2.2.1 Definition No 1 ;

Includes all the operations (washing, selection, peeling, slicing etc) that must be carried out before blanching in a conventional processing line that keep the food a living tissue. (Rolle and Chism, 1987)

2.2.2 Definition No 2 ;

Includes products that contain live tissues or those that have had slight modifications to their freshness condition but have kept their quality and character similar to those of fresh products. (Wiley, 1994)

2.3 Method of fresh cut production.

First, fresh disease free fruits or vegetables should harvest. Then do sorting and grading. After the preliminary sorting the vegetables are graded according to size. It is done by hand or with the help of grading machines. The graded vegetables are properly washed with soaking, agitating or spraying in pure water. We can disinfect the vegetables by socked them in to dilute solution of Potassium permanganate ($KMnO_4$) or washed by using Chlorine water. The unwanted particle of the vegetable is removed by using hand or knife. Then vegetables are cut shred or chop according to the type of vegetables. If necessary suitable preservative is added to prevent Browning reaction. We can use (KMS/SMS- potassium or Sodium meta -bisulphaite, Citric acid, etc.) After pack is done by using suitable packing material. Finally packed products are stored under suitable cold room condition until consume. If these are transport cold chain should follow. Otherwise quality of fresh cut will be loss.

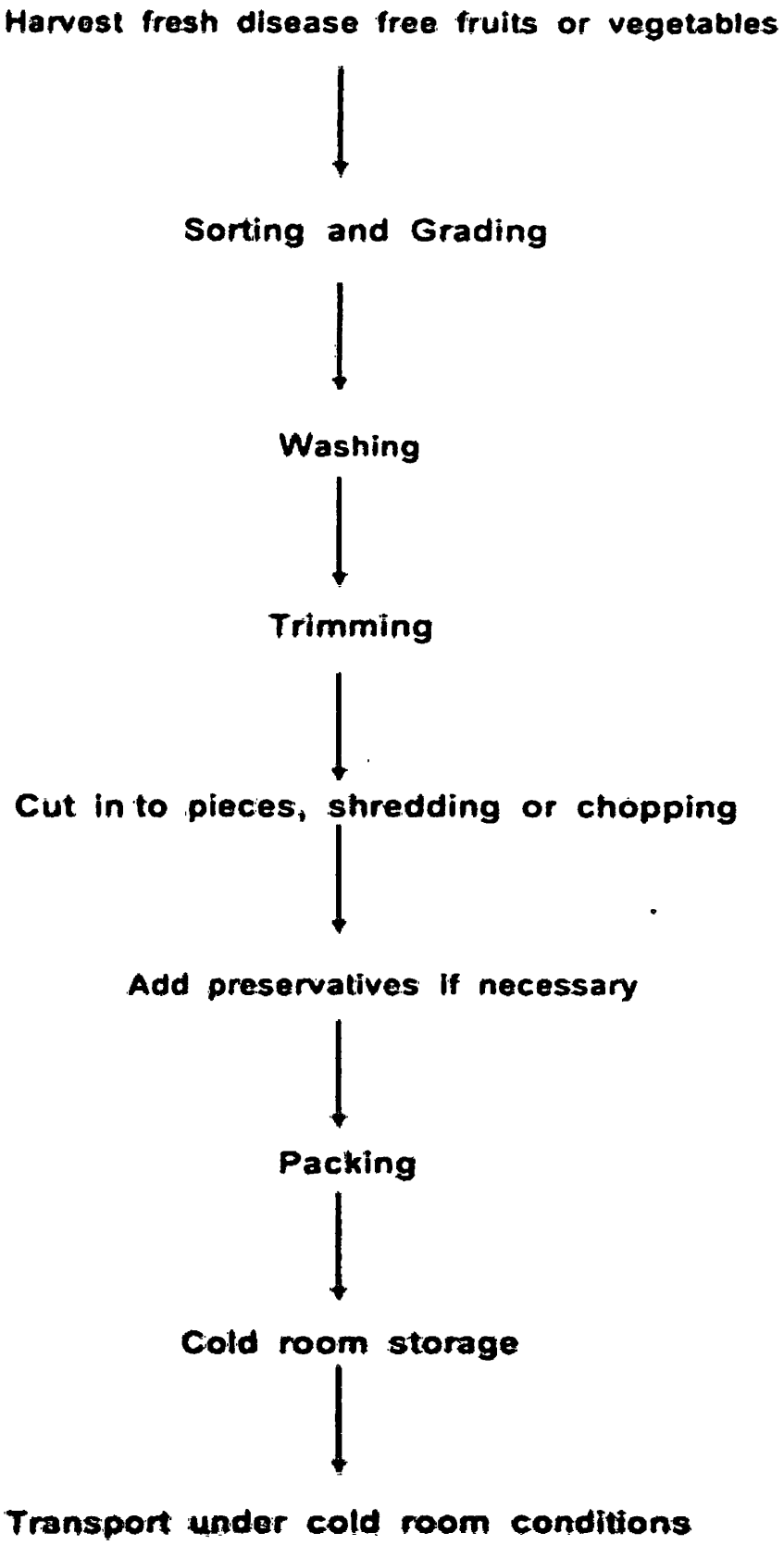

Figure 2.1 - Process flow of fresh cut fruits or vegetables. (Throughout the procedure cold chain should be followed.)

2.4. Shelf life of fresh- cut vegetables.

As living tissue, fresh cut products have a limited energy supply. Respiration converts the stored energy into usable energy to sustain life. Basically, the higher the respiration, the shorter the shelf life. (Rolle and chism, 1987). So suppression of respiration is important for all fresh cut produce.

In addition, minimally processed produce are essentially wounded tissues, and thus undergo reactions designed to repair the damage. Unfortunately many of these reactions are deleterious to quality (Rolle and Chism, 1987). The wounding of living plant tissue results in an increase in respiration and ethylene production, both of which will result in shortened shelf life. The ethylene will also accelerate ripening, softening and senescence. (Philosoph – Hadas et al, 1991). Wounding also induces other metabolic pathways that result in secondary metabolites that can cause dis-colouration, off-flavour and texture changers. Cell disruption at the cut surface leads to decom patmentation of enzymes and substrates. For example, Phenylalanine, Ammonialyase and Polyphenol oxidase contribute to browning reactions when combined with Oxygen and Monophenolic substrates. (Arthey and Ashurst, 2001).

Finally, almost all minimally processed foods have all or part of the peel or outer protective coating removed. This allows entrance of spoilage organisms and dehydration of the fruit tissue. Dehydration may be partially responsible for some of the oftening that is observed in fresh cut produce. (Arthey and Ashurst, 2001).

Shelf life of minimally processed vegetable shorter than its unprocessed vegetable. Shelf life of some fresh cut are 6-10 days some are can keep 21 days. It depend on the type of vegetable. (Robert C. Wiley, 1994).

2.4.1. Methods of extend the shelf life.

1). Rinsed in 50- 200 ppm Chlorine or Chlorine dioxide (Reduction of Browning reactions and Micro organisms).

2). Use of Ozone and Ultraviolet radiations.

3). Storage of Controlled or Modified atmosphere conditions.

4). Use chemical preservatives.

5). Apply mild heat treatments.

6). Modification of PH.

7). Reduction of water activity (a_w) (fresh cut fruits and vegetables which normaly have a_w around 0.97-0.99) (Robert C. Wiley - 1994).

8). Apply irradiation.

9). Apply edible wax coating.

10). Use Plastic or Polyethelene package.

Quality is best maintained if the product is chilled to optimum temperature levels which are maintained until purchased by the consumer ("Cold chain").

2.5. Storage and Packaging of fresh cut products.

When we consider storage of fresh cut, we use controlled atmosphere(CA) or Modified atmosphere(MA) condition. Polymeric film or Plastic materials are use as a packing materials. Storage temperature depend on type of food products.

Modification of concentration of O_2, CO_2 and/or C_2H_4 (and water vapor or Relative humidity) in the atmosphere around the product to different levels than those in air, what is known as Controlled atmosphere(CA) or Modified atmosphere(MA).

MA that reduce senescence and deterioration of Minimally processed foods. MA package help to extends their shelf life 50-400 times. (Pedro Fito et. al., 1997)

In this condition internal package atmosphere concentration of O_2 relatively low and CO_2 concentration is relatively high. So aerobic respiration of the product is reduce.

To maintain above condition permeability characteristics are very important. These are mentioned in following table.

Permeability characteristics of several Plastic film with potential for use as MAP of fresh and Minimally processed produce.

Table 2.1 Permeability characteristics of different plastic film.

Film type	Transmission rates		
	O_2	CO_2	H_2O
1). Low-density polyethylene. (LDPE)	3,900-13000	7,700-77000	6-23.2
2).Medium density polyethylene. (MDPE)	2600- 8283	7,700- 38,750	8-15
3). High density polyethylene. (HDPE)	520- 4,000	3,900-10,000	4-10
4). Polypropylene. (PP)	1,300-6,400	7,700-21000	4-10.8
5). Polyvinylchloride. (PVC)	620-2,248	4,263- 8,138	-
6). Polystyrene. (PS)	2000- 7,700	10,000-26,000	108.5-155

(Source- Minimally processed refrigerated fruits and vegetable, Robert C. Wiley,. 1994).

2.6. Sulper dioxide (SO_2)

It is also well known to be effective against molds, yeasts and bacteria. It is a food grade chemical. It has been used to control microorganisms on soft fruits, vegetables, fruits juices, wines, pickles, leafy greens. It is most effective ant-browning agent, (prevent enzymatic browning). Assist to preserve vitamin C and less toxic.

Sulphur dioxide available in the form of Sulphites. Sodium and Potassium sulphites (Na_2O2SO_2 / K_2O2SO_2) are widely use as preservatives. Potassium sulphite (KMS) - is more crystalline than Sodium sulphite (SMS). Hence it is more stable. But chemical reaction is same. (Robert C. Wilys, 1994)

$$H_2O+SO_2 \rightleftharpoons H_2SO_3^- \rightleftharpoons HSO_3+H^+ \rightleftharpoons SO_3^-+2H^+$$

- 1 mole of KMS /SMS contain 2 mole of SO_2.
- Moleculer weight of SO_2 is 64g.
- Moleculer weight of KMS is 222g.
- So 222g of KMS contain 128g of SO_2.
- Therefore theoretically percentage availability) =(128 / 222) *100 %
  Of SO_2 in KMS = 57.65 %

2.7. Browning reaction in food.

Fundamentally, browning reactions are of two types :

i. Enzymatic browning.

ii. Non-Enzymatic browning.

This reaction results in organoleptic defects and deterioration of foods during processing and storage. We can control browning reaction by using many chemicals like Sulphites, Ascorbic acid, Erythrobic acid, Ascorbic acid- 2-phosphate, Acidulants and Chelating agents.

2.7.1. Enzymatic browning(EB)

Enzymatic browning ubiquitions in fruits and vegetables is generally of two types.

a) Polyphenol oxidase catalysed oxidation of polyphenol compounds in fruits and vegetables to quinines which then polymerize to dark melanine pigments of unknown structures.
b) Reaction of polyphenol derived quinones with free amino acids and proteins to form.

2.7.2 Non-Enzymatic Browning.(NEB)

Also known as Maillard Reaction(MR). Maillard reaction comprises of the following reactions.

I. Heat catalysed amino acid and protein interactions specifically reactions of amines, amino acids, Peptides and proteins with reducing sugars.
II. Protein oxidized fatty acid reactions

III. Heterocyclic amine formation.

IV. Caramalization.

2.7.3 Prevention of Browning

Conventional methods employ heat treatment, such as steam and water blanching to control browning. Unfortunately although these are equally detrimental to the texture of fruits and vegetables.

Siphiting agents can use to control browning of fruits and vegetables. Alternatives of control browning.

1) Reducing agents – Ascorbic acid.
2) Enzyme inhibitors – Cinnamic acid, kojic acid and Benzoic acid.
3) Chelating agents – Cyanide, EDTA, Azide, etc.
4) Acidulants.
5) Copmlexing agents- Cyclodextrins, cyclic oligosaccharides.

In this method we apply two or more suitable preservation method together. As an example in this concept we can apply to prevent browning, low PH, reduction of water activity, mild heat treatment.

This method is very important when we consider minimally processing. (Indian food packer, 1998)

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2.8. Microbiology of Minimally processed food.

Almost all minimally processed foods have all or part of the peel or outer protective coating removed. This allows entrance of spoilage organisms.

Microbiological spoilage represents significant economic loss and cause to food illnesses. But relatively few types of microorganisms cause the majority of food borne diseases. (Wiley, 1994).

Spoilage organisms can produce spoilage symptoms that are associated with ;

- ✓ General appearance ;
- ✓ Colour ;
- ✓ Texture ;
- ✓ Odour or flavour ;
- ✓ A mixture of the above;

Cut product should be washed to remove cellular content from the surface that favour microbial growth. (Arthey and Philip, 2001).

Washing fresh cuts are important to control microbial loads that include mesophilic micro flora, Lactic acid bacteria, Coliforms, Feacal coliforms, yeast, mold and pathogenic micro flora. (Arthey and Ashurst, 2001).

We can control microorganisms by applying Modified atmosphere packaging, Low temperature and preservatives.

To minimized microbial contamination protect sanitary conditions throughout the processing line and it should be maintain until consume.

All member of the food industry share a responsibility to provide consumers with safe wholesome food. Profits should be secondary to safe. (Wiley, 1994)

CHAPTER – 03

MATERIALS AND METHODS.

3.1 MATERIALS.

3.1.1 Elabatu. *(Solanum melongena.)*

Elabatu was bought from Peradeniya market.

3.1.2 Immature jak fruits. *(Artocarpus heteropyllus.)*

Immature jak fruit was harvested from agriculture farm Gannoruwa.

3.1.3 Banana Blossoms. *(Musa acuminata.)*

Banana Blossoms was harvested from agriculture farm Gannoruwa and also bought from Peradeniya market.

3.1.4 Stainless steel shape knives.

This knives was used to cut the vegetable in to small pieces and protect hygiene also minimizing the damage to the cutting surface.

3.1.5 Plastic Jars.

It was used to dip the vegetable pieces in to sodium metabisulphaite (SMS) solution.

3.1.6 Sodium metabisulphaite. (Na_2O2SO_2)

It was act as a preservative and anti browning agent.

3.1.7 Packing materials.

Polypropylene was used to pack the treated vegetable pieces.

3.1.8 Refrigerators.

Three refrigerators was used to store minimally processed vegetables at three different temperature.

3.1.9 Thermometer.

Dial thermometer was used to measure temperature of each refrigerators.

3.1.10 Other materials.

Glassware (petridishers, pipette, burette, beakers, glass rod, conical flask, condenser, measuring cylinders.), Electric sealer, Seaves, Refract meter, PH meter, Autoclaver, Color cord, Parafilm, Nutrient agar, Quebec colony counter.

3.2 METHODOLOGY.

Priparation of fresh cut vegetables by using Elabatu, Immature jak fruits and Banana blossoms.

Initially grading and sorting was done to select desirable once. Vegetables were washed by using pure running water. Trimming was done to remove unnecessary parts. Then Elabatu and immature jackfruits was cut in to pieces and removed unnecessary parts of inside the vegetables, also banana blossoms was shredded. Just after cutting or shredding these three types of vegetables was dipped in to (S.M.S) Sodium Metabisulphaite solutions for 5 (five) minutes.

Items	Strength of SMS solution
• Elabatu	0.4%
• Banana Blossoms	0.1%
• Immature Jak Fruit	0.3%

Then the solution was filtered out and allow to 5 minutes to drain off excess water from the products. After vegetables were packed by using (PP) Polypropylene bags of ISO gauge thickness. All the bags were heat sealed. Weight of each sample was approximately 100g. Finally packed vegetables were stored under Refrigerator conditions at 8 ^{o}C.

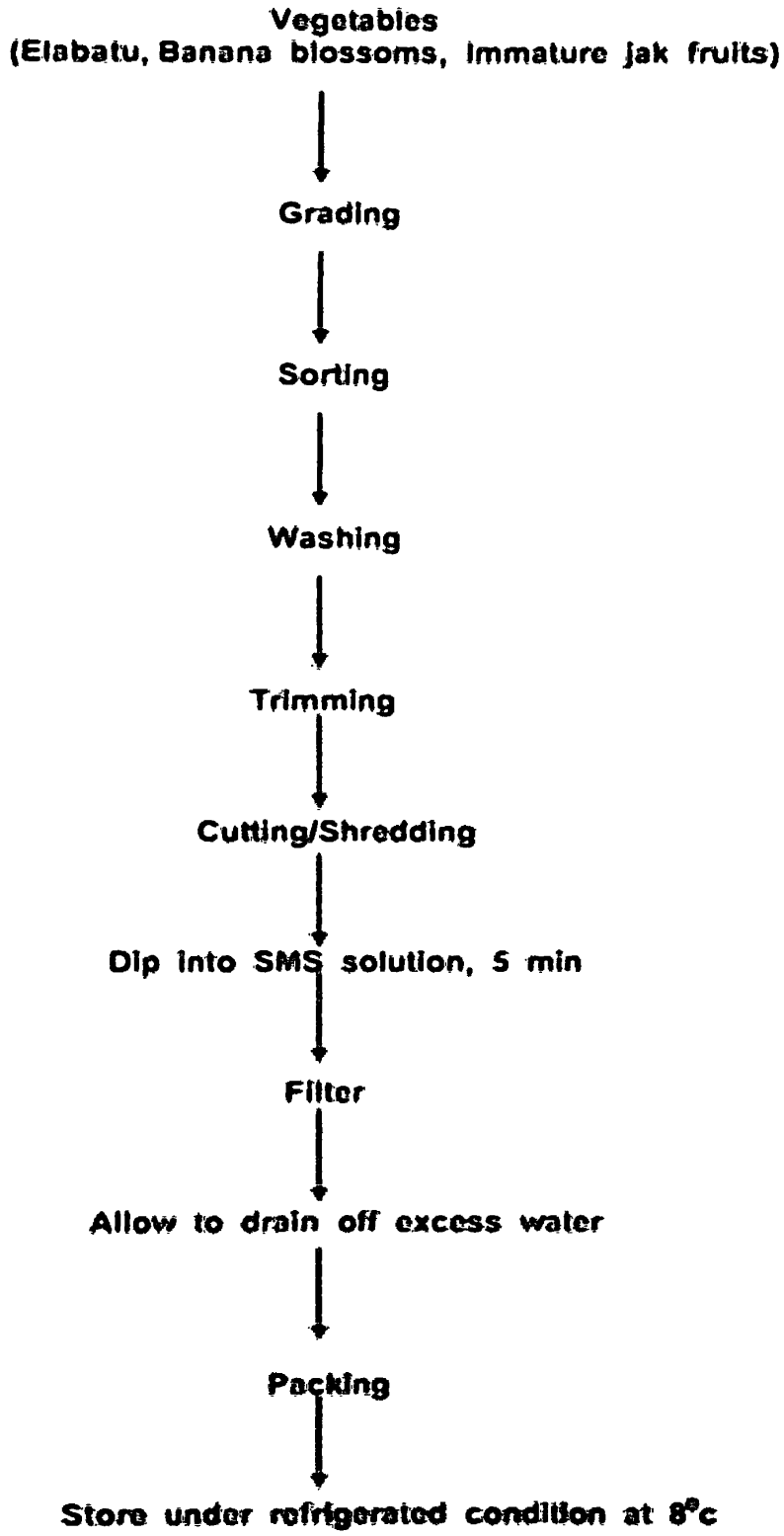

Figure 3.1- Process flow for Fresh-cut vegetables.

3.2.1. Analysis of residual Sulphur Dioxide.

Reagents;

0.05 N standardized Iodine solution.
1% Starch solution.
Previously boiled distilled water.
Concentrated Hydrochloric acid.

Procedure;

100g of grinded vegetables (Elabatu, Immature jak fruits, Banana blossoms) was weighted and put into 1000ml round bottomed flask. Also 200ml of distilled water was added into it. The adapter was dipped under the surface of about 300ml of distilled water in a 500ml beaker. To this water was added a few drops of 0.05N Iodine solution and a 5ml of Starch solution. Then 20ml of concentrated Hydrochloric acid was added into the round bottomed flask. The flask was connected to the remainder of the apparatus. Then the sample was heated until boiled. From a burette 0.05N Iodine solution was run into the beaker as the distillation proceeds. So that blue colour of the "Starch Iodide" just remains.

The end point is taken when the initial blue colour persists for one minute. The procedure was repeated three times for each sample.

The SO_2 content is calculated in parts per million from the formula.

$$SO_2 \text{ in ppm} = (V * 0.016/W * 10^{-6})$$

1ml of 0.05N I_2 = 0.016g of SO_2

V= Needed Iodine amount of the titration.

W= Weight of the sample.

3.2.2. Determination of Total Soluble Solids (T.S.S.).

Reagent;

Distilled water.

Procedure;

10g of fresh cut vegetable was grinded and measured amount of water was added if necessary. Then mixture was homoginzed and was filtered through the cloth. Brix value of the filtrate was measured by using Refractometer (Erma Hand Refractometer, range 0-32°). This procedure was repeated three times for each sample.

Calculation;

T.S.S. = Refractometer reading * Dilution factor.

Dilution factor=(Weight of the sample+Volume of Water)/Weight of the sample

3.2.3. Select best preservative and concentration.

Select best preservative;

Reagent;

Citric acid.
Sadium Metabisulphaite(SMS).
Distilled water.

Procedure;

Just after cutting same weight of immature jak fruits, Banana blossoms and Elabatu were separately dipped in freshly prepared 0.1% SMS and 0.1% Citric acid solutions and also in distilled water as a control. Vegetable were kept in solution for about 5 minutes. And allowed to drained off water. Then every fresh cut vegetable samples were packed by using polypropilene bags of 150 guage thickness. All the bags were heat sealed and stored in a refrigerated condition at 12°c. External appearance were measured by using Visual quality rating. Nine point Hedonic scale were used. 9 – was repreconted extreamly good and 1 – was repreconted extreamly bad respectively.

Determine better concentration of the preservative;

Just after cutting same weight of Immature jak fruits, Banana blossoms and Elabatu were seperatly dipped in freshly prepared 0.1%, 0.2%, 0.3%, 0.4% and 0.5% SMS Solution. Cut vegetable were kept solutions for about 5 minutes. And allowed to drain off water. Then packed every fresh cut vegetable sample by using polypropilene bags of 150 guage thickness. All the bags were heat sealed and stored in a refrigerated condition at 12°C. External appearance were measured by using Visual quality rating.

3.2.4. Selection of suitable packing material.

Just after the cutting same weight of Elabatu, Immature jak fruits and banana blossoms were separately dipped in 0.4%, 0.3% and 0.1% SMS solution respectively. Fresh cut were kept in solutions for about 5 minutes. And allowed to drain off water. Then packed every fresh cut samples by using Low Density polyethylene (guage 150), polypropilene (guage 150), Styraform boxes and Plastic boxes. Sample were stored under refrigerated condition at 12°C. External appearance and weight was measured every day.

3.2.5. Select best temperature;

Just after cutting same amount of Immature jak fruits, Elabatu and Banana blossoms were dipped in to 0.3%, 0.4% and 0.1% SMS solutions. Vegetable were kept in 5 minutes and allowed to drain off water. Then every samples were packed by using Polypropilene bags and heat sealed. Store under 8°C, 10° C and 12° C in refrigerated condition. Sensory evaluation was done for fresh cut Immature jak fruits, Elabatu and Banana blossoms, After 4, 5 and 7 days of storage respectively.

3.2.6. Microbiological test.

Total Plate Count (T.P.C.)
[Standard Plate Count / Aerobic Plate Count]

Culture media;

Nutrient agar (NA)

Methods of preparation - NA medium;

23g of Nutrient agar was added to one litter of distilled water and it was boiled until gel dissolve. Then the medium was sterilized by autoclaving for 20 minutes at 15 lbs/sq inch.

Sterilization of Glass ware;

Petridishaes, Pipettes and Test tubes were sterilized by oven drying for one hour at 170°C.

Procedure;

Lamina Air Flow surface and hands was sterilized chemically by using 70% Ethyl alcohol.

1g of Minimally processed vegetable sample was put into test tubes and 10ml of sterilized distilled water was added into it by using Pipette. Then mixture was shacked by the help of shacker.

After preparation of mother solution following dilution series was prepared 10^{0}, 10^{-1}, 10^{-2} and 10^{-3}.

Two plates was prepared by using each dilution.

Preparation of plates;

Initially 1ml of inoculum was added into petridish in the Lamina Air Flow environment. Then 20ml of NA was added into the petridish and it was shaked well to proper mixing. Then petridish was sealed by sticking the parafilm.

Each plate was prepared by using above procedure. All the plates was incubated at 30-35°C for 48 hours.

After 48 hours colonies were counted by the help of colony counter.
(Garbutt, 1997)

Calculation;

$$N = C/(n_1 + 0.1n_2)d$$

N – Number of Micro organisms per ml/ per g of the sample.

d - dilution factor corresponding to the first dilution.

C – Sum of colonies counted on all the dishes retained.

N_1 - Number of dishes retained in the first dilution.

N_2 – Number of dishes retained in the second dilution.

3.2.7. Sensory evaluation;

Paired preference Test.

Sensory evaluation was done at the final day of the shelf life of the fresh cut Elabatu, Banana blossoms and immature jak fruits, by the help of 20 panalist in Food Research Unit.

Procedure;

Minimally processed vegetable sample and fresh vegetable sample was cooked identically. Then two sample was put into two dishes and it was labled by using three digit random numbers. Then both cooked samples was served to panelists with Cream-cracker biscuits for sensory evaluation. Hedonic scale included questionnaire was given to them for mark their preference.

Final results was analysed statistically by using Paired t- test.

CHPTER-04

Results and discussion.

4.1 Residual so_2 content ;

Table 4.1 Residual SO_2 content in Banana blossoms, Immature jak fruits and Elabatu at the very first day of preparation.

Fresh cut products	sample	0.05N I_2 ml	SO_2 ppm
Banana blossoms(dipped in 0.1 % SMS)	1	O.15	24
	2	0.15	24
	3	0.20	32
Immature jak fruit. (dipped in 0.3% SMS)	1	0.35	56
	2	0.40	64
	3	0.45	72
Elabatu. (dipped in o.4 % SMS)	1	0.15	24
	2	0.25	40
	3	0.20	32

- At the very first day of the preparation average residual SO_2 content of fresh cut Banana blossoms 26.6 ppm.
- At the very first day of the preparation average residual SO_2 content of the fresh cut Immature jack fruit is 64 ppm.
- At the very first day of the preparation average SO_2 content of Elabatu is 32 ppm.
- Residual SO_2 content depend on the type of vegetable.
- All the above residual SO_2 amount below the 70 ppm [According to SLS standard optimum residual SO_2 amount of Ready to serve drink (RTS) is 70 ppm] Therefore it is good for consumption. Because still not publish standard residual SO_2 amount for fresh cut vegetables.
- When cooking significant amount of residual SO_2 liberate. So cooked product contain rather low amount of residual SO_2.

4.2 Total Soluble Solids (TSS) content.

Table 4.2.1 TSS variation of the final products.

Days	Average TSS of Banana blossom	Average TSS of Immature jak fruit	Average TSS of Elabatu
1	1.5^{d}	2.5^{c}	2.5^{d}
2	1.5^{d}	2.5^{c}	2.5^{d}
3	1.5^{d}	2.6^{b}	2.6^{c}
4	1.6^{c}	2.6^{b}	2.6^{c}
5	1.6^{c}	2.7^{a}	2.7^{b}
6	1.7^{b}		2.8^{a}
7	1.8^{a}		
Significunt different effect at 5% level	**	**	**

** Means with the same letter are not significantly different at 5% level.

- TSS content increase with the storage time.
- Banana blossoms have low TSS content than other two.
- TSS variation is most probably equal these three types of vegetables.

4.3. preservative for each Visual quality rating (VQR) with time to select best vegetables.

Banana blossoms ;

Table 4 3 1 Average VQR with different preservatives within the storage time.

Days	Average VQR for SMS	Average VQR for Citric acid	Average VQR for Distilled water
1	9	9	7
2	9	9	7
3	9	8	6
4	8	7	4
5	8	7	4
6	8	6	3
7	8	6	2
8	7	6	2
9	7	5	1
10	6	4	1
Total	79	67	37
average	7.9	6.7	3.7

- Average VQR of controlled sample is very small. It mean VQR is very less.
- In the other two average VQR of SMS added sample is higher than the Citric acid added sample.
- The data was analysed using statistical package Minitab, by the heap of Non parametrics Kruscal wallis test.
- Then average values were ranked.
- So SMS added samples give good VQR. According to the results of ranking SMS is the best preservative for Banana blossom.

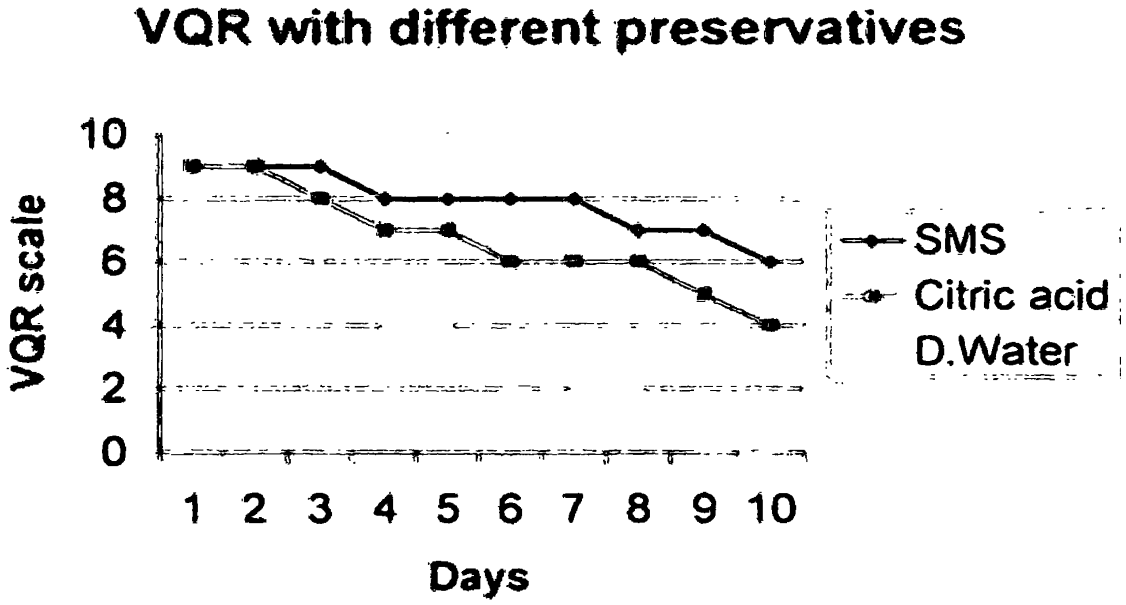

Figure 4.2 Changes VQR with days under different preservatives for Banana blossoms.

Immature jak fruit;

Table 4.3.2 Change of average VQR with different preservatives during the storage time.

Days	Average VQR of SMS	Average VQR of Citric acid	Average VQR of D.Water
1	9	7	6
2	8	5	5
3	8	5	4
4	7	4	4
5	7	4	4
6	6	3	3
Total	47	28	26
Average	7.8	4.6	4.3

- Average VQR of SMS added sample is very much higher than the other two. So SMS is the better preservative for immature jak fruit.
- Above data were analysed by using Non parametrics Kruscal Wallis test.
- Average values were ranked to find best treatment.

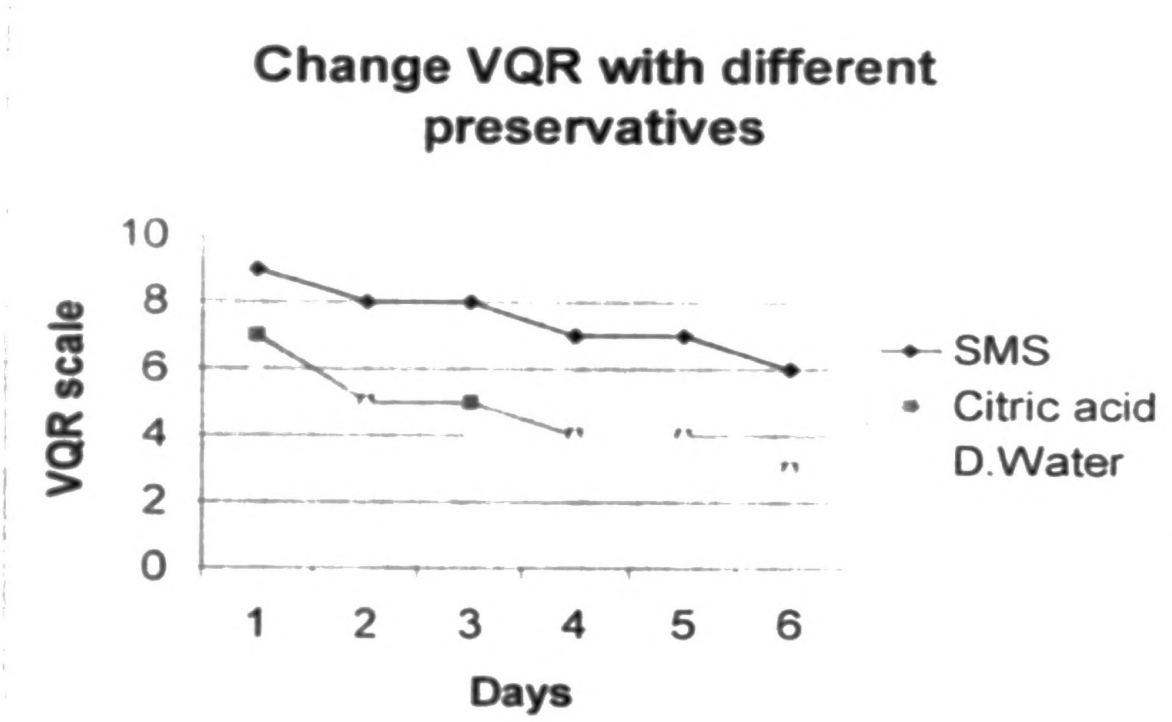

Figure 4.3 Change average VQR with days under different preservatives.

Elabatu;

Table 4.3.3 Change of VQR with different preservatives during the storage time.

Days	Average VQR for SMS	Average VQR for Citric acid	Average VQR for D.Water
1	8	8	8
2	8	8	8
3	8	7	7
4	7	7	7
5	7	6	6
6	6	6	5
7	6	6	4
Total	50	48	45
Average	7.14	4.8	6.4

- Average VQR of SMS added sample is higher than the other two. So SMS is the better preservative for Elabatu.
- Above data were analysed by using Non parametrics Kruscal wallis test and average values were ranked to find the best treatments.

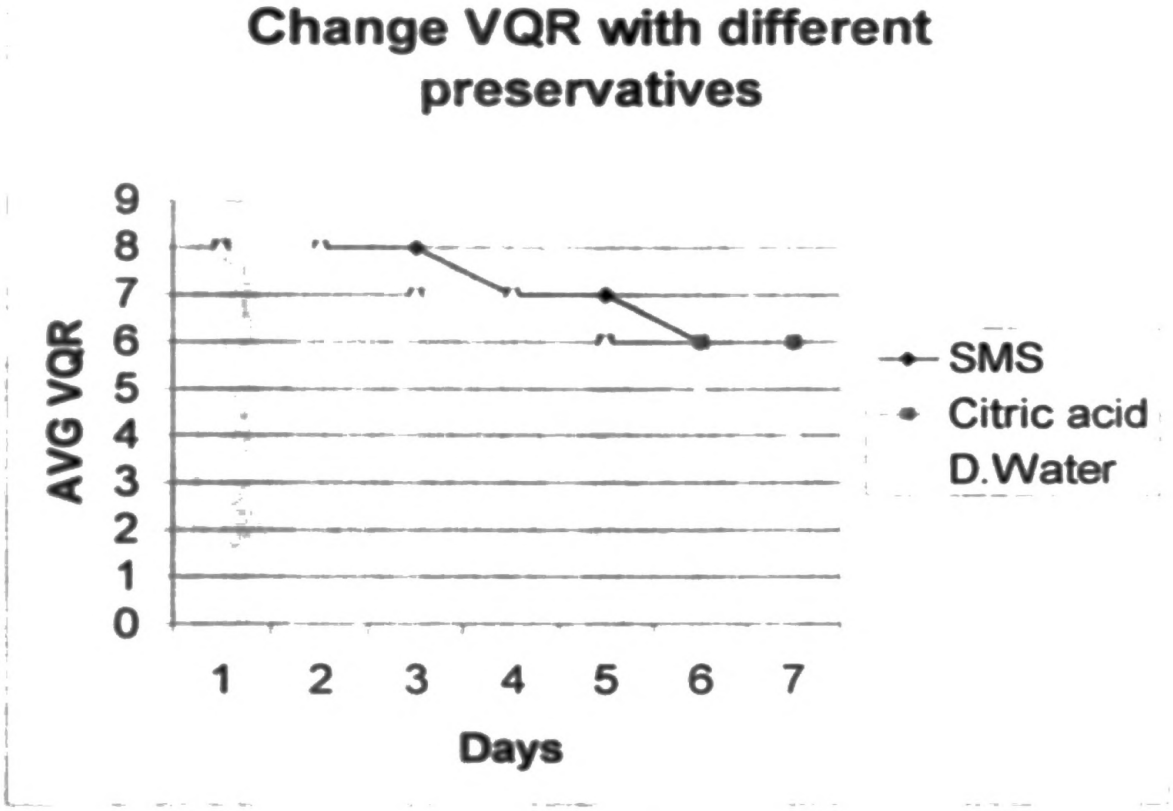

Figure 4.4 Change AUG VQR with days under different preservatives.

- **Visual Quality Rating with days to select best SMS concentration for each vegetable.**

Banana blossom ;

Table 4.3.4 Change of VQR with different SMS concentrations

Days	SMS 0.1%	SMS 0.2%	SMS 0.3%	SMS 0.4%	SMS 0.5%
1	9	9	9	8	7
2	9	9	9	8	7
3	9	9	8	8	7
4	8	8	8	7	6
5	8	8	7	7	6
6	8	8	7	6	5
7	8	8	6	6	4
8	7	7	6	5	4
Total	66	66	60	55	46
Average	8.25	8.25	7.5	6.8	5.7

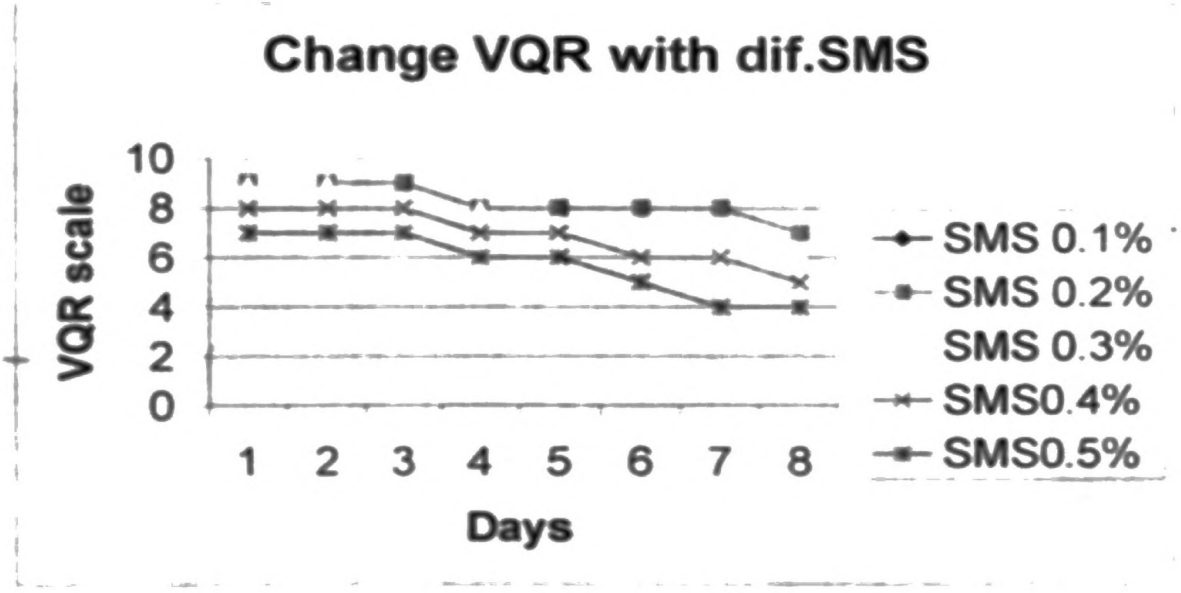

Figure 4.5 Change VQR with different SMS concentration during storage time.

- Average VQR value of 0.1% and 0.2% SMS solutions treated are higher than others and same. But we select low concentration solution to treat Banana blossoms.
- So the best concentration is 0.1% for Banana blossoms.
- If add high concentration the product was bleached.
- These data were analysed by using Non parametrics Kruscal Wallis test and average values were ranked to find the best concentration.

Immature jak fruits ;

Table 4 3.5 Change in VQR with different SMS concentrations

Days	SMS 0 1%	SMS 0.2%	SMS 0 3%	SMS 0 4%	SMS 0 5%
1	9	9	9	9	9
2	8	8	9	8	8
3	7	8	9	8	7
4	7	7	8	7	7
5	7	7	8	6	6
Total	38	39	43	38	37
Average	7 6	7.8	8 6	7.6	7.4

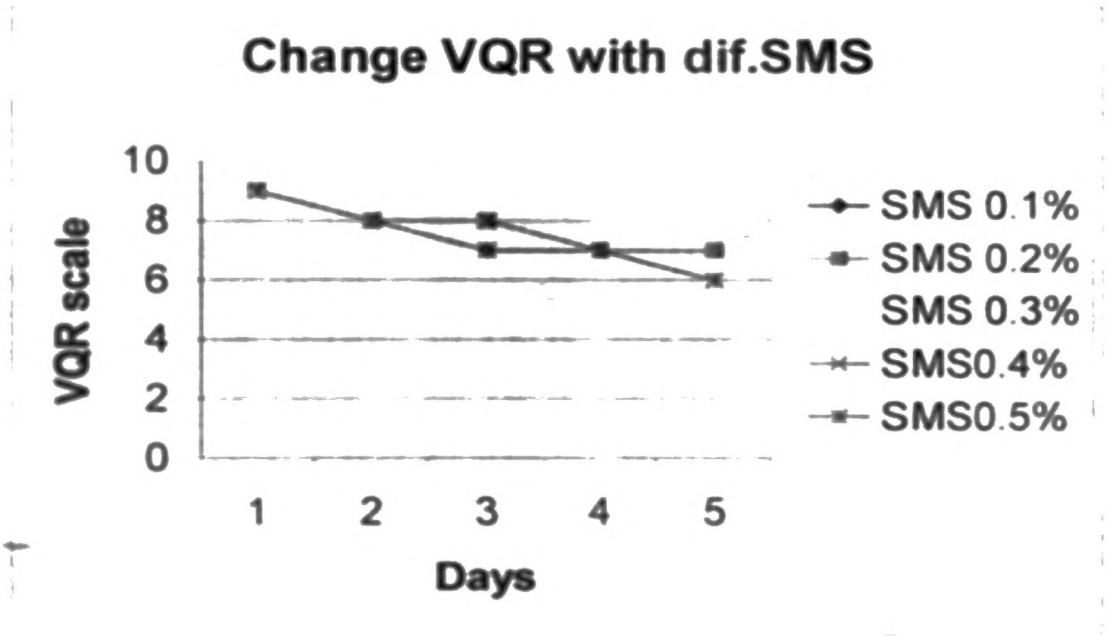

Figure 4.6 Change in VQR of different concentration SMS solutions during the storage time.

- Average VQR value of o.3% SMS samples are higher than others. Therefore it is the best SMS concentration for preserve immature jack fruit.
- If added high dose of SMS pink colour was developed in the product.
- Above data were analysed by using Non parametrics Kruscal Wallis test and average values were ranked to find the best concentration.

Elabatu ;

Table 4.3.6 , change in average VQR with different concentration of SMS during the storage time.

Days	SMS 0.1%	SMS 0.2%	SMS 0.3%	SMS 0.4%	SMS 0.5%
1	8	8	9	9	9
2	8	8	9	9	9
3	8	7	8	9	9
4	7	7	8	8	8
5	7	7	7	8	8
6	6	7	7	8	8
Total	44	44	48	51	51
Average	7.3	7.3	8	8.5	8.5

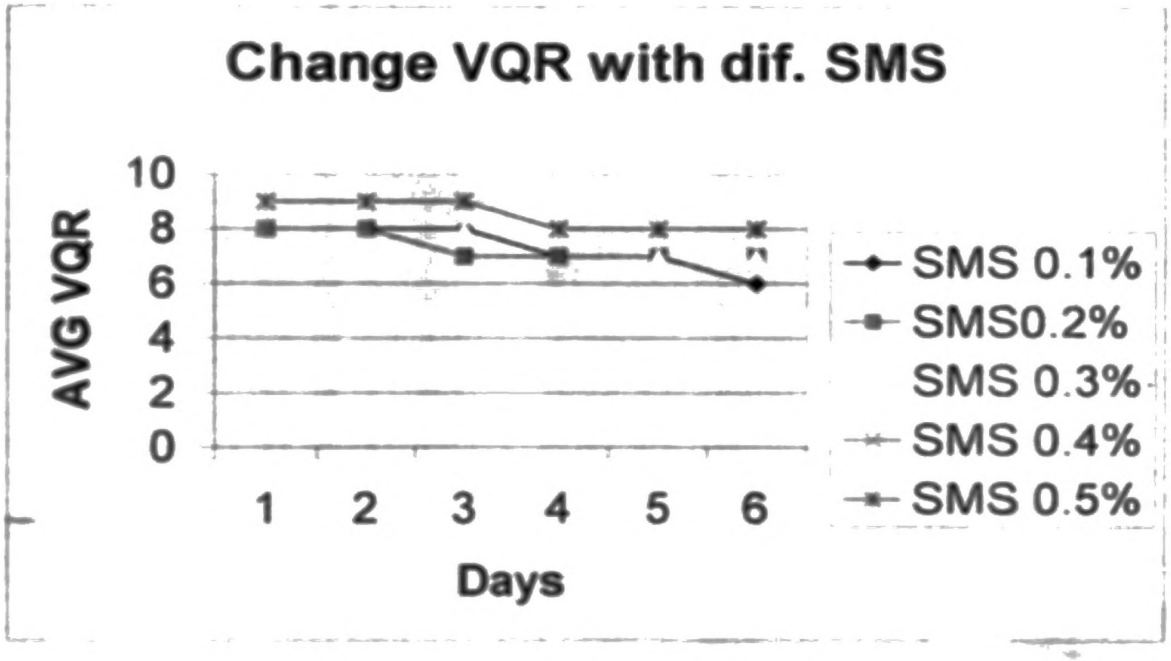

Figure 4.7; Changes in average VQR with different concentration of SMS solutions during storage time.

- **Average VQR value of 0.4% and 0.5% SMS solutions are higher than others and same. Low concentration is more better for consumption. So 0.4% SMS is good for Elabatu.**
- **Above data were analysed by suing Non parametrics Kruscal wallis test and average values were ranked to select best concentration.**

4.4 Visual quality rating for select best packing material;

4 4 1 Average VQR for Elabatu

Days	polyethylene	Polypropilene	Straform box	Plastic box
1	8	8	8	8
2	8	8	8	8
3	7	8	7	7
4	7	7	7	6
5	6	7	6	6
6	6	6	5	4
7	6	6	4	4
Tot	48	50	45	43
AVG	6.8	7.14	6.4	6.14

4.4.2 Average VQR for Banana blossoms.

Days	polyethylene	Polypropilene	Styraform box	Plastic box
1	9	9	9	9
2	9	9	9	9
3	8	9	8	8
4	8	8	7	7
5	8	8	7	7
6	7	8	7	7
7	7	7	7	6
8	6	7	6	6
9	6	7	5	5
10	5	6	5	5
Tot	73	78	70	69
AVG	7.3	7.8	7.0	6.9

4.4.3 Average VQR for Immature Jak fruits.

Days	Polyethylene	Polypropilene	Styroform box	Plastic box
1	9	9	9	9
2	9	9	9	9
3	8	9	8	8
4	8	9	7	7
5	7	8	6	6
6	6	8	6	5
Tot	47	52	45	44
AVG	7.8	8.6	7.5	7.3

- Above data were analysed by using Non parametrics Kruscal Wallis test and average values were ranked.

- Average VQR is higher in Polypropilene bags contain fresh cut vegetable samples then the Polyethylene bags, Plastic boxes and Styraform boxes contained vegetable samples.

4.4.4 Percentage weight loss – Elabatu

Days	Polyethylene	Polypropilene	Styraform box	Plastic box
1	0	0	0 2	0 2
2	0 4	0 2	0 5	0 3
3	0 8	0 4	0 8	0 7
4	1 0	0 6	1 0	0 9
5	1 4	0 8	2 5	1 3
6	1 8	1 0	2 8	1 4
7	2 6	1 2	3 5	1 8

4.4.5 Percentage weight loss – Banana blossoms

Days	Polyethylene	Polypropilene	Styraform box	Plastic box
1	0 1	0	0.3	0.2
2	0 2	0.1	0.6	0.4
3	0 3	0.15	0.9	0.6
4	0.35	0.3	1.3	0.75
5	0.45	0.35	1.7	0.9
6	0 5	0.45	1.9	1.2
7	0.65	0.6	2.5	1.6
8	0 9	0 7	3.0	2.0
9	1.4	0.65	3.4	2.2
10	1 8	1.2	3.8	2.5

4.4.6 Percentage weight loss Immature Jak fruits

Days	Polyethelene	Polypropilene	Styraform box	Plastic box
1	0.1	0	0.5	0.4
2	0.3	0.2	0.7	0.7
3	0.7	0.5	1.3	0.9
4	0.9	0.7	1.8	1.4
5	1.4	0.9	2.5	1.8
6	1.7	1.1	3.5	2.7

- According to the above data percentage weight loss also less in polypropilene bags contain fresh cut samples than others.
- So Polypropilene is the best packing material for Elabatu, Immature jack fruits and Banana blossoms.

4.5 Select best temperature;

4.5.1 Change of VQR for Elabatu at different storage temperature

Days	8°C	10°C	12°C
1	8	8	8
2	8	8	8
3	8	7	7
4	7	7	7
5	7	6	6
6	6	6	5
7	6	6	4
Tot	50	48	45
AVG	7 14	6.8	6.4

4.5.2. Average VQR for Banana blossoms at different storage temperature.

Days	8°C	10°C	12°C
1	9	9	9
2	9	9	8
3	9	8	8
4	8	7	7
5	8	6	7
6	8	6	6
7	7	6	5
8	7	5	5
9	6	5	4
10	6	4	4
Tot	77	65	63
AVG	7.7	6.5	6.3

4.5.3 Average VQR for Immature Jak Fruits at different storage temperature.

Days	8°C	10°C	12°C
1	9	7	6
2	8	7	6
3	8	6	6
4	7	6	5
5	7	5	5
6	6	5	4
Tot	47	40	32
AVG	7.8	6.6	5.3

- Above data were analysed by using Non parameirics Kruscal Wallis iesi and average values were ranked.

- Average VQR is higher than the above three types of fresh cut vegetables which were stored at 8^{0}c than 10^{0}c and 12^{0}c.

4.6 Total plate count (T.P.C) [Aerobic plate count]

- Aerobic plate count of Minimally processed immature jack fruit was $1.1*10^{4}$ cfu / g after 5 days of storage.

- Aerobic plate count of Minimally processed Elabalu was $1.2*10^{4}$ cfu / g after 6 days of storage.

- Aerobic plate count of fresh cut Banana blossom was $1.4*10^{4}$ cfu / g after 7 days of storage.

- These microbial amounts are very low level of acceptable range.
- The reasons of present such a low amount of microbial content are low temperature storage, Modified atmosphere packaging and maintain proper sanitary conditions. And also SMS contribute to controlled significant amount of micro organisms.

4.7 Sensory evaluation ;

Paired preference test;

For Immature jak fruits;

4.7.1. Data – Immature jak fruits.

Judges	Sample B	Sample A	Difference
	914	148	
1	8	6	2
2	8	5	3
3	7	4	3
4	8	7	1
5	8	7	1
6	6	8	-2
7	7	4	3
8	9	6	3
9	9	6	3
10	8	7	1
11	8	7	1
12	8	6	2
13	8	8	0
14	6	9	-3
15	8	4	4
16	8	6	2
17	9	8	1
18	6	7	-1
19	3	8	-5
20	8	8	0
Tot	150	131	19
Mean	7.5	7.5	0.95

914 – Unprocessed fresh, cooked Immature Jak Fruit sample.

148 - Minimally processed, cooked Immature Jak Fruit sample.

- Calculated t-value is 1.863.
- T-value of table is 2.093.
- 1.863 is not greater than the table value (2.093).
- The conclusion is that there is no significant difference in the jack fruits minimally processed and unprocessed curry samples.

For Elabatu ;

4.7.2 Data – Elabatu

Judges	Samples	Samples	Difference
	716	581	
1	7	4	3
2	7	8	-1
3	7	8	-1
4	8	7	1
5	7	4	3
6	7	6	1
7	7	8	-1
8	7	8	-1
9	9	7	2
10	7	8	-1
11	8	7	1
12	7	8	-1
13	6	8	-2
14	8	7	1
15	8	6	2
16	6	7	-1
17	9	8	1
18	9	6	3
19	8	8	0
20	8	7	1
	150	140	10
	7.5	7.0	0.5

716 – Unprocessed fresh, cooked Elabatu sample.

581 – Minimally processed, cooked Elabatu sample.

- Calculated t-value is 1.5223
- T-value of table is 2.093
- 1.468 is not grater than the table value (2.093).
- The conclusion is that there is no significant difference in the Elabatu, minimally processed and unprocessed curry samples.

For Banana blossom ;

4.7.3. Data – Banana blossoms

Judges	Samples 314	Samples 628	Difference
1	7	6	1
2	6	8	-2
3	8	7	1
4	8	6	2
5	9	7	2
6	5	8	-3
7	7	4	3
8	6	6	0
9	7	6	1
10	9	6	3
11	8	7	1
12	7	8	-1
13	9	6	3
14	8	6	2
15	9	8	1
16	7	6	1
17	7	7	0
18	7	9	-23
19	6	8	-2
20	9	5	4
Tot	149	134	15
Mean	7.45	6.7	0.75

314 – Unprocessed fresh, cooked Banana blossoms sample.

628 - Minimally processed, cooked Banana blossoms sample.

- Calculated t-value is1.69
- T-value obtain from table is 2.093.
- 1.69 is not grater than the t-value 2.093
- The conclusion is that there is no significant difference in the Banana blossoms minimally processed and unprocessed cooked samples.

Fig. 4.8. Picture of the raw materials.

Fig. 4.9. Picture of the finished products. (Minimally processed Banana blossoms, Elabatu and Immature jak fruits)

CHAPTER-05

CONCLUSIONS

Following conclusions were obtained from this study.

Banana blossoms ;

- Best packing material is low density polypropilene.
- Best storage temperature is 8°C.
- Best preservative is SMS, concentration is 0.1%.
- Optimum shelf life is 7 days.

Immature jack fruit ;

- Best packing material is low density polypropilene.
- Best storage temperature is 8°C.
- Best preservative is SMS, concentration is 0.3%.
- Optimum shelf life is 4 days.

Elabatu ;

- Best packing material is low density polypropilene.
- Best storage temperature is 8°C.
- Best preservative is SMS, concentration is 0.4%.
- Optimum shelf life is 5 days.

Above three products are microbiologically safe.

Cooking quality between Minimally processed vegetables and unprocessed vegetables haven't significant difference at 5% level.

Residual SO_2 amount of the fresh cut are in desirable level to consumption. After cooking this SO_2 amount further reduce.

Suggestions for further study ;

- ✓ Study about suitable pack size for these fresh cut vegetables.(Surface :Volume ratio).
- ✓ Find good alternative for SMS.

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APPENDIX;

PAIRED PREFERENCE TEST

Name:----------

Date:----------

Product:----------

Taste these two samples and mention how much you like or dislike each one.

9 Like extremely.

8 Like very much.

7 Like moderately.

6 Like slighily.

5 Nether like or dislike.

4 Dislike slighily.

3 Dislike moderately.

2 Dislike very much.

1 Dislike extremely.

Sample No:	Sample No:
716	318
———	———

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