UNIVERSITY OF NAIROBI

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DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY

TITLE: EFFECT OF OSMOTIC DEHYDRATION ON QUALITY OF MANGO SLICES FROM SELECTED LOCALLY UTILIZED VARIETIES

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DECLARATION

I, **ABOK ELISHA ONYANGO**, hereby declare that this is my original work and has not been presented for a degree in any other college or University.

Sign………………………………………………………………Date…………………………

Abok Elisha Onyango

This report has been submitted for examination with supervision and approval of;

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CHAPTER ONE

1.0 INTRODUCTION

Fruits and vegetables contribute a crucial source of nutrients in daily human diet. The world fruit production is estimated to be 434.7 million metric tons and vegetables 90.0 million metric tons, mango is not an exception. Fruits and vegetable losses in the developing countries are considerably high (KUMAR et al 2002).

Post-harvest loss in a measurable quantitative and qualitative loss of the product at any moment during post-harvest chain and includes the change in the availability, edibility, wholesomeness or quality of the food that prevent its consumption (ADEOYE et al, 2009). Post-harvest loss of fruits and vegetables is estimated to be 30-40% in developing countries (KARIM et al, 2005).

The perishable fruits are available as seasonal surpluses during certain parts of the year in different regions and are wasted in large quantities due to inadequate facilities and technical know-how for proper handling, distribution, marketing, processing and storage.

Massive amounts of the perishable fruits produced during a particular season results in a glut in the market and become scarce during other seasons. Quality of fruits pre and post- harvest influences consumer acceptance. The physical and chemical changes that occur determine the quality and in turn the economic returns to the farmers and processors (MANGARAJ et al, 2005).

Fresh quality product demand by consumers is increasing, processors resorts to minimally processed products in an attempt to combine freshness with convenience to the point that even traditional whole fresh fruit or vegetable is being packaged and marketed in ways formerly reserved for processed products (TAPIA et al, 1996).

Food preservation in a broad sense refers to all measures taken against any spoilage of food, it is directed against food spoilage due to microbial or biochemical action. Preservation technologies are based mainly on the inactivation of microorganisms and prevention of their growth. However, they must operate through those factors that most effectively influence survival and growth of microorganisms (ICMSF, 1980).

Dehydration of fruits and vegetables is one of the oldest forms of food preservation. Although food preservation is one of the primary aims for dehydration, dehydration also lowers the cost of packaging, storage and transportation by reducing both the weight and volume of the final product. Given the improvement in the quality of dehydrated foods alongside increased focus on instant and convenience foods, the potential of dehydrated fruits and vegetables is greater than ever (SOMOGYI et al, 1986).

Sensorial quality of dried fruits can be improved by osmotic dehydration; this is carried out by immersing the fruit pieces in a hypertonic solution containing one or more solutes. The different osmotic pressure between fruit pieces and solution promotes the simultaneous flow of water and solutes counter currently. Solute transfer is usually limited due to differential permeability of cellular membrane (BIDWELL, 1979).

Osmotic dehydrated products are part of the intermediate moisture foods (IMF) and should be consumed in a relatively short time or be subjected to conservation steps (FERNANDES et al, 2008), (RAMALLO et al, 2010). Osmotic dehydration has received a greater attention in the recent years as an effective method for preservation of fruits and vegetables. Being a simple process, it facilitates processing of tropical fruits and vegetables with retention of initial fruit and vegetable characteristics such as: color, aroma and nutritional quality (POKHARKAR et al, 1998). It is less energy intensive as compared to air or vacuum drying methods since it can be done at ambient temperature.

The aim of this study is to establish the effect of osmotic dehydration on the quality of mango slices obtained from selected locally utilized varieties.

1.1 PROBLEM DESCRIPTION

There exist a need of producing shelf-stable mango slices which retain juiciness as well as essential nutrients such as vitamin A, vitamin C, vitamin B complex and minerals. The effect of osmotic dehydration on varieties of locally available and utilized mangoes is not well established (ALAKALI et al 2006) and hence the reason for this research.

1.2 JUSTIFICATION

Short shelf-life when associated with inadequate handling results in production loss and hinders the fruits commercialization. An immediate consequence is a raise of the products price. Therefore it is necessary to establish and develop a technology which enables extension of post-harvest shelf-life, reaching the consumer with its sensory qualities minimally altered and at compensatory prices (SOUZA et al, 2007).

Marketing, handling and transportation are simplified as the size of mango fruit is reduced into sizable pack, the mangos can then be made available to consumers throughout the year as there is much demand for high quality minimally processed fruit which can be used for fruit formulations (ALAKALI et al, 2006).

Conventional methods of sun drying and deep freezing require high energy input and massive investment in terms of equipment. The flavor and texture is difficult to maintain in this conventional drying operation which is not the case in osmotic dehydration (TORRES et al, 2007).

1.3 OBJECTIVES

1.3.1 OVERALL OBJECTIVE

To determine the nutritional and sensorial quality variation in Apple and Tommy Atkins mango slices during osmotic dehydration.

1.3.2 SPECIFIC OBJECTIVES

1. To determine the initial moisture content, vitamin C and vitamin A in Tommy Atkins and Apple mangoes.
2. To dehydrate the obtained mango slices in sucrose syrup and in sucrose crystals.
3. To determine the final moisture content and vitamin C in the osmotic dehydrated mango slices.
4. To determine material balance.
5. To assess the sensory attributes of dehydrated mango slices.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.0.1 MANGO PRODUCTION IN KENYA

Mango seedlings as a rule start to bear fruit within 4-7 years while grafted trees (if allowed) may bear a few fruits in their second year in field. Mango production in Kenya has to be differentiated according to production system. There is traditional mango growing system and commercial and market oriented mango cultivation. (FAO, 2003)

Out of an average annual mango production in Kenya of about 140,000 tones during 1999/2000, approximately 3300 tones were exported (annual report, horticultural crops development authority, ministry of agriculture Nairobi). Some distinct differences between the location of production and the performances of the orchard can be identified, such as harvest period, the fruit quality and yield level. Due to varying ecological conditions in Kenya, mangoes are available almost all year round. (FAO, 2003)

In the main production area the coastal region, two supply season scan be differentiated. The first and main season runs from November to February and the second from June to August. In areas of high altitude such as Murang'a and Mwea the harvest season is 4-6 weeks later than at the coast, with peak in February and March. The mango picking season in Kenya competes with that of other mango producing countries and extends over a period of between 5 and 6 months (FAO, 2001).

Production depends on a number of factors, including quantity of previous crop, weather and soil conditions, altitude, control of pests and diseases, fertilization and cultivar. Even in the case of same cultivar, yields vary greatly because mango is grown under widely varying agro climatic conditions and cultural practices.

Biennial or irregular bearing occurs often with mango and it is common for some cultivars to bear heavily in one season and sparsely in the next season. One of the reasons for this phenomenon is that trees over bear in one year , thus inhibiting adequate flower bud formation the following year. Under these circumstances, it is difficult to get accurate local long –term yields records. However, it is well known that yields of 25t/ha and more for Kent, Sabine, Tommy Atkins and keit is not uncommon.

Cultivar trials carried out under rain fed conditions at Government prison farms in Kenya indicate that even higher yields could be achieved (GRIESBACH, 1992).

Maturity

Depending on cultivars and environmental conditions, it takes about 90 to 160 days after flowering for Kenya mangoes to reach maturity. Not all fruits on one tree will ripen at the same time; a great problem is to determine precisely the stage at which the fruit is ripe for picking (HCD, 2014). Fruits harvested too early will be inferior in quality after storage. However, fruits picked too ripe cannot be stored for any length of time and may give rise to problems such as jelly seed (FRESHPLAZA, 2013.)

The fruit will have its best flavor if allowed to ripe on the tree (MFARM, 2013.) none of the tests (acid, sugar content or specific gravity) used to determine ripeness however are fully reliable. A penetrometer is in many cases to determine the degree of ripeness by measuring the amount of pressure required to push the plunger of the meter through the skin and fleshy mesocarps of the fruit (FAO, 2003).

The fruits are generally picked when they begin to change color. This may occur first in a small area or the change will cover most of the fruits surface. However, the destructive tests for maturity that can be applied even before the color break starts is to examine the color of the flesh around the seed. When this begin to change from green to white to yellow or orange, it indicates that the fruit is beginning to ripen and may therefore be picked(WORLDAGROFORESTRY, 2013)

Harvesting

The fruit is removed from the tree by cutting the fruit stalk about 2cm from the fruit. This will prevent the latex (exudes from the cut stalk) adhering to the skin of the fruit staining it and rendering it unattractive (ARIAHU, 2006). Ladders or long picking poles with a cutter blade and an attached canvas bag held open by a ring are also used (TRUST, 2013). To avoid physical injury, the picked mangos should be carefully placed into clean wooden plastic containers and never gunny bags. If there is a delay in the transfer of fruits they should be kept in a shelter place to minimize sunburn, loss of moisture and accumulation of dust (FRESHPLAZA, 2013).

After any sorting, grading, washing, fungal treatment and perhaps waxing, the fruits are ready for packaging preferable into shallow single layered trays of 4-5kg each (KARI, 2013). Because mangos are harvested during summer months, the fruit temperature may be as high as 35^0C and more. This has a detrimental effect on the shelf-life of the fruit. It is therefore advisable to move the packed fruits into cold storage as quickly as possible to help them loose inherent heat. The recommended storage temperature must however not drop below 7^0C as otherwise cold injury may occur (FAO, 2003).

2.2 MANGO PROCESSING

Mangoes are processed at two stages of maturity. Green fruit is used to make chutney pickles, curries and dehydrated products. Ripe mangoes are processed as canned and frozen slices, puree, juices, nectar and various dried products (RAYALL et al, 1982).

Ripe mangoes are dried in form of pieces, powder and flakes. Drying procedures such as sun drying, tunnel dehydration, vacuum drying, and osmotic dehydration may be used. Packaged and stored properly, dried mangoes are stable and nutritious (RAOUL, 1994).

Some mangoes are processed as fresh cuts for sale to retailers and food service industries. Fresh cuts are held at 5^0C as opposed to whole fruit that are held at 12^0C (BRECHT, 2011

Chutney are produced from green mangos, green mangos are usually knocked off the tree and go into waste. They are best utilized in making chutney (REAP, 2011).

There are many defects in mango that calls for quick processing and at some extent hinders the production of quality product. Some of this defects include: stem end rot caused by different fungus, brown grey or black lesions starts at the stem end of mango, latex staining, anthracnose caused by field fungus, chill injury forming grayish scalding and uneven ripening (BETH, 2010).

Flesh firmness vs. ripeness stage of mango

RIPENESS STAGE	**FLESH FIRMNESS(1b force with 5/16 inch tip penetrometer)**	**Notes**
Mature green	>14	Treat with ethylene for 48hrs
Partially ripe	10-14	Treat with ethylene for 24hrs
Firm ripe	6-10	Best stage for retailing
Soft ripe	2-6	Best for eating
Over ripe	<2	Good for juice

Source: ADEL, KADER UC DAVIS 2010

2.3 NUTRITIONAL QUALITY OF MANGOS

Mangos peel and pulp contain other compounds such as pigment carotenoids and polyphenols, omega3 and omega 6 PUFA. Preliminary studies indicates that certain compounds in the mango skin have potential to lower risk of diseases such as diabetes, high cholesterol level and forms of cancer.

Mango triterpene, lupeol is an effective inhibitor in laboratory models of prostrate and skin cancers (RALPH, 1966). Flavor of mango fruit is constituted by several volatile organic chemicals mainly belonging to terpenes, furanones, lactones and ester classes. Ethylene is known to cause changes in flavor apart from inducing ripening.

NUTRITIONAL COMPOSITION OF A MANGO PER 100g

Nutrient	**Weight composition in 100g**	**Nutrient**	**Weight**
Protein	0.51g	Iron	0.13mg
Fat	0.27g	Sodium	2mg
Carbohydrate	17g	Zinc	0.04mg
Energy	65kcal	Copper	0.11mg
Sucrose	9.9g	Vitamin C	27.7mg
Glucose	0.7g	Vitamin K	4.2micro-gram
Fructose	2.9g	Manganese	0.027mg
Moisture	81.71g	Selenium	0.6micro-gram
Fibre	1.8g	Beta carotene	445micro-gram
Calcium	10mg	Vitamin E	1.12mg
Magnesium	9mg	Folacin	14 microgram
Phosphorous	11mg	Niacin	0.584microgram
Potassium	1.56mg		

Source: FAO 2003

2.4 OSMOTIC DEHYDRATION

Mango contains about 85g H_2O/100g solids and highly perishable (SALUNKHE et al, 1984). Dehydration to low moisture content can extend the shelf life. Conventional sun drying and freezing methods are normally time and energy consuming and hence most often uneconomical. Osmotic dehydration has been suggested by many researchers as a pre-treatment for reducing the high water content of fresh fruits and vegetables before further processing.

Partial dehydration of fruits by osmosis in sucrose syrup was investigated by (PONTING et al, 1966). A reduction of about half of the original weight of the fruits was achieved before freeze or vacuum drying to the desired moisture content. (Magee et al, 1983) studied the osmotic dehydration rates of apples while (LERICI et al, 1985) reported reduction of 60% & 65% respectively for moisture content and drying time of fruits and vegetables by osmotic pre-dehydration process.

A detailed review by (TORREGIANI, 1993) indicated that osmotic products maintained a significant proportion of their freshness qualities and that color, flavor and texture of air, freeze or vacuum dried fruits and vegetables could be improved by osmotic pre-concentration.

During osmotic dehydration, the fruits and vegetables are immersed in a solution of high osmotic pressure. Generally, sucrose is used for fruits and sodium chloride is used for vegetables. (ADE- OMOWAYE et al, 2002). Sucrose is also cheaper than glucose, fructose and other low molecular weight simple sugars as osmotic agents for pre-dehydration of fruits. Water in the material (fruit) is lost into the sucrose syrup while there is a simultaneous movement of sugar molecules into the product by diffusion. Information about the advantages and limitation of osmotic dehydration process as a pre-treatment method was reviewed by (RAOULT, 1994) and (RAHMANet al, 1996)

(VIAL et al, 1991 and HENG et al, 1990) studied the osmotic kinetics and product quality of Kiwi fruits and Papaya respectively, in sucrose and glucose syrups. Mango products treated either as slices or puree by osmotic dehydration are reported by (MOY et al, 1978), (RAMAMURTHY et al, 1978). In this case the water loss and solid gain are plotted with osmosis time as a function of operating conditions. This plot gives qualitative information of the process. Quantitative knowledge and modeling of the kinetics of mass transfer (water loss and solid gain) are necessary for osmotic dehydration process design and control.

Partial osmotic dehydration of fruits may be accomplished by placing them in sugar and syrup. The optimum sugar fruit ratio for dry sucrose is quite narrow also close to 1:1 (PONTING, 1966). The rate of osmosis increases with temperature but above 120^0F enzymatic browning and flavor less deterioration begins to occur (ROGERNALD, 2010). The heavy syrup is an effective inhibitor of the enzyme polyphenol oxidase which causes browning. The fruit is reduced to about 50% of its original weight by osmotic dehydration in 2-3 hours after which it is drained and dried further in air or vacuum oven or frozen. The rate of osmotic dehydration in fruits after this is slightly less. In addition, it is less hygroscopic (FOREY et al, 2010).

The principle of osmosis (movement of water from low concentrated solution to high concentrated solution via a semi-permeable membrane is used). Cut pieces of fruit are immersed in concentrated solution of sugar. A flux of water out of the food and of other solutes into the food stuff develops due to difference in osmotic pressure. The product thus loses some water to the external solution (ALAKALI, 2006).

Osmotic dehydration is non-destructive technology to reduce the water content, as well as to improve the quality of the final product. This process is being used in industries to dehydrate fruits, vegetables, meat and fish but the industrial application is still limited (SHARMA 2011).

The objective of this work would be to examine the effect of osmotic dehydration on

CHAPTER THREE

3.0 MATERIALS AND METHODOLOGIES

3.0.1 Sample preparation

Mangos varieties of apple and Tommy Atkins that were firm and ripe were obtained from Kangemi market, 20 in number for each variety. Washed, peeled, deseeded and sliced into 1.5cm by 0.5cm.

3.0.2 Osmotic dehydration

IA 3 X 2X 2 factorial design consisting of 80% syrup concentration, 70% syrup concentration and sugar crystals, two temperature of (40^{0}C and 60^{0}C) and the two mango varieties was used.

Dehydration was carried out for 6hours based on report by Ruiz-Lopez\ et al, 2010 Lombard et al, 2008

In another experimental trial, the slices were subjected to dehydration for 48 hours.

Based on results obtained in the slices was subjected to osmotic dehydration at 80 ^{o} brix and 40^{0}C for both varieties and in equal weight sugar crystals at 40^{0}C for both varieties for 30 hours.

Dehydrated slices were drawn from syrup cyristals and rinsed quickly in running tap water to remove surface sugar and blot d dried to remove surface moisture.

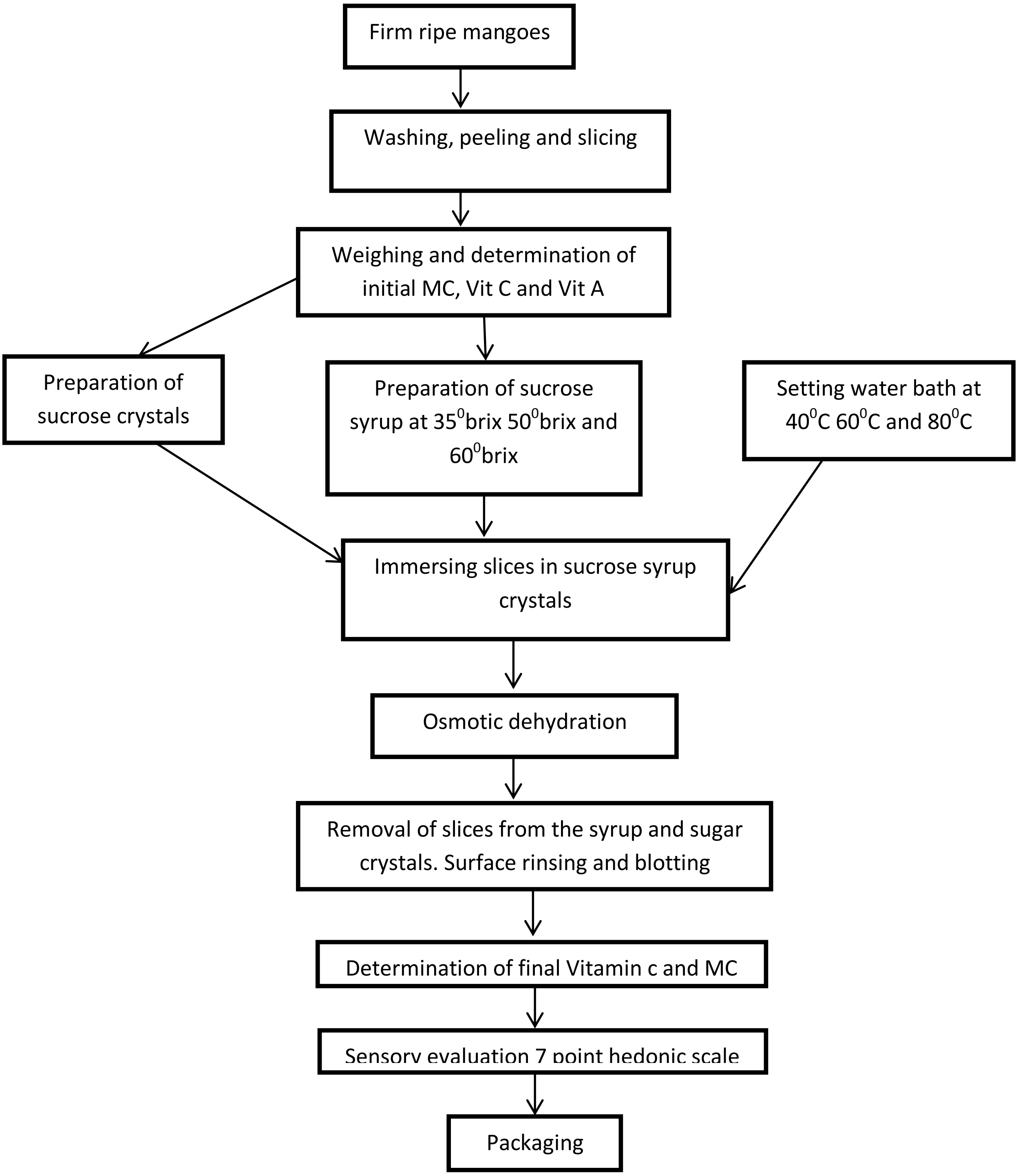
Final vitamin C the dehydrates slices was determined using TCA Bromosuciinamide methods.

Peeling and slicing done using a sharp clean knife from pilot plant.

Thermometer was used to monitor the temperatures of the water baths.

Air oven set at 105^{0}C was used to determine the moisture content by subjecting samples and allowing to dry to constant weight.

3.1 Process low diagram



Preliminary investigation suggests that at 90^0C and above there was excessive browning and collapse of the tissue and the tissue structure (ALAKALI et al, 2006). Hence the experiment was restricted to below 90^0c.

Sensory evaluation

A seven point hedonic scale was used to analyze on color, taste, texture and aroma using 10 panelists who responded by filling a sample of form shown below:

Score evaluation

Sample	color	texture	aroma	taste
A				
B				
C				
D				

Sensory scale

7. Like very much

6. Like moderately

5. Like slightly

4. Neither like nor dislike

3. Dislike slightly

2. Dislike moderately

1. Dislike Extremely

General comments……………………………………………………………………………………
……………………………………………………………………………………………………
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4.0 RESULTS AND DISCUSSION

Table 1.1 Initial MC, vitamin C and B- carotene

Component	Tommy Atkins	Apple	Theoretical value
MC	84.72	83.58	81.71
Vitamin C	4.834mg	12.108mg	27.7mg
Total carotenoids	11.08mg	8.54mg	-
B –carotene	173.27micrograms	954.77micrograms	445microgram

Tommy is high in total carotenoids than apple although apple is higher in B-carotene than tommy. This is an indication that tommy contains a lot of oxygenated xanthophyll carotenoids ration to carotene. Apple has shown higher proportion of carotene than tommy.

Since the varieties were picked from the market with little background of the source and farm management operation that produced them. Variation in nutritional composition from the theoretical value is evitable.

Nutritional composition is influenced by type of soil, cultivar, age of mango tree, climatic conditions, stage of harvesting and farm management practices hence a likely variation as indicated by the results.

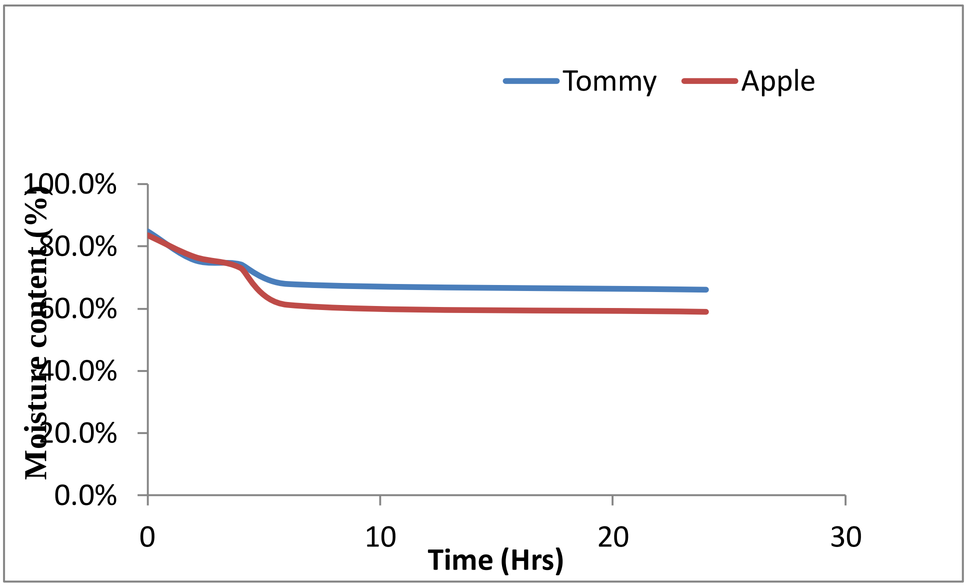

fig1: moisture content change at 650C for the 2 varieties at 35% syrup concentration.

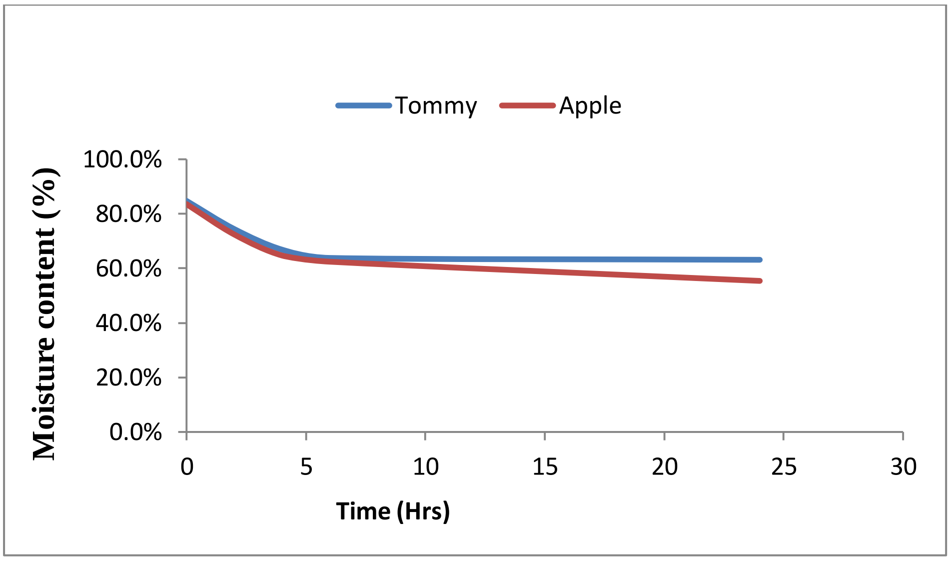

Fig2: moisture change at 60^0 for dehydration at 50% syrup concentration

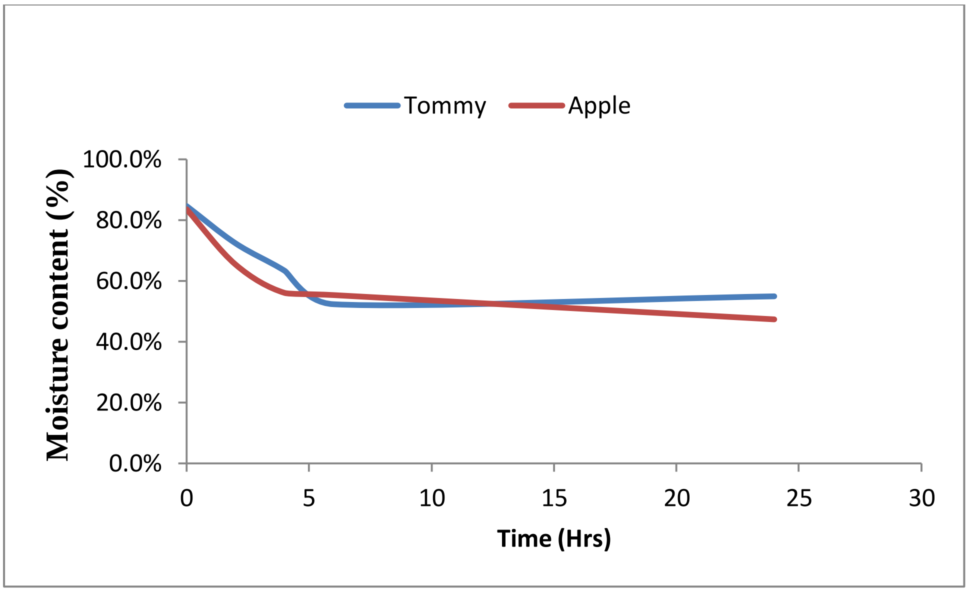

Fig 3: Moisture content change at 60^0C at 70% syrup concentration

There was faster loss at 70% concentration shown by the steep gradient within the first hours as opposed to 35% and 50%. Concentration induces a greater osmotic pressure that promotes water loss from the slices matrix.

From all the concentrations it is evident that osmotic dehydration was more effective on apple slices than tommy. This may be attributed to the slightly higher initial moisture content.

The rate of mass transfer increased with time, high temperature above 60^0C, the tissue characteristics are modified, favouring impregnation phenomena and thus solid gain instead of water loss (SHARMA, 2011). This is shown by the setting of equilibrium after 5hours. The moisture content at this time is far much higher than IMF range of 15%-40%.

After 24hours the desired moisture content was not yet achieved. The product obtained stayed on bench at 25^0C for only 7 days due to higher moisture content associated with higher water activity that favoured the spoilage by microorganisms.

The slices appeared dark in colour, at high temperature above 45^0C enzymatic browning and flavour deterioration occurs this is shown by a great decline in final vitamin C. caramelization of sugar and maillard interaction of the mango amino acids and the sugars is also a likely occurrence hence the darkening of the colour.

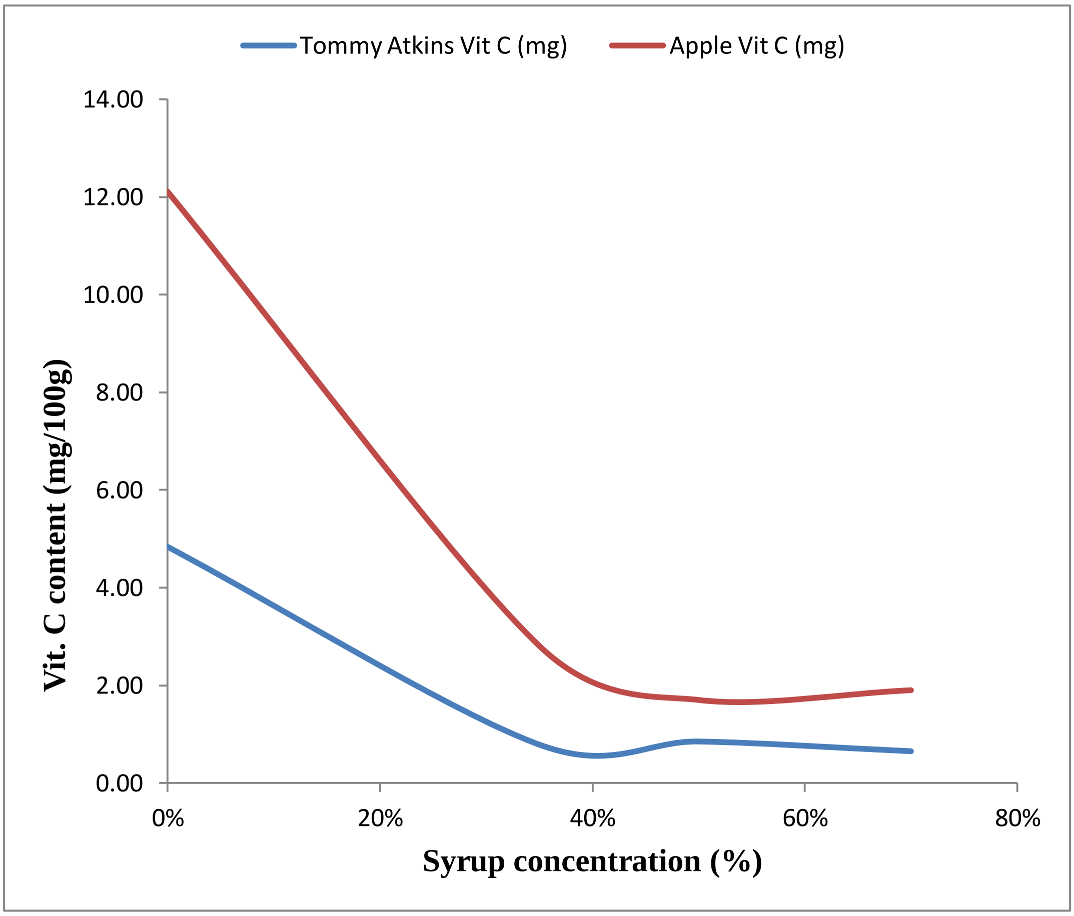

Fig4: vitamin C change at 60^0C vs. Syrup concentrations.

From the graph a great decline in final vitamin C from the initial vitamin C is registered. High temperature of 65^{0}C destroys vitamin C which is highly heat sensitive and very volatile; it escapes faster from the slices matrix owing to the induced kinetic energy of the dehydration temperature.

Syrup concentration has little effect on the loss as final vitamin c for all the concentrations shows slight difference. But the fact that vitamin C is water soluble, it dissolves in the water phase of the slices matrix and a great osmotic potential by higher sucrose concentration favoured a relative decline for different concentrations as some are lost dissolved in the water leaving slices. Impregnation phenomena that retards water loss is a great spare to loss via water dissolution.

EFFECTS OF HIGH TEMPERATURE ON QUALITY OF MANGO SLICES

i. Initiates oxidation of the vital components such as carotenoids and reduction of ascorbic acid thus loss.
ii. Induces maillard interactions of reducing sugars and amino acids in the mango slices hence the darkening of colour.
iii. Impregnation phenomena occur resulting into solids gain instead of water loss.

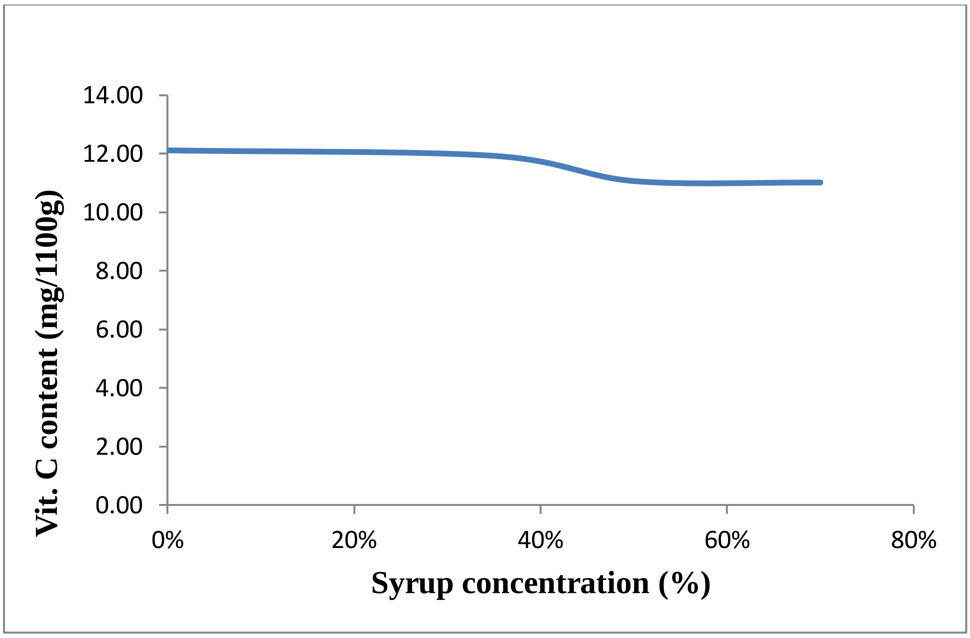

Fig5: vitamin C change vs. Syrup concentration for apple at 40^{0}C for 6hrs.

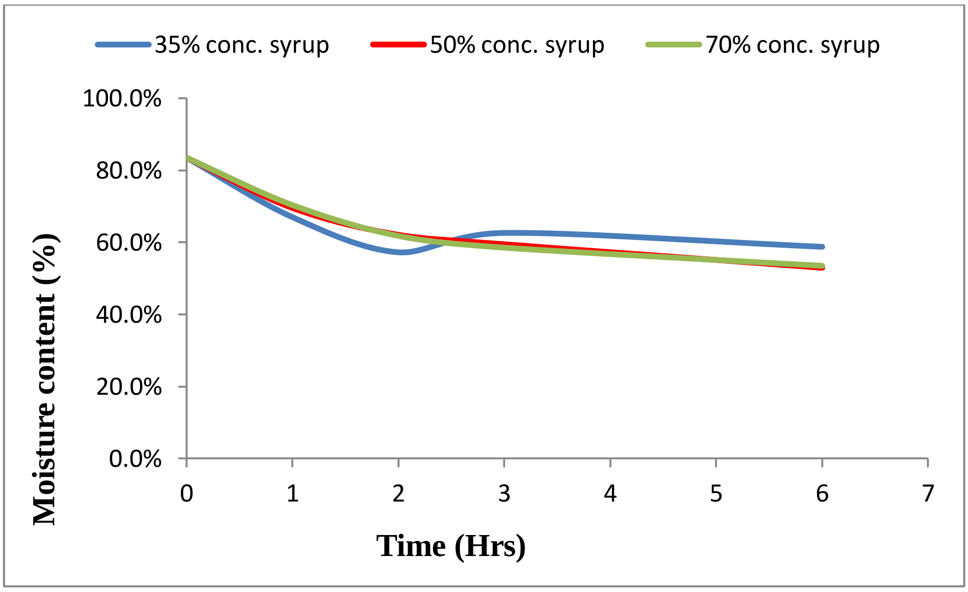

Fig 6: moisture content change at 40^{0}C for apple vs. time

35% syrup concentration induced a greater loss of water for the first 2hours than the rest. At low concentration solubility is higher hence faster diffusion rate.

For 50% and 70% sucrose syrup concentrations there was a gradual decline in moisture content until the onset of equilibrium at about 4 hours. At low concentration the sugar solutes dissolve rapidly and diffuse into the slices matrix, with time the slices become more hypertonic to the syrup solution thus water take up instead of loss as shown by the rise in moisture content after two and half hours.

Though the IMF moisture range is not yet achieved, there was a great conservation of vitamin C. owing to the adverse effects on quality of mango slices dehydrated at 65^{0}C and observed desirable quality attributes at 40^{0}C dehydration. This prompted the change of experimental design to restrict it at 40^{0}C and increaser sucrose syrup concentration to 80% and also introduce dry sucrose crystals for osmotic dehydration.

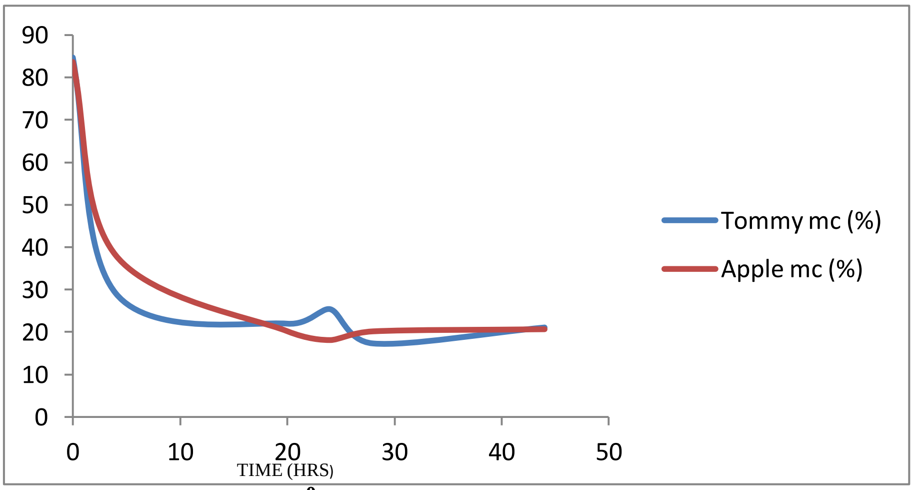

fig7: moisture change at 40^{0}C vs. Time using crystals

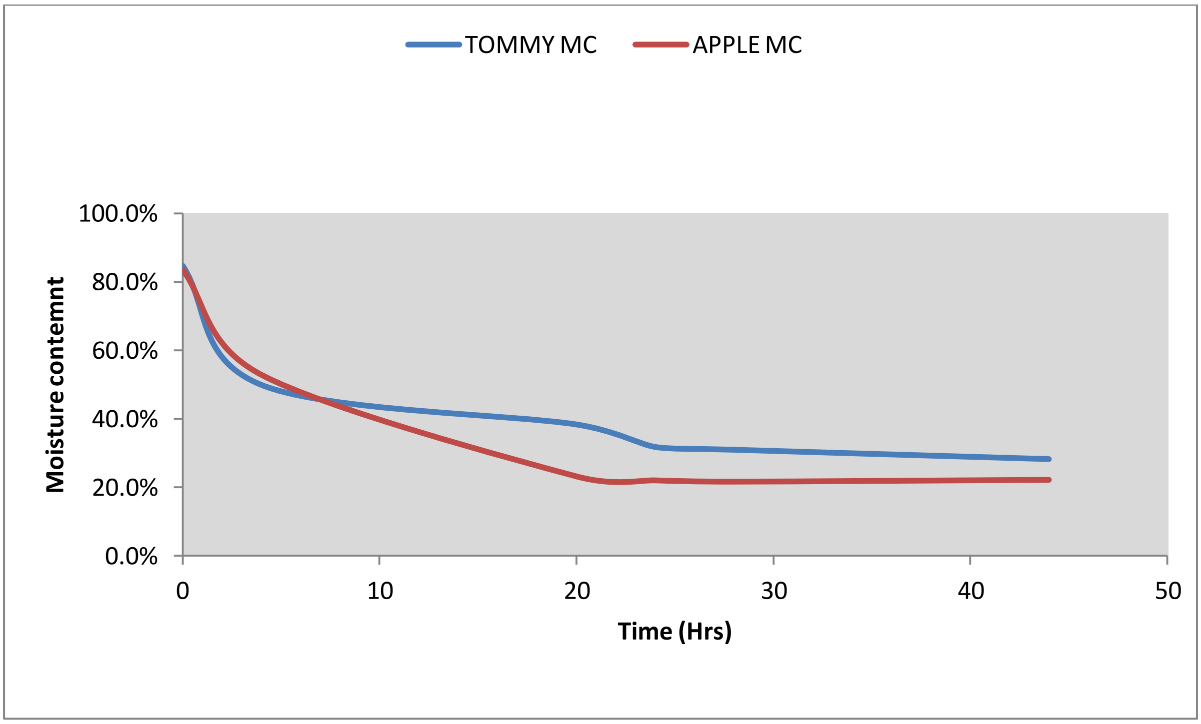

Fig8: moisture content change vs. Time at 40^{0}C using syrup at 80%

Very steep gradient is achieved using crystals for the first 2 hours than using sucrose crystals. For the first few hours water loss in tommy is much greater than that of apple.

If one would have liked to get apple and tommy slices with the same moisture content then it would be possible to dehydrate for 7 hours using sucrose syrup at 80% or for 17 hours using sugar crystals in which case sucrose syrup would be more appropriate due to short time.

After 7 hours for syrup dehydration and 17 hours for crystals dehydration, osmotic dehydration seemed to be more effective on apple than tommy.

Although crystals give more effective dehydration effect than syrup, fluctuation in moisture content is observed, at one point the moisture content being higher than the previous. It is hard to control uniformity of the mix and dehydration depends on the amount of crystals on the surface of the slices. This non- uniformity is a factor in fluctuating moisture content. With sucrose syrup agitation facilitates uniform distribution of the particles thus a gradual decline in moisture content is realized.

Equilibrium is established after 24 hours thus it is not economical to dehydrate beyond 24 hours in terms of energy costs. Long periods of dehydration results into fermented flavour of the slices as the sugars are being fermented due to long exposure to the yeast substrate and the low temperature.

PROBLEMS

Dehydration at relatively low temperature of 40^0Cfor longer periods initiate fermentation of mango slices. Thus induced fermented flavour on slices which is not desirable.

Low temperature dehydration should be done for short time

FINAL VITAMIN C AND MOISTURE CONTENT

	Tommy	**Apple**
80% sucrose MC	28.29	22.23
Syrup vitamin C	2.14mg/100g	11.09mg/100g
Sugarcrystals MC	21.09	20.17
Vitamin C	2.4831mg/100g	11.02mg/100g

Optimum conservation of vitamin C Final MC is within the range of IMF but the water content is still high thus the shelf life of slices may not be long as expected.

MEAN MC AND VITAMIN C CHANGE

COMPONENT	**TOMMY**	**APPLE**
MC IN SYRUP	**66.62%**	**73.12%**
MC IN CRYSTALS	**75.15%**	**75.25%**
VITAMIN C	**48.69%**	**8.99%**

Apple registered great water loss than apple as indicated by the mean percentage changes, in terms of vitamin C retention, apple still registered greater retention percentage as opposed to almost Tommy's almost 50% loss. In general, osmotic dehydration is more effective on apple than Tommy.

Material balance

Weight of materials

$$\text{Slices in } crystals = 350g$$
$$syrup = 465g$$

Total moisture in the product

$$= \frac{84.72}{100} x\ 350$$
$$= 296.52g\ for\ crystals$$

$$= \frac{84.72}{100} x\ 405$$
$$= 343.116g\ for\ syrup$$

Final weight of slices

$$crystals = 205g$$
$$syrup = 210g$$

Total water content of dehydrated slices

$$syrup = \left(\frac{28.29}{100} x\ 210\right) = 54.409g$$
$$crystals = \left(\frac{21.09}{100} x\ 205\right) = 43.235g$$

Case 1

Water lost

$$syrup = (\ 343.116 - 59.409) = 283.707g$$
$$crystals = (\ 296.52 - 43.2345) = 253.286g$$

Weight of sugar used

$$syrup = (\ 470 + 100) = 570g$$
$$crystals = (920 - 266) = 654g$$

Water lost to syrup = $(283 - 70)g$

Weight of syrup and container = $(654 - 283.707)$g

$$= 370.293\text{g}$$
$$\text{Crystal taken up} = (570 - 370.293)$$
$$caseli = 199.707g\ of\ sugar$$

Case 2

Crystal dehydration

$$weight\ of\ sugar\ uses = 300g$$
$$water\ lost = 253.280g$$
$$sugar\ takes\ in = (\ 341.068 - 253.280g)$$
$$= 87.788g$$
$$sugar\ not\ taken\ in = (300 - 87.788)$$
$$= 212.212g$$

In summary in syrup dehydration sugar taken up by slices was 199.09g per 405g of slices and for crystal dehydration was 87.788g per 350g.hence syrup dehydration promotes solid gain than crystal dehydration, though solid gain is not desirable but it gives effective water loss.

SENSORY EVALUATION RESULTS AND DISCUSSION

Table of summary: showing means and l.s.d of sensory evaluation.

	Aroma	Colour	Taste	Texture
A (Tommy, syrup at 80%)	4.9	4.6	5.4	4.9
B (Tommy, crystal	5.3	5.2	5.7	5.3
C (apple, crystals)	5.9	6.6	6.2	6.1
D (apple, syrup at 80%)	5.5	5.8	5.6	5.5
L.S.D	1.194	0.800	1.053	1.094
P-value`12	0.404	<0.001	0.0471	0.181

AROMA

There is no significant difference in terms of effect of treatments on aroma retention as indicated by mean differences which are less than the L.S.Ds. at 5%

COLOR

There is a significant difference between A and D, A and C, B and C. Treatment A and B showed no difference i.e. has the same effect on colour retention. Treatment C showed the highest ability to give quality colour attributes.

TASTE

Influence of different treatments on taste showed no significant difference, thus, treatments had same effects on taste.

TEXTURE

A and C showed a significant difference. Treatment by sugar crystals for apple gives the best texture relative to treatment of Tommy by syrup

4.3 CONCLUSION

Osmotic dehydration has shown desirable nutritional and sensorial quality mango slices. Though the desired dried fruit moisture content had not been achieved there was great conservation of vitamin C, aroma, taste, colour and texture.

4.1 RECOMMENDATIONS

With the many health benefits of consuming the fruit, I urge for more research on improving theseasonal fruits shelf life be carried out so as to create availability and wide spread commercialisation.

Mediate extension farmer linkages in an effort to encourage and enhance skills on production and preservation of the fruits by the farmers.

Spent liquor can be recycled or fermented to alcoholic beverages that have a partial mango flavour.

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